3.ULUSLARARASI

MARDİN

BİLİMSEL ARAŞTIRMALAR VE İNOVASYON KONGRESİ

28-29 Haziran 2025
MARDİN

KONGRE KİTABI

Editors:
Prof. Dr. Gencay SARIIŞIK
Assist. Prof. Dr. Casim YAZICI
Assist. Prof. Dr. Gönül GÖKÇAY



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INDEX

CONGRES ID		II
PROGRAM		V- XXIV
GALLERY		XXV- XXVIII
ACADEMIC INCENTIVE		XXIX
NOTIFICATIONS		XXX

CONGRESS ID

CONGRESS TITLE

3rd INTERNATIONAL MARDIN SCIENTIFIC RESEARCH AND INNOVATION CONGRESS

DATE AND PLACE

28-29 JUNE 2025, MARDİN ONLINE PRESENTATIONS

ORGANIZATION

ISARC INTERNATIONAL SCIENCE AND ART RESEARCH CENTER

GENERAL COORDINATOR

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ISBN '978-625-378-262-7'

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29.06.2025
SUNDAY / 10:30-12:30

SESSION-1 HALL-1
MODERATOR: Assoc. Prof. Serap ŞAHİN

AUTHORS	AFFILIATION	TOPIC TITLE
Gülümser DURGUN Sevilay ERDEN Songül KARADAĞ	Çukurova University TÜRKİYE	The Role Of Nursing In Robotic Cardiac Surgery: Processes, Advantages, Disadvantages, And Recommendations For Practices In Turkey
Gülümser DURGUN Sevilay ERDEN	Çukurova University TÜRKİYE	Virtual Reality In Perioperative Nursing: Innovative Approaches For Pain Management In Obese Patients Undergoing Robotic Surgery
Murat BAZO Mehmet KÜÇÜKOFLAZ	Kafkas University TÜRKİYE	Sheep Farming Profile Of The Tra2 Region
Elif ÖZGÜLER Assoc. Prof. Serap ŞAHİN	Afyonkarahisar Health Sciences University TÜRKİYE	Investigation Of Cytotoxic Effect Of Trimetazidine Dihydrochloride On Hela Cancer Cells
Assist. Prof. Dr. Samed ŞİMŞEK Tuğçe VAROL	Erzincan Binali Yildirim University TÜRKİYE	Biological Evaluation Of Chenopodium Foliosum: Focusing On Antioxidant And Anticancer Activities
Dr. Kemal PANÇ Sümeyye SEKMEN	Ministry of Health Karakoçan State Hospital TÜRKİYE	Integrative Machine Learning Model Leveraging Dce-Mri And Psa Density For Advanced Risk Stratification In Prostate Cancer
Dr. Kemal PANÇ Sümeyye SEKMEN	Ministry of Health Karakoçan State Hospital TÜRKİYE	Multi-Cnn Deep Feature Fusion And Stacking Ensemble Classifier For Breast Ultrasound Lesion Classification
Dr. Kemal PANÇ Sümeyye SEKMEN Hasan GÜNDOĞDU	Ministry of Health Karakoçan State Hospital TÜRKİYE	Liver And Pancreatic Fat Fractions As Predictors Of Disease Severity In Acute Pancreatitis: An Mr Ideal-Iq Study
Dr. Kemal PANÇ Sümeyye SEKMEN Hasan GÜNDOĞDU	Ministry of Health Karakoçan State Hospital TÜRKİYE	Enhancing Bone Metastasis Prediction In Prostate Cancer Using Quantitative Mpmri Features, Isup Grade, And Psa Density: A Machine Learning Approach

29.06.2025
SUNDAY / 10:30-12:30

SESSION-1 HALL-2

MODERATOR: Prof. Dr. Sevilay ERDEN

AUTHORS	AFFILIATION	TOPIC TITLE
Ömer Can ERCE PhD. Aydın SEVER Ramazan GÜNDOĞDU Lütfi BEHÇET	Bingöl University TÜRKİYE	Investigation Of Cytotoxic Effect Of Some Salvia Species Combined With Aurora-B Inhibitor On Breast Cancer Cell Line
Onur AKYAPI PhD. Aydın SEVER Mehmet Kadir ERDOĞAN Lütfi BEHÇET	Bingöl University TÜRKİYE	Anti-Cancer Effect Of Some Salvia Species Combined With Resveratrol On Breast Cancer
Resc. Assist. Beşir ÇAKIR Assoc. Prof. Dr. Duygu AYAR Resc. Assist. Sebahat KUŞLU	Gaziantep İslam Bilim ve Teknoloji University TÜRKİYE	Supplementary Nutrition In Children And Nursing: What Are The Current Approaches To Transition To Supplementary Food?
Resc. Assist. Beşir ÇAKIR Assoc. Prof. Dr. Duygu AYAR Resc. Assist. Sebahat KUŞLU	Gaziantep İslam Bilim ve Teknoloji University TÜRKİYE	Current Vaccination Calendars Used In Countries And Nursing: How Are We Doing With Childhood Vaccines?
Dr. Hemş. Birgül BELGIN Prof. Dr. Sevilay ERDEN	Çukurova University TÜRKİYE	Evidence-Based Practices To Prevent Surgical Site Infections
Dr. Hemş. Birgül BELGIN Prof. Dr. Sevilay ERDEN	Çukurova University TÜRKİYE	Precautionary Packages Used To Prevent Surgical Site Infections In Patients Undergoing Craniotomy And The Roles Of The Nurse
Merve İCAT Gülay ALTUN UĞRAŞ Prof. Dr. Sevilay ERDEN	Mersin Toros Devlet Hastanesi TÜRKİYE Çukurova University TÜRKİYE Mersin University TÜRKİYE	The Use Of Robotic Surgery In Plastic, Reconstructive And Aesthetic Surgery And Nursing Approaches
Merve İCAT Sevilay ERDEN	Mersin Toros Devlet Hastanesi TÜRKİYE Mersin University TÜRKİYE	The Latest Technology In Plastic, Reconstructive And Aesthetic Surgery: Artificial Intelligence And Nursing Approaches

29.06.2025
SUNDAY / 11:00-13:00

SESSION-2 HALL-3
MODERATOR: Assoc. Prof. Dr. M. Fatih KARAHAN

AUTHORS	AFFILIATION	TOPIC TITLE
Noor ALLAHHAM Mustafa ÇAKIR	Iskenderun Technical University TÜRKİYE	Machine Learning In Health Predictions: Transforming Data To Value
Mehmet GÖL Ahmet YAPICI	Iskenderun Technical University TÜRKİYE	Finite Element Investigation Of The Ballistic Performance Of Boron Carbide Ceramic Body Armor Covered With Kevlar 29 Fabric
Mitat UYSAL Aynur UYSAL Assist. Prof. Dr. Üyesi Elif ERÇELIK	Doğuş University TÜRKİYE	Support Vector Machines And Their Optimization Using Smo, Mbo, And Pso: A Comparative Study
Melek ARI Kemal Anıl GÜVENÇ Batuhan EYÜBOĞLU Hüseyin Ardıl KARASUNGUR Gürkan KIZIK Birsen GÜLDEN ÖZDEMİR Yiğit AYDOĞAN	Doğuş University TÜRKİYE	Cosmalyze: An Ai Supported Cosmetic Analysis Mobile Application
İslam POLAT Prof. Dr. Gencay SARIIŞIK	Harran University TÜRKİYE	A Multi-Criteria Decision-Making Approach For Erp Software Selection In The Electricity Distribution Sector: A Comparison Of Ahp, Topsis, And Vikor
Hüseyin KALIN Prof. Dr. Gencay SARIIŞIK	Harran University TÜRKİYE	Prioritization Of It Investment Projects In The Electricity Distribution Sector Using Multi-Criteria Decision-Making Methods: An Application Of Ahp, Promethee, And Vikor
Ömer Faruk ÇİRİŞ Süleyman ADAK Hasan CANGİ Ramazan ALTINTAŞ	Kahramanmaraş Sütçü İmam University TÜRKİYE Mardin Artuklu University TÜRKİYE Hasan Kalyoncu University TÜRKİYE	Investigation Of The Particle Swarm Optimization Method In Maximum Power Point Tracking Of Photovoltaic Systems
Assoc. Prof. Dr. M. Fatih KARAHAN	Manisa Celal Bayar University TÜRKİYE	Multiple Scales Lindstedt Poincare Method For Solving Strongly Septic Duffing Equation
Serdar VOLKAN Erkan GÜLER	Dokuz Eylül University TÜRKİYE	Investigation Of Enrichment Conditions Of Çukuralan Region Gold Ore By Leaching Method

29.06.2025
SUNDAY / 11:00-13:00

SESSION-2 HALL-4
MODERATOR: Assist. Prof. Dr. Nurhilal BURAK

AUTHORS	AFFILIATION	TOPIC TITLE
Assist. Prof. Dr. Nurhilal BURAK	Bursa Teknik University TÜRKİYE	The Impact Of Salutogenic Design On Sensory Integration In Children's Spaces
Dr. Furkan Şahin Muhammed Mustafa ÇALIŞ	Nişantaşı University TÜRKİYE	Behavior Of A 5-Storey Seismic Isolated Building Under The Effect Of 4 Different Earthquakes That Took Place In Our Country
Bilal DÖRTTEPE Osman BABAYİĞİT	Karamanoglu Mehmetbey University TÜRKİYE	A Study On The Effect Of Air Velocity And Water Temperature On Supply Air In Evaporative Cooling Process
Büşra DURDAĞI Sevda Duygu KOLBAY	İstanbul Gedik University TÜRKİYE	An Examination Of Energy Efficient Design Principles Through Traditional Vernacular Architecture And Contemporary Regional Design Practices In The Hot-Humid Climate Zone
Gamze Nur CÜRE Sevda Duygu KOLBAY	İstanbul Gedik University TÜRKİYE	The Role Of Prefabricated Buildings In Earthquake Zones: A School Project In Hatay
Dr. Rejhan RAHMAN	Harran University TÜRKİYE	The Impact Of Albania's Nato Membership On Regional Security
Aslıhan TURGUT	Selçuk University TÜRKİYE	Investigation Of Key Factors Affecting Success In Disaster Logistics Management
Nargiz AİTUGANOVA	Bolu Abant İzzet Baysal University TÜRKİYE	Economic Analysis Of Wheat Production In Northern Kazakhstan:Productivity, Exports, And International Comparison

29.06.2025
SUNDAY / 11:00-13:00

SESSION-2 HALL-5
MODERATOR: Assist. Prof. Dr. Gönül GÖKÇAY

AUTHORS	AFFILIATION	TOPIC TITLE
Tuğçe KOLAÇ Turgay KOLAÇ Gülsüm YETİŞ KOCA Perihan GÜRBÜZ	İnönü University TÜRKİYE	Chrosophora Tinctoria (L.) A. Juss. Comparison Of The Antioxidant Activity Of Different Plant Parts Of Flour And The Total Amounts Of Phenolic Substances
Sultan AYTEKİN Gülsen TİRYAKİOĞLU Öğr. Gör.Filiz KOÇOĞLU SAĞLAM Prof. Dr.Yeliz KINDAP TEPE	Ondokuz Mayıs University TÜRKİYE	An Investigation Of Digital Addiction In Adolescents According To Demographic Variables
Büşra Nur Arslan Yağmur Öztürk Filiz KOÇOĞLU SAĞLAM Yeliz KINDAP TEPE	Ondokuz Mayıs University TÜRKİYE	The Effect Of Digital Detox On Smartphone Addiction And Smartphone Craving: An Investigation In Terms Of Demographic Characteristics
Assist. Prof. Dr. Gönül GÖKÇAY Ferhat AKTUZ	Kafkas Üniversitesi TÜRKİYE	Vaccine Rejection And Its Effects On Maternal And Child Health
Volkan UCA Assist. Prof. Dr. Gönül GÖKÇAY	Kafkas Üniversitesi TÜRKİYE	The Relationship Between Parents' Health Beliefs, Antibiotics Perceptions And Vaccine Attitudes
Muhammed AYDIN	Aydın Adnan Menderes University TÜRKİYE	Spiritual Counseling And Guidance Practices In Our Country: Basic Qualifications And Competencies
Major Gheorghe GIURGIU Prof dr med Manole COJOCARU	Deniplant-Aide Sante Medical Center ROMANIA Titu Maiorescu University ROMAINA	Natural Modulation Of The Gut Microbiota In Patients With Food Allergies. Impact Of Alergiplant
Kadri ATAY	Mardin Research and Training Hospital TÜRKİYE	Evaluation Of The Efficacy Vedolizumab And Ustekinumab In The Treatment Of Crohn's Disease: A Single Center Cohort Study

29.06.2025
SUNDAY / 11:00-13:00

SESSION-2 HALL-6
MODERATOR: Assoc. Prof. Dr. İbrahim ARMAN

AUTHORS	AFFILIATION	TOPIC TITLE
Lect. Mesut YILMAZ Dr. Mehmet DEMİRHAN	Malatya Turgut Özal University TÜRKİYE	Systematic Review Of Graduate Theses Focusing On Early Fatherhood Experiences In Turkey (0-2 Age Group)
Uzman Öğretmen Yücel PEKGENÇ Dr. Mehmet DEMİRHAN	Malatya Turgut Özal University TÜRKİYE	Sample Selection In Research Methods: The Difference Between Quantitative And Qualitative Approaches
Songül KAYIK Selahattin Barış ÇELEBİ	Batman University TÜRKİYE	Solar Radiation Prediction With Deep Learning Base Time Series
M. Reşit AKKAYA Yıldız KOÇ Özkan KÖSE	İskenderun Teknik University TÜRKİYE	Thermodynamic Performance Evaluation Of A Lng-Cooled Low-Grade Heat Recovery Supercritical Co 2 Cycle
Dr.Serkan SAYAR	Suleyman Demirel Anatolian High School TÜRKİYE	Anti-Zionism In The Jewish Tradition: A Theological Assessment In The Context Of The Three Oaths
Dr.Serkan SAYAR	Süleyman Demirel Anatolian High School TÜRKİYE	Sibling Rivalry In Tanah: Ethno-Theological Foundations Of Collective Identity
YL. Öğr. İsmail Karakaya Assoc. Prof. Dr. İbrahim ARMAN Resc. Assist. Dr. Aycan ÇELİK Resc. Assist. Dr. Utku Can ATILGAN	Zonguldak Bülent Ecevit University TÜRKİYE	In-Silico Evaluation Of Potassium Sorbate As A Multi-Target Antimicrobial Agent Against Enterococcus Faecalis

29.06.2025
SUNDAY / 11:00-13:00

SESSION-2 HALL-7
MODERATOR: Assist. Prof. Dr. Gökçe GÜVEN

AUTHORS	AFFILIATION	TOPIC TITLE
Ecrin ÇETİN Assist. Prof. Dr. Dilek ARDUZLAR KAĞAN	Doğuş University TÜRKİYE	Use Of Local Herbs In Gastronomy In Seven Regions Of Turkey
Melisa DOYMAZ Assist. Prof. Dr. Dilek ARDUZLAR KAĞAN	Doğuş University TÜRKİYE	Traditional And Nearly Forgotten Tastes Of The Central Anatolia Region
Assist. Prof. Dr. Gökçe GÜVEN	Trakya University TÜRKİYE	Claude Debussy's Piano Music
Ensar Abdullah GÖKALP Dr. Oya ÇEPNİ ÖNALAN	Safranbolu Science And Art Center TÜRKİYE Karabuk University TÜRKİYE	Effects Of Stress Factors On Employees And Coping Methods
Miray YILMAZ DURMUŞOĞLU Assist. Prof. Dr. İlke Bezen TOZKOPARAN	Firat University TÜRKİYE	Innovative Eco-Friendly Technologies And Ecological Footprint: Harmonious Approaches For A Sustainable Future
Mustafa Yunus GÜMÜŞ	Malatya Turgut Özal University TÜRKİYE	The Sound-Meaning Relationship In Divan Poetry: Onomatopoeic Words
Samet KAHYA Prof. Dr. Murat YAZICI	Bursa Uludağ University TÜRKİYE	Creating A Quarter Vehicle Model With Variable Damper Coefficient On Matlab To Be Used In Regenerative Suspension Design Calculations
Taner BİLGİN Seda Nur ÜSTÜN	Bilecik Seyh Edebali University TÜRKİYE	Administrative Division And Local Government Structure Of Bilecik Between 1930-1945
Yulduz RAMAZANOVA Elmira NAGHIYEVA Malahat ABBASOVA Kamala MAMMADOVA Solmaz AFANDIYEVA Safiyya MELIKOVA	İnstitute of Additive Chemistry of the Ministry of Science and Education of the Republic of AZERBAYCAN	Biosustainable Engine Oil For Marine Diesel Engines

29.06.2025
SUNDAY / 11:00-13:00

SESSION-2 HALL-8
MODERATOR: Dr. Casim YAZICI

AUTHORS	AFFILIATION	TOPIC TITLE
Mehmet Ali TÜMKAYA Mustafa YÜKSEK	Iskenderun Technical University TÜRKİYE	Meta-Material Based Circular Ring Resonator Frequency Selective Structure
Emre ERGEN Lect. Mustafa PEHLİVAN	Samsun University TÜRKİYE	Experimental Investigation Of The Effect Of Silicium Oxide Added Ultra Ever Dry® Coatings On The Wettability Performance Of Stainless-Steel Surfaces
Hülya AKTAŞ	Dogus University TÜRKİYE	Differences Between Late Payment Interest And Contractual Interest And Their Practical Implications: An Analysis On Credit Card Debt
Hülya AKTAŞ	Dogus University TÜRKİYE	Public Guarantee In The Protection Of Savings: The Strategic Role Of The Savings Deposit Insurance Fund
Dr. Casim YAZICI	Ağrı İbrahim Çeçen University TÜRKİYE	Seismic Performance Prediction Of Rc Buildings Using Visual Screening And Machine Learning
Dr. Casim YAZICI	Ağrı İbrahim Çeçen University TÜRKİYE	Numerical Evaluation Of Reinforced Concrete Beam–Column Connections Under Monotonic Loading With Variable Reinforcement And Concrete Strengths
Nelya NOVOTORZHINA Shafa KAZIMZADEH Jamila AHMEDOVA Mekhpara SAFAROVA Gahramanova GARIBA İngilab İSMAYILOV	Institute of Additive Chemistry of the Ministry of Science and Education of the Republic AZERBAYCAN	Anti-Seize Additive For Semi-Synthetic Oils

29.06.2025
SUNDAY / 12:00-14:00

SESSION-3 HALL-9

MODERATOR: Dr. Subhashish DEY

AUTHORS	AFFILIATION	TOPIC TITLE
Taskeen FATIMA Mahna FATIMA Adnan Sarwar CHAUDHARY	Hajvery University PAKISTAN	An Overview Of Cad; Etiological Factors & Surgical Managements
Taskeen FATIMA Mahna FATIMA	Hajvery University PAKISTAN	Formulation And Evaluation Of Otf Of Cetirizine For Rapid Systemic Action
Taskeen FATIMA Mahna FATIMA	Hajvery University PAKISTAN	Correlation Study On Etiological Factors Of Heart Disease In Diabetic Patients In Lahore, Pakistan
Hejab FATIMA Maryam DAWOOD	University of Management and Technology	The Role Of Networking In Job Opportuniies; A Cross Sectional Study
Taskeen FATIMA	Hajvery University PAKISTAN	The Clinical Significance Of Normal Physiological Blood Parameters In Health Assessment
Taskeen FATIMA	Hajvery University PAKISTAN	The Impact Of Liver Cirrhosis On The Progression And Complications Of Diabetes Mellitus
Dr. Subhashish DEY	Gudlavalleru Engineering College INDIA	Effect Of Cbr Results For Fly Ash Purified Clayey Soil Materials
Dr. Subhashish DEY	Gudlavalleru Engineering College INDIA	Application Of Machine Learning For Crackdetection On Concrete Structures Using Cnn Architecture

29.06.2025
SUNDAY / 12:00-14:00

SESSION-3 HALL-10
MODERATOR: Prof. Dr. Muhammad TAYYAB

AUTHORS	AFFILIATION	TOPIC TITLE
Prof. Dr. Muhammad TAYYAB	University of Veterinary and Animal Sciences PAKISTAN	Enzymes And Poultry Feed Industry
Saloni SHARMA Suhani SHARMA	Deemed to be University INDIA	Gender Differences In The Co-Occurrence Of Celiac Disease And Autoimmune Thyroiditis
Saloni SHARMA Suhani SHARMA	Deemed to be University INDIA	Circular Chemistry: Designing Waste-Free Reactions For A Sustainable Future
Mrs. E. ELAVARASI Yuvaraj AR J. JAYADURKA Dr. R. SRINIVASAN	Faculty of Pharmacy INDIA	Acetylcholine, Molecular Characteristics, And Applications
Mrs. E. ELAVARASI Yuvaraj AR J. JAYADURKA Dr. R. SRINIVASAN	Bharath Institute of Higher Education and Research INDIA	Bioprinting In The Pharmaceutical Industry
Mrs. E. ELAVARASI Yuvaraj AR J. JAYADURKA Dr. R. SRINIVASAN	Bharath Institute of Higher Education and Research INDIA	Novel Concepts Regarding Diabetes And End-Stage Renal Disease
Mrs. E. ELAVARASI Yuvaraj AR J. JAYADURKA Dr. R. SRINIVASAN	Bharath Institute of Higher Education and Research INDIA	Chicory Plant: Extraction, Purification, And Uses In Herbal Drug Technology
Mrs. E. ELAVARASI Yuvaraj AR J. JAYADURKA Dr. R. SRINIVASAN	Bharath Institute of Higher Education and Research INDIA	Diabetic Treatment With Diabetic Medication As Oral Administration

29.06.2025
SUNDAY / 12:00-14:00

SESSION-3 HALL-11
MODERATOR: Dr. Hamid GADOURI

AUTHORS	AFFILIATION	TOPIC TITLE
Dr. Kalsoom TARIQ Hashim KHAN Bela INAYAT	Khyber Girls Medical College PAKISTAN	Role Of Asymmetrical Dimethyl Arginine In Cardiovascular Diabetology
ARRAJI Maryem CHAHBOUNE Mohamed	Hassan First University MOROCCO	Determinants Of Medication Adherence: A Key Challenge In Chronic Disease Management
Dr. Hamid GADOURI Dr. Brahim MEZIANI	Khemis Miliana University ALGERIA	Comparative Review Of The Roles Of Natural Pozzolana, Barium Compounds, Sodium Silicate, And Polypropylene Fibers In Mitigating Sulfate-Induced Distress In Lime-Stabilized Soils
Khadija CHANNAN Khalid HILAL Ahmed KAJOUNI	Sultan Moulay Slimane University MOROCCO	Optimal Control Of A Cocaine–Heroin Epidemiological Model Involving The Psi-Caputo Fractional Time-Derivative
R. VIDHYALAKSHMI Dr. K. RAJAGANAPATHY Dr. R. SRINIVASAN R.VIDHYALAKSHMI	Bharath Institute of Higher Education and Research INDIA	The Gut-Brain Axis In Autism Spectrum Disorder: Microbiome Dysbiosis, Probiotics And Potential Mechanisms Of Action
R. VIDHYALAKSHMI Dr. K. RAJAGANAPATHY Dr. R. SRINIVASAN R.VIDHYALAKSHMI	Bharath Institute of Higher Education and Research INDIA	Formulation Development Of Novel Drug Delivery Systems: Challenges And Opportunities
R. VIDHYALAKSHMI SARANYA. P PRATHEEBA.G DANISH KHAN C.REJITHA Dr. R. SRINIVASAN	Bharath Institute of Higher Education and Research INDIA	Understanding The Mechanisms Of Alzheimer's Disease
R. VIDHYALAKSHMI SARANYA. P PRATHEEBA.G DANISH KHAN C.REJITHA Dr. R. SRINIVASAN	Bharath Institute of Higher Education and Research INDIA	The Impact Of Diabetes On Global Health

29.06.2025
SUNDAY / 12:00-14:00

SESSION-3 HALL-12
MODERATOR: Assit. Prof. Dr. Meha PANT

AUTHORS	AFFILIATION	TOPIC TITLE
Tanimu BALA Usman HASSAN Ibrahim Bello ABUBAKAR	Aliko Dangote University NIGERIA	Mitigating Misinformation In Nigeria Using Machine Learning And Information Literacy
M. K. VIJAYALAKSHMI Puniparthi SUNITHA K. POOJA	-	Understanding Hydrops: Causes, Diagnosis, And Management Across Life Stages
Shashwath M. Shyam D. Vishaal S. Vishnu L. Banu Prakash S.	RMK ENGINEERING COLLEGE INDIA	Temperature Management And Safety Enhancement In Ev Batteries
Abbas Eghbal MEHRAN Kosar ADIBANKHAH	Shahid Chamran University of Ahvaz IRAN Payam Noor University of South IRAN	Studying The Impact Of Military Schools And Military Units On The Development Of Sports In Iran During The Qajar Period
K. POOJA Dr. M. K. VIJAYALAKSHMI	Bharath Institute of Higher Education and Research Faculty of pharmacy INDIA	Reiew On Anticoagulant Therapy Management
Izuogu, C. U. Okonwe, P. N. Njoku, L. C. Olaolu, M. O. Ibrahim-Olesin, S. Umeh, N. E. Agou, G. D. Iroegbu, S. C.	Alex Ekwueme Federal University NIGERIA	Access And Use Of Information And Communication Technology Among Rice Farmers In Ishielu, Ebonyi State, Nigeria.
Abdessamad DIDI Mustapha KRIM Jawad BOUZID Mohamed BENAICH Hindou BADDIH Zouhair SADOUNE	University Hassan First MOROCCO University Ibn Tofail MOROCCO	Towards A Low-Carbon Future: A Comparative Techno-Economic Evaluation Of Energy Sources For Sustainable And Cost-Effective Transitions
Research Scholar Abeeta HILAL Assit. Prof. Dr. Meha PANT	Sharda University INDIA	From Ceasefire To Crisis: The Unfolding Of Recent Violence In Gaza

29.06.2025
SUNDAY / 12:30-14:30

SESSION-4 HALL-1
MODERATOR: Assoc. Prof. Dr. Naseem AKHTER

AUTHORS	AFFILIATION	TOPIC TITLE
Assoc. Prof. Dr. Naseem AKHTER	Shaheed Benazir Bhutto Women University PAKISTAN	Women In Power: Political Participation And Empowerment During The Abbasid Caliphate
Assoc. Prof. Dr. Naseem AKHTER	Shaheed Benazir Bhutto Women University PAKISTAN	Empowerment And Participation: Women In Early Islamic Public Administration
V.VIJITHA S. MADHUMITHA M. RAGUL S. PUNITHAVALLI Prof. K. RAJAGANAPATHY	Bharath Institute of Higher Education and Research INDIA	Advances In Drug Design: A Review Of Recent Trends, Challenges And Future Scope
V.VIJITHA S. MADHUMITHA M. RAGUL S. PUNITHAVALLI Prof. K. RAJAGANAPATHY	Bharath Institute of Higher Education and Research INDIA	Revolutionizing Pharmacy With Artificial Intelligence: Applications And Challenges
Prof. Dr. Ilir MAZREKU Artiola TOVËRLANI Bleartë BERISHA Lina HASHANI Mirlinda TOVËRLANI	University of Prishtina "Hasan Prishtina" KOSOVA	The Effect Of Injection Administration Of Mercury(Ii) Chloride On Blood Parameter , Enzymes (Alt,Ast) And Glucose In "Mus Musculus"
Verora VUTHAJ Anesa VELIU Meritor ZHDRELLA Prof. Dr. Ilir MAZREKU	University of Prishtina KOSOVA	The Impact Of Dichloromethane (Dcm) And It's Toxic Effects On Mus Musculus
Prof. Dr. Ilir MAZREKU Emira HADŽIĆ Fjona KASTRATI Leonita SELMANI Dino VUJIĆ	[1]University of Prishtina "Hasan Prishtina" KOSOVA	Effect Of Sulfuric Acid On Oxidative Stress And Activity In Helix Pomatia
NAZDAN Samsul BAKRI Indra Gumay FEBRYANO TUGIYONO	University of Lampung INDONESIA	The Practice Of Floating Net Cage Cultivation In Lampung Bay Lampung Province, Indonesia

29.06.2025
SUNDAY / 12:30-14:30

SESSION-4 HALL-2
MODERATOR: Dr. DAUDA

AUTHORS	AFFILIATION	TOPIC TITLE
Dr. Tahir QURESHI Dr. Mohammad Owais FAROOQUI Dewa SAFI	Deemed University INDIA University of Sharjah ARAB EMİRATES Monash University Australia	Pre-Emptive Self Defence And The Un Charter: A Legal Analysis
Dr. DAUDA	-	Influence Of Technology Incubation Support Services On The Growth And Sustainability Of Small-Scale Enterprises In Kano State
PHD. Adel SEDDIKI	University M'hamed Bougara of Boumerdes ALGERIA	A Qualitative Study Of A Nonlinear Dynamical System With Generalized Derivatives
M' Bark ELHAID Ahmed BATAH Omar Id El MOUDEN Rachid SALGHI Belkhaouda M'HAMMED Abdelkarim CHAOUIKI	University Ibn Zohr MOROCCO Yeungnam University KOREA	Designing Environmentally-Friendly 3d Organic Architecture For Protective Surface Using Dip-Coating Process: Electrochemical Perspective
Ph.D. Abubakar, Zainab ALIYU Ph.D. Chadi, Aishatu MUHAMMAD	Abubakar Tafawa Balewa University NIGERIA	The Prediction Of Teacher Related Variables On Academic Achievement Of Colleges Of Education Students In Business Mathematics In North-East Nigeria
Chadi, Aishatu MUHAMMAD PhD Abubakar, Zainab ALIYU PhD	Abubakar Tafawa Balewa University NIGERIA	Learning Environment As Moderator Of University Students Attitude Towards Achievement In Business And Self-Reliance
Ahmed OSMANE Khadija ZIDAN Moustapha BELMOUDEN	Agadir University Ibn Zohr MOROCCO University Cadi Ayyad FAS	Assessing Pearl Millet's Health Benefits In Semi-Arid Regions: Impact Of Trickling Filter-Treated Wastewater Irrigation
Ahmed OSMANE Khadija ZIDAN Moustapha BELMOUDEN	Agadir University Ibn Zohr MOROCCO University Cadi Ayyad FAS	Processes For Olive Mill Waste Water Treatment

29.06.2025
SUNDAY / 12:30-14:30

SESSION-4 HALL -3
MODERATOR: Dr. Gwaison Panan DANLADI

AUTHORS	AFFILIATION	TOPIC TITLE
Hassane MOURTAKIB	Hassan II University of Casablanca MOROCCO	State Of The Art On Nano-Enhanced Phase Change Materials For Solar Thermal Energy Storage
Abderrahim BAHOUM Mohamed EL HATTAB Youness EL HAMMAMI	Ibn Zohr University MOROCCO Mohammed Ben Abdellah University MOROCCO	Mixed Mhd Convection Of A Hybrid Nanofluid In A Cubic Cavity Under Magnetic Field: A Numerical Approach
Mouad LAZRAK Ghita ait BADDI Bouchra CHEBLI Btissam MOURIA	Ibn Zohr University MOROCCO	Bokashi Composting As An Emerging Biotechnological Approach For Waste Valorization: A Comparative Study Of Sustainable Biofertilizer And Biopesticide Production
Imane ALIOUAT Safae ABDESSADKI Rachida MOUSTAKIM Naima CHIKHI Mziwira MOHAMED	Hassan II University MOROCCO	Prevalence And Association Between Hyperuricemia, Abdominal Obesity And Metabolic Syndrome In Adult Population Living In Tetouan Northern Morocco
Adel DELIOU Khmissi BELKAID Abdelkader FIDJAH Meriem DEHBI Mohamed CHAOUR	University of UMSB of Jijel ALGERIA University of Djelfa ALGERIA	Analysis Of Tensile Characteristics In Epoxy Composites: Assessing Twarmat And Woven Glass Fiber Reinforcements
Vini. K. R. SANKAR Nissamudeen K. M.	"Memorial SNDP Yogam Arts and Science College INDIA" SAT Campus INDIA	Photonic Applications Of Yttriuimoxide Based Nanaophosphors
Vahyala Adamu TARi, PhD Dr. Gwaison Panan DANLADI	Nigeria Police Academy NIGERIA	An Interrogation Of Climate Change And The Legal Framework For Environmental Protection In Nigeria
R. RAGAVI	Nadar Saraswathi College of Arts and Science INDIA	Fragrance Production From Waste Materials By Pseudomonas Putida Through Microbial Processes

29.06.2025
SUNDAY / 12:30-14:30

SESSION-4 HALL -4
MODERATOR: Dr. V. Rakshana

AUTHORS	AFFILIATION	TOPIC TITLE
Mansouri Asmaa Belabbas Meriem Faiza Benabi Ahmed Kerfouf	University center of Naama ALGERIA University of Sidi Bel Abbes ALGERIA	Biodiversity Of Macrophytes In The Coastal Water From Algerian West Coast
Mehtougui Mohamed Samir Meliani Habib Arjoum Safia Ahmed Kerfouf	University of Sidi Bel Abbes ALGERIA	Impact Of Desalination Of Sea Water On A Coastal Environment From Algerian West Coast
Divya. K Dr. V. Rakshana	Bharath Institute of Higher Education and Research INDIA	Hiv (Human Immunodeficiency Virus)
Divya. K Dr. V. Rakshana	Bharath Institute of Higher Education and Research INDIA	Epilepsy
Saraswathi.V R. Vidhyalakshmi Kowsika.M Dhanush kumar.S Sastha.K Prashanth.S Dr.W.Helen Dr.R.Srinivasam	Bharath Institute of Higher Education and Research INDIA	Environmental Stress And Plant Biochemisty
Saraswathi.V R. Vidhyalakshmi Kowsika.M Dhanush kumar.S Sastha.K Prashanth.S Dr.W.Helen Dr.R.Srinivasam	Bharath Institute of Higher Education and Research INDIA	Genetic Engineering Of Tomatoes For Enhanced Nutrient Content
V.Vijitha S.Madhumitha S.Punithavalli M.Rahul Dr.K.Rajaganapathy	Bharath Institute of Higher Education and Research INDIA	Antiobiotic Resistance: Challenges And The Role Of Pharmacists

29.06.2025
SUNDAY / 12:30-14:30

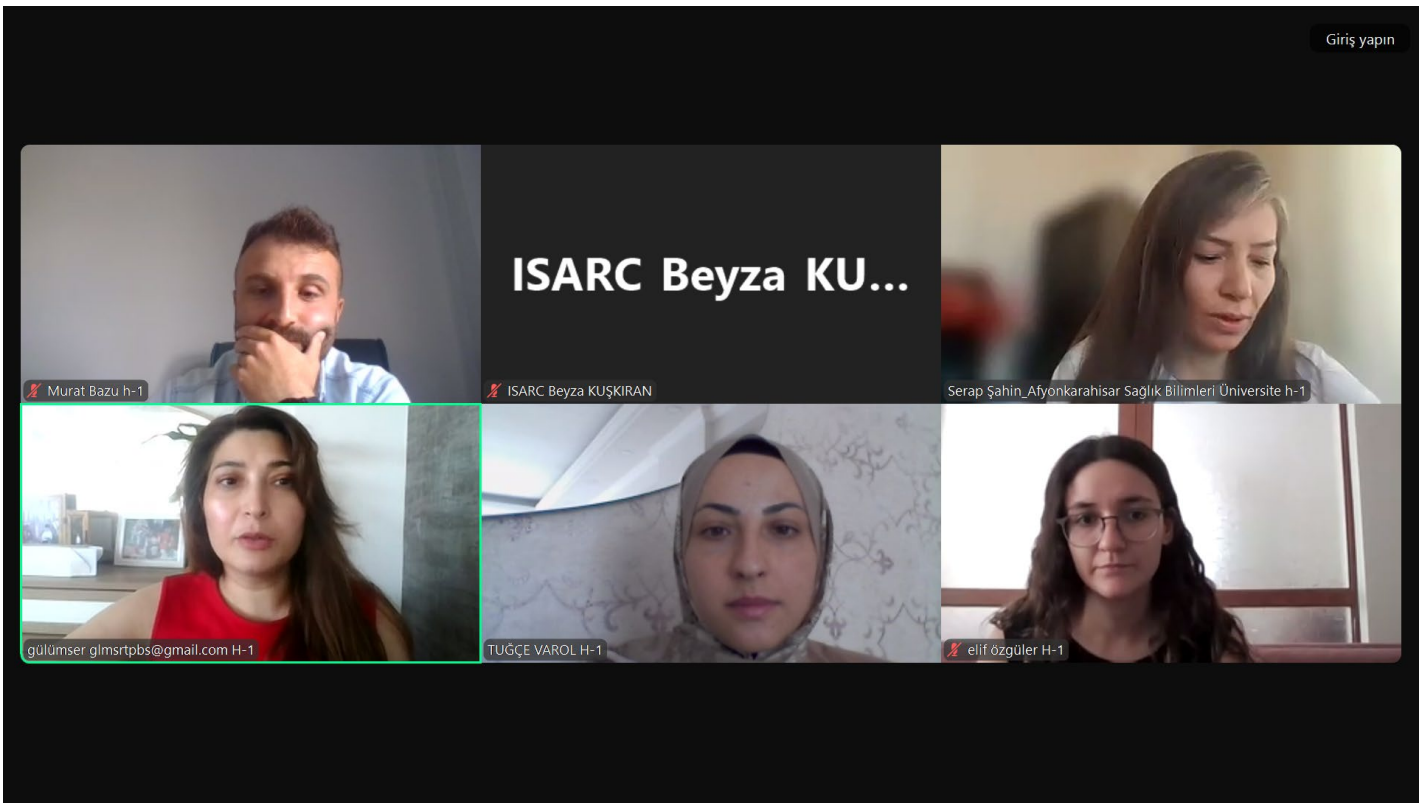
SESSION-4 HALL -5
MODERATOR: DR.R.Saravanan

AUTHORS	AFFILIATION	TOPIC TITLE
PUNIPARTHI SUNITHA M.K.VIJIYALAKSHMI	Bharath Institute of Higher Education and Research INDIA	Pharmacovigilance In The Era Of Personalized Medicine: Opportunities And Limitations
JAYARAMAKANI.N KOWSIKA.M SARASWATHI.V PURUSOTHAMAN.S TAMILARASAN.R SURESH.K	Bharath Institute of Higher Education and Research INDIA	Alzheimer's Disease
S.punithavalli V.Vijitha S.Abinaya R.Vidhyalakshmi DR.R.Saravanan		Role Of Pharmacovigilance In Ensure Drug Safety
S.punithavalli V.Vijitha S.Abinaya R.Vidhyalakshmi DR.R.Saravanan		Mechanisms And Management Of Drug Induced Hepatotoxic
Saraswathi.V R.Vidhyalakshmi Kowsika.M Dhanush kumar.S Sastha.K Prashanth.S Dr.W.Helen Dr.R.Srinivasam	Bharath Institute of Higher Education and Research INDIA	In Vitro-In Vivo Correlation (Ivivc) In Drug Development
J JAYARAMAKANI.N KOWSIKA.M SARASWATHI.V PURUSOTHAMAN.S TAMILARASAN.R SURESH.K	Bharath Institute of Higher Education and Research INDIA	Medication Safety

29.06.2025
SUNDAY / 12:30-14:30

SESSION-4 HALL -6
MODERATOR: Dr.R.Srinivasan

AUTHORS	AFFILIATION	TOPIC TITLE
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka Dr.R.Srinivasan	Bharath Institute of Higher Education and Research INDIA	Bioavailability And Bioequivalence Studies
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka Dr.R.Srinivasan	Bharath Institute of Higher Education and Research INDIA	Sustained And Controlled Release Formulations
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka Dr.R.Srinivasan	Bharath Institute of Higher Education and Research INDIA	Qsar (Quantitative Structure-Activity Relationship) In Drug Development
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka Dr.R.Srinivasan	Bharath Institute of Higher Education and Research INDIA	Synthesis And Sar Of Antihypertensive Agents
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka Dr.R.Srinivasan	Bharath Institute of Higher Education and Research INDIA	Green Chemistry In Pharmaceutical Synthesis
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka Dr.R.Srinivasan	Bharath Institute of Higher Education and Research INDIA	Heterocyclic Compounds In Drug Design
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka Dr.R.Srinivasan	Bharath Institute of Higher Education and Research INDIA	Rational Use Of Medicines: Role Of The Pharmacist
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka Dr.R.Srinivasan	Bharath Institute of Higher Education and Research INDIA	Analytical Techniques In Pharmaceutical Quality Control
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka Dr.R.Srinivasan	Bharath Institute of Higher Education and Research INDIA	Chicory Plant: Extraction, Purification, And Uses In Herbal Drug Technology


Giriş yapın
ISARC Beyza KU...
Murat Bazu h-1
ISARC Beyza KUŞKIRAN
Serap Şahin_Afyonkarahisar Sağlık Bilimleri Üniversite h-1
gülümser glmsrtpbs@gmail.com H-1
TUĞÇE VAROL H-1
elif özgüler H-1


Giriş yapın
Kaydediliyor...
Görüntüle
Salvia türleri
• Neden bitkiler
• Kemoterapi yan etkileri
• Sinerjizm?
Salvia splendus
Saucy Red
Salvia coccinea
Summer Jewel Red
Salvia x hybrida
Scarlet Sage
Salvia elegans
Pineapple Sage
ISARC Beyza KU...
ISARC Beyza KUŞKIRAN
AYDIN SEVER
birgül belgin h-2
birgül belgin h-2
Duygu Ayar H-2
Ses
Video
Katılımcılar
Sohbet
Tepki ver
Paylaş
Toplantı bilgileri
Uygulamalar
Ara odalar
Kaydı duraklat/durdur
Daha fazla
Odadan çık

Giriş yapın Kaydediliyor... Görüntüle

Göç Eden Kuşlar Optimizasyonu

Göç Eden Kuşlar Optimizasyonu (Migrating Birds Optimization - MBO) a
göç eden kuşların V formasyonundaki uçuş düzeninden esinlenen doğa
meta-sezgisel optimizasyon tekniğidir. Bu formasyonda kuşlar belirli ar
pozisyon değiştirir; lider kuş önde uçar, diğerleri ise sırayla onun arkası
liderlik yükünü dengeler. Bu yapı, liderin rehberliğinde grubun ortak har
aynı zamanda arama uzayında yeni bölgelerin keşfedildiği dağıtık bir op
sürecini taklit eder.



ISARC Beyza KU...
ISARC Beyza KUŞKIRAN
Elif Erçelik h-3
Serdar Volkan h-3
Serdar Volkan h-3
Gürkan Kızık h-3
Gürkan Kızık h-3

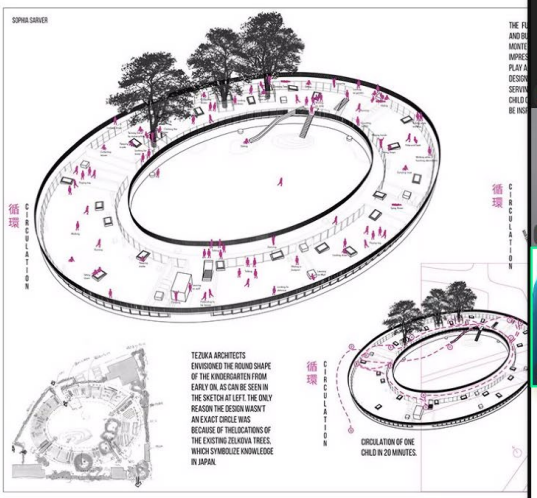
Ses Video 16 Katılımcılar Sohbet Tepki ver Paylaş Toplantı bilgileri Uygulamalar Ara odalar Kaydı duraklat/durdur Daha fazla Odadan çık

Giriş yapın Kaydediliyor... Görüntüle

OKUNABİLİRLİK VE YÖNELİM KABİLİYETİ / READABILITY AND ORIENTATION

- Bir mekân çocuk için ne kadar okunabilir? Çocuklar mekânda yönlerini nasıl bulur? Giriş kapısının konumu, ışığın geliş yönü, renklerin kullanımı, katlar arası geçişlerin nasıl çözüldüğü gibi unsurlar, mekânsal yönelim kabiliyetini belirler. Özellikle 2–6 yaş arası çocuklar için yön duygusu henüz gelişme aşamasındadır ve sembolik okuma becerileri sınırlıdır. Bu nedenle mekânlar, sade, tekrarlı ve tutarlı olmalıdır.

- How much can a place be read for a child? How do children orientate themselves in space? The position of the entrance door, the direction of light, the use of colours, how the transitions between floors are solved determine the ability to orientate spatially. Especially for children between the ages of 2–6, the sense of direction is still in the developmental stage and their symbolic reading skills are limited. For this reason, spaces should be simple, repetitive and consistent.



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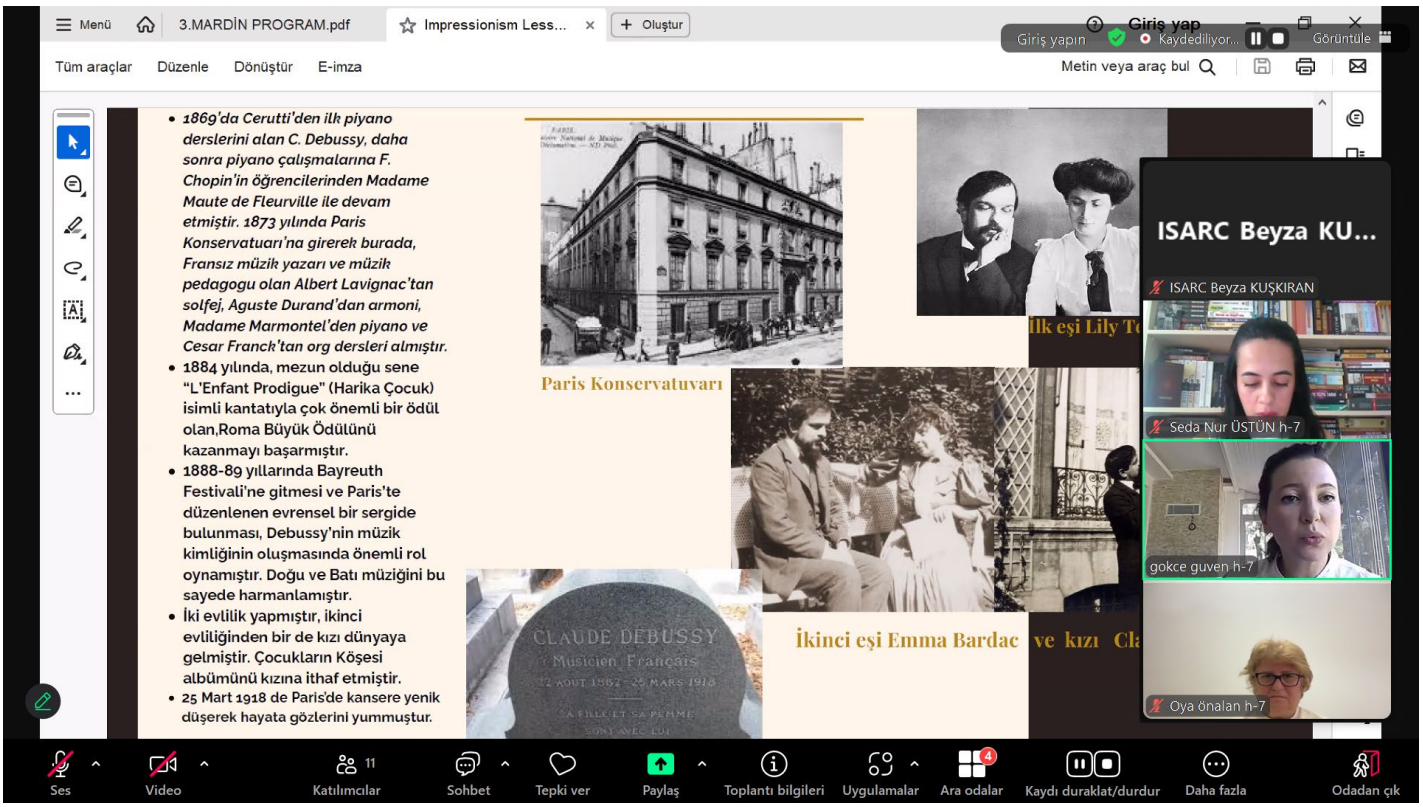
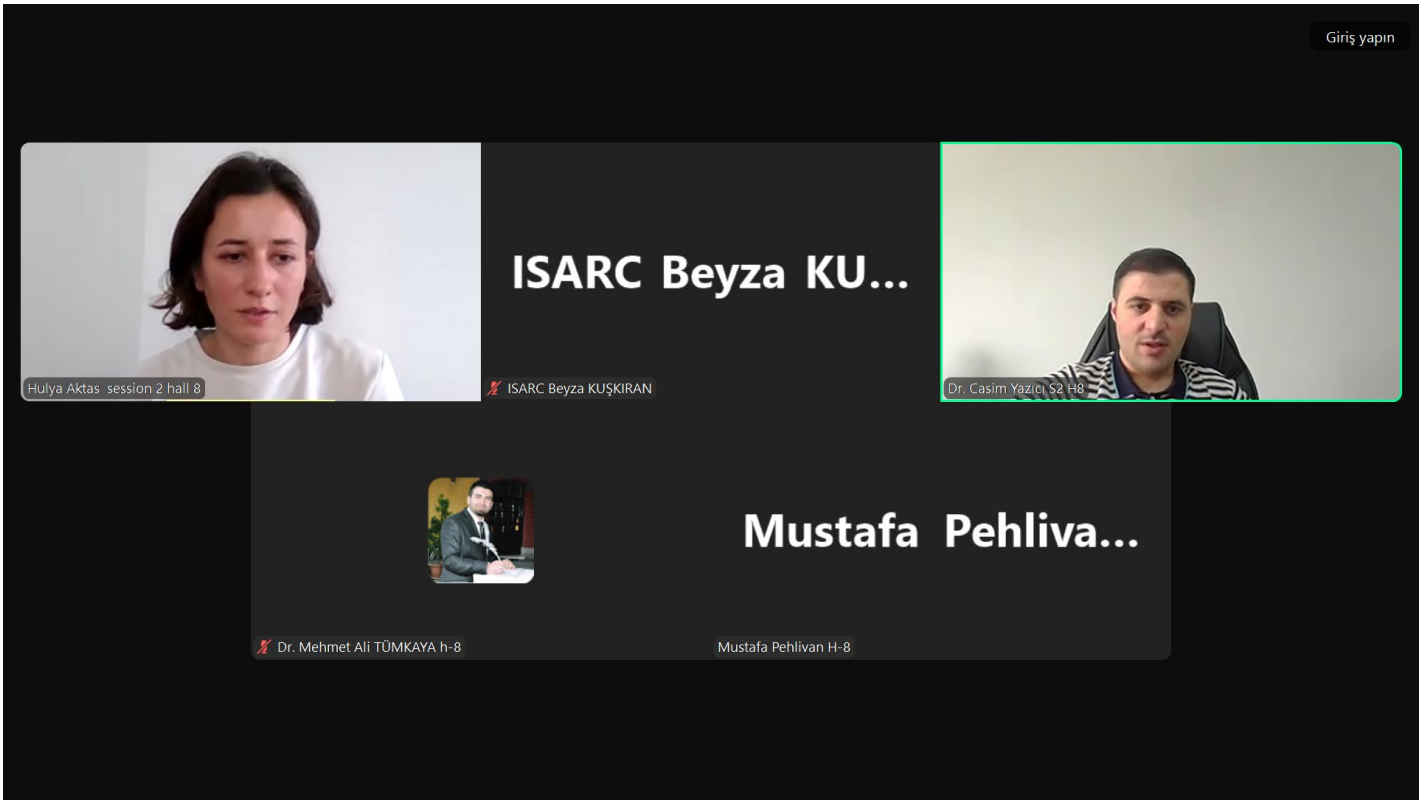
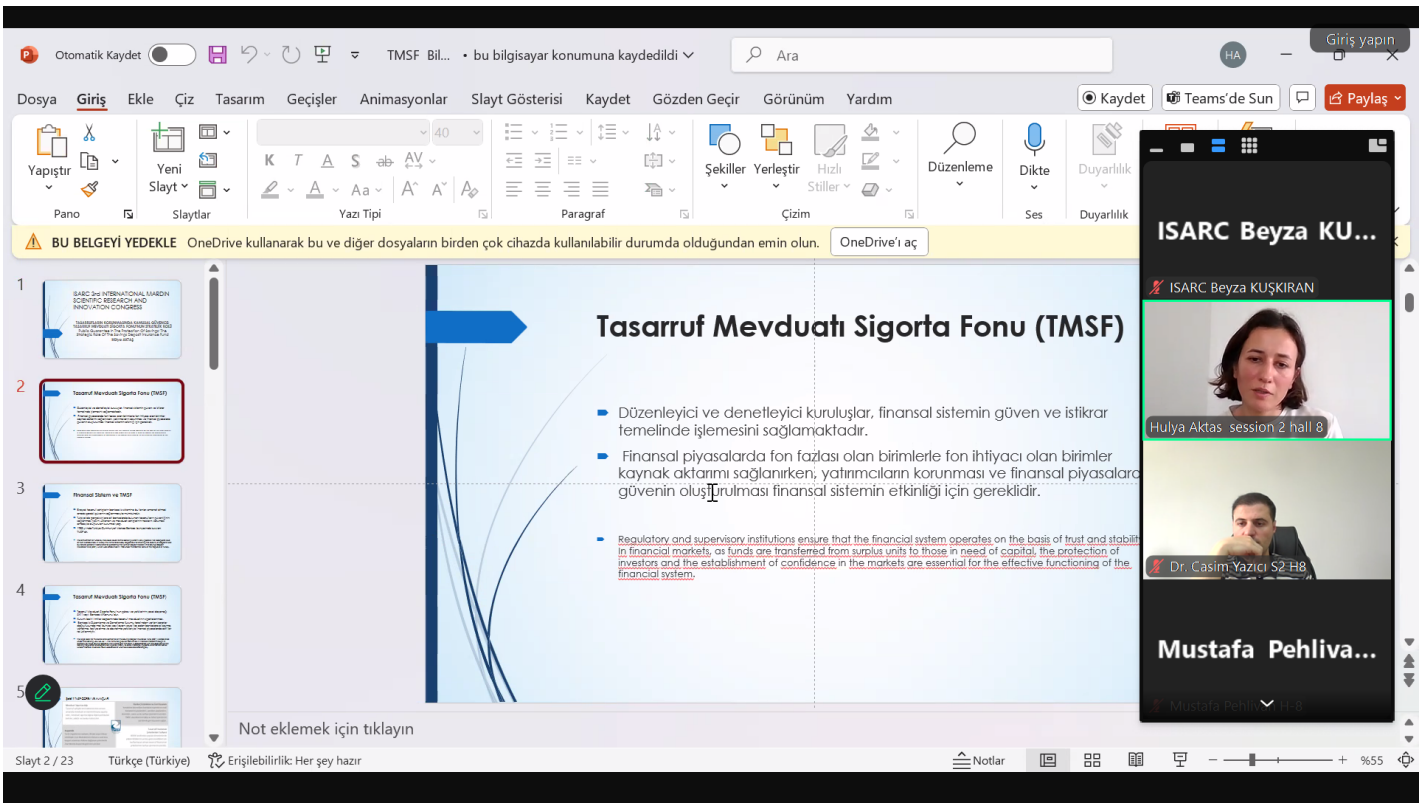
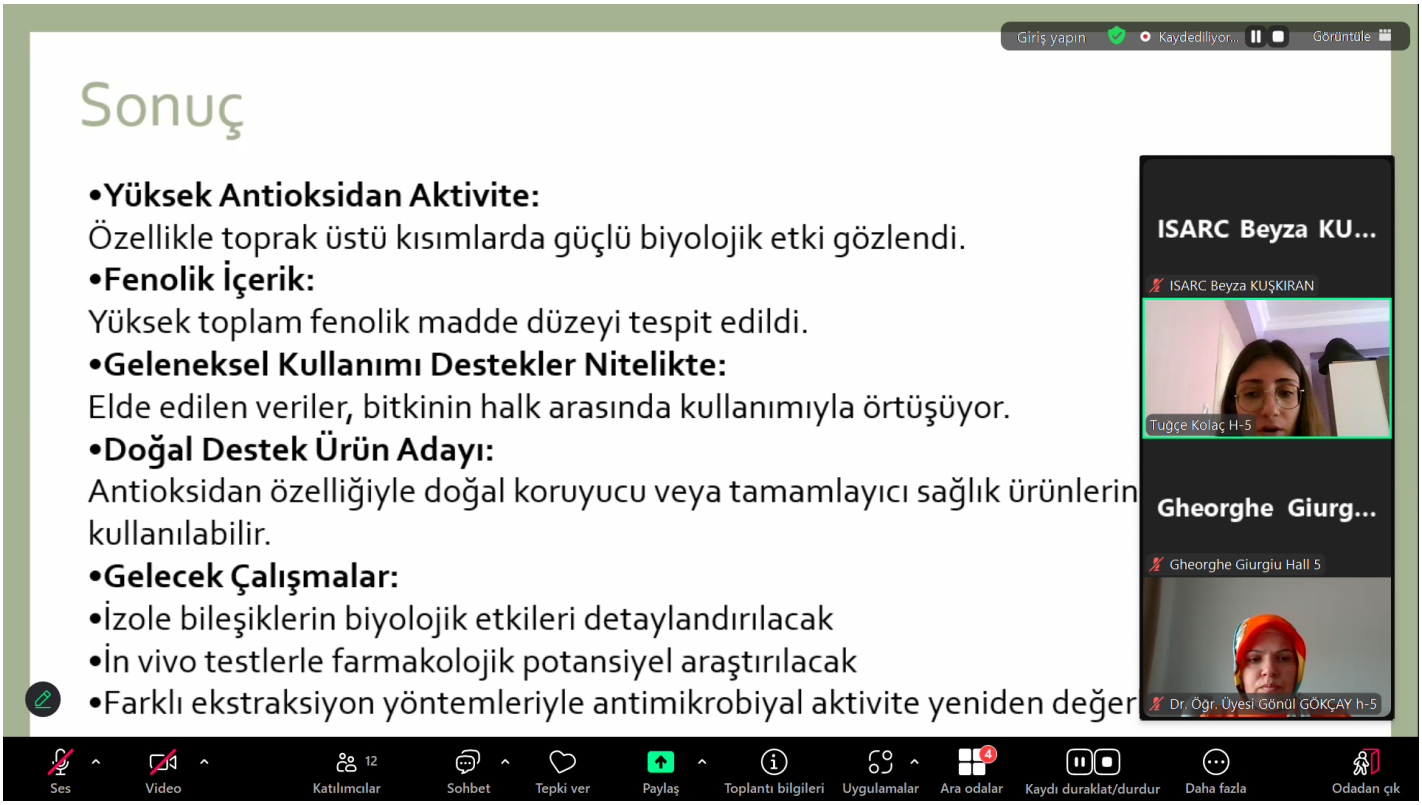
ISARC Beyza KUŞKIRAN
Gamze Nur Coşkun HALL-4
Nurhilal BURAK H-4
Büşra Durdağı-hall 4

Ses Video 8 Katılımcılar Sohbet Tepki ver Paylaş Toplantı bilgileri Uygulamalar Ara odalar Kaydı duraklat/durdur Daha fazla Odadan çık


Menü
3.MARDİN PROGRAM.pdf
Impressionism Less...
Oluştur
Giriş yap
Giriş yapın
Kaydediliyor...
Görüntüle
Tüm araçlar
Düzenle
Dönüştür
E-imza
Metin veya araç bul
1869'da Cerutti'den ilk piyano derslerini alan C. Debussy, daha sonra piyano çalışmalarına F. Chopin'in öğrencilerinden Madame Maute de Fleurville ile devam etmiştir. 1873 yılında Paris Konservatuarı'na girerek burada, Fransız müzik yazarı ve müzik pedagogu olan Albert Lavignac'tan solfej, Aguste Durand'dan armoni, Madame Marmontel'den piyano ve Cesar Franck'tan org dersleri almıştır.
1884 yılında, mezun olduğu sene "L'Enfant Prodigue" (Harika Çocuk) isimli kantatıyla çok önemli bir ödül olan,Roma Büyük Ödülünü kazanmayı başarmıştır.
1888-89 yıllarında Bayreuth Festivali'ne gitmesi ve Paris'te düzenlenen evrensel bir sergide bulunması, Debussy'nin müzik kimliğinin oluşmasında önemli rol oynamıştır. Doğu ve Batı müziğini bu sayede harmanlamıştır.
İki evlilik yapmıştır, ikinci evliliğinden bir de kızı dünyaya gelmiştir. Çocukların Köşesi albümünü kızına ithaf etmiştir.
25 Mart 1918 de Paris'de kansere yenik düşerek hayata gözlerini yummuştur.
Paris Konservatuvarı
İkinci eşi Emma Bardac
CLAUDE DEBUSSY
Musicien Français
ISARC Beyza KU...
ISARC Beyza KUŞKIRAN
Seda Nur ÜSTÜN h-7
gokce guven h-7
Oya önalan h-7
Ses
Video
11
Katılımcılar
Sohbet
Tepki ver
Paylaş
Toplantı bilgileri
Uygulamalar
Ara odalar
Kaydı duraklat/durdur
Daha fazla
Odadan çık


Giriş yapın
Hulya Aktas session 2 hall 8
ISARC Beyza KU...
ISARC Beyza KUŞKIRAN
Dr. Casim Yazıcı S2 H8
Mustafa Pehliva...
Dr. Mehmet Ali TÜMKAYA h-8
Mustafa Pehlivan H-8


Tasarruf Mevduatı Sigorta Fonu (TMSF)
Düzenleyici ve denetleyici kuruluşlar, finansal sistemin güven ve istikrar temelinde işlemesini sağlamaktadır.
Finansal piyasalarda fon fazlası olan birimlerle fon ihtiyacı olan birimler kaynak aktarımı sağlanırken, yatırımcıların korunması ve finansal piyasalara güvenin oluşturulması finansal sistemin etkinliği için gereklidir.
Regulatory and supervisory institutions ensure that the financial system operates on the basis of trust and stability in financial markets, as funds are transferred from surplus units to those in need of capital, the protection of investors and the establishment of confidence in the markets are essential for the effective functioning of the financial system.
Not eklemek için tıklayın
ISARC Beyza KU...
ISARC Beyza KUŞKIRAN
Hulya Aktas session 2 hall 8
Dr. Casim Yazıcı S2 H8
Mustafa Pehliva...


Sonuç
•Yüksek Antioksidan Aktivite:
Özellikle toprak üstü kısımlarda güçlü biyolojik etki gözlendi.
•Fenolik İçerik:
Yüksek toplam fenolik madde düzeyi tespit edildi.
•Geleneksel Kullanımı Destekler Nitelikte:
Elde edilen veriler, bitkinin halk arasında kullanımıyla örtüşüyor.
•Doğal Destek Ürün Adayı:
Antioksidan özelliğiyle doğal koruyucu veya tamamlayıcı sağlık ürünlerin
kullanılabilir.
•Gelecek Çalışmalar:
•İzole bileşiklerin biyolojik etkileri detaylandırılacak
•İn vivo testlerle farmakolojik potansiyel araştırılacak
•Farklı ekstraksiyon yöntemleriyle antimikrobiyal aktivite yeniden değer
ISARC Beyza KU...
ISARC Beyza KUŞKIRAN
Tuğçe Kolaç H-5
Gheorghe Giurg...
Gheorghe Giurgiu Hall 5
Dr. Ögr. Üyesi Gönül GÖKÇAY h-5

INTERNATIONAL SCIENCE AND ART RESEARCH CENTER

REF: AKADEMİK TEŞVİK **08.07.2025**

İLGİLİ MAKAMA

3.ULUSLARASI MARDİN BİLİMSEL ARAŞTIRMLAR VE İNOVASYON KONGRESİ 28-29 HAZİRAN 2025 tarihleri arasında TÜRKİYE'de ve online olarak 14 farklı ülkeden (Türkiye:138 ve diğer Ülkeler:289; Toplam:427 akademisyen/araştırmacıların katılımı ile gerçekleşmiştir. Kongre, 16 Ocak 2020 Akademik Teşvik Ödeneği Yönetmeliğine getirilen '' Tebliğlerin sunulduğu yurt içinde veya yurtdışındaki etkinliğin uluslararası olarak nitelendirilebilmesi için Türkiye dışından en az 5 ülkeden farklı tebliğ sunan konuşmacının katılım sağlaması ve tebliğlerin yarıdan fazlasının Türkiye dışından katılımcılar tarafından sunulması esastır. '' değişikliğine uygun düzenlenmiştir. Bilgilerinize arz edilir. Saygılarımla

Sefa Salih BİLDİRİCİ
HEAD OF İSARC

CONTENTS

AUTHOR	TITLE	No
Büşra DURDAĞI Sevda Duygu KOLBAY	AN EXAMINATION OF ENERGY EFFICIENT DESIGN PRINCIPLES THROUGH TRADITIONAL VERNACULAR ARCHITECTURE AND CONTEMPORARY REGIONAL DESIGN PRACTICES IN THE HOT-HUMID CLIMATE ZONE	1-7
Abbas Eghbal Mehran Kosar Adibankhah	STUDYING THE IMPACT OF MILITARY SCHOOLS AND MILITARY UNITS ON THE DEVELOPMENT OF SPORTS IN IRAN DURING THE QAJAR PERIOD	8
TASKEEN FATIMA	THE CLINICAL SIGNIFICANCE OF NORMAL PHYSIOLOGICAL BLOOD PARAMETERS IN HEALTH ASSESSMENT	9
TASKEEN FATIMA MAHNA FATIMA	CORRELATION STUDY ON ETIOLOGICAL FACTORS OF HEART DISEASE IN DIABETIC PATIENTS IN LAHORE, PAKISTAN	10
TASKEEN FATIMA	THE IMPACT OF LIVER CIRRHOSIS ON THE PROGRESSION AND COMPLICATIONS OF DIABETES MELLITUS	11
TASKEEN FATIMA MAHNA FATIMA ADNAN SARWAR CHAUDHARY	AN OVERVIEW OF CAD; ETIOLOGIC FACTORS & SURGICAL MANAGEMENTS	12
TASKEEN FATIMA MAHNA FATIMA	FORMULATION AND EVALUATION OF OTF OF CETIRIZINE FOR RAPID SYSTEMIC ACTION	13
Mesut YILMAZ Mehmet DEMİRHAN	SYSTEMATIC REVIEW OF GRADUATE THESES FOCUSING ON EARLY FATHERHOOD EXPERIENCES IN TURKEY (0-2 AGE GROUP)	14
Kadri Atay	EVALUATION OF THE EFFICACY VEDOLIZUMAB AND USTEKINUMAB IN THE TREATMENT OF CROHN'S DISEASE: A SINGLE CENTER COHORT STUDY	15-16
Ilir Mazreku Emira Hadžić Fjona Kastrati Leonita Selmani Dino Vujić	EFFECT OF SULFURIC ACID ON OXIDATIVE STRESS AND ACTIVITY IN HELIX POMATIA	17
Ömer Faruk ÇİRİŞ Süleyman ADAK Hasan CANGİ Ramazan TAŞALTIN	INVESTIGATION OF THE PARTICLE SWARM OPTIMIZATION METHOD IN MAXIMUM POWER POINT TRACKING OF PHOTOVOLTAIC SYSTEMS1	18-30
Hamid Gadouri Brahim Meziani	COMPARATIVE REVIEW OF THE ROLES OF NATURAL POZZOLANA, BARIUM COMPOUNDS, SODIUM SILICATE, AND POLYPROPYLENE FIBERS IN MITIGATING SULFATE-INDUCED DISTRESS IN LIME-STABILIZED SOILS	31
Naseem Akhter	WOMEN IN POWER: POLITICAL PARTICIPATION AND EMPOWERMENT DURING THE ABBASID CALIPHATE	32
Naseem Akhter	EMPOWERMENT AND PARTICIPATION: WOMEN IN EARLY ISLAMIC PUBLIC ADMINISTRATION	33

Saloni Sharma Suhani Sharma	GENDER DIFFERENCES IN THE CO-OCCURRENCE OF CELIAC DISEASE AND AUTOIMMUNE THYROIDITIS	34- 41
Saloni Sharma Suhani Sharma	CIRCULAR CHEMISTRY: DESIGNING WASTE-FREE REACTIONS FOR A SUSTAINABLE FUTURE	42- 52
Vahyala Adamu Tari Gwaison Panan Danladi	AN INTERROGATION OF CLIMATE CHANGE AND THE LEGAL FRAMEWORK FOR ENVIRONMENTAL PROTECTION IN NIGERIA	53- 61
ARRAJI Maryem CHAHBOUNE Mohamed	DETERMINANTS OF MEDICATION ADHERENCE: A KEY CHALLENGE IN CHRONIC DISEASE MANAGEMENT	62
Ilir Mazreku Artiola Tovërlani Bleartë Berisha Lina Hashani Mirlinda Tovërlani	THE EFFECT OF INJECTION ADMINISTRATION OF MERCURY(II) CHLORIDE ON BLOOD PARAMETER,ENZYMES (ALT,AST) AND GLUCOSE IN "MUS MUSCULUS"	63
Abderrahim BAHOUM Mohamed EL HATTAB Youness EL HAMMAMI	MIXED MHD CONVECTION OF A HYBRID NANOFLUID IN A CUBIC CAVITY UNDER MAGNETIC FIELD: A NUMERICAL APPROACH	64
M'Bark Elhaid Ahmed Batah Omar Id El Mouden Rachid Salghi Belkhaouda M'hammed Abdelkarim Chaouiki	DESIGNING ENVIRONMENTALLY-FRIENDLY 3D ORGANIC ARCHITECTURE FOR PROTECTIVE SURFACE USING DIP-COATING PROCESS: ELECTROCHEMICAL PERSPECTIVE	65
Adel SEDDIKI	A QUALITATIVE STUDY OF A NONLINEAR DYNAMICAL SYSTEM WITH GENERALIZED DERIVATIVES	66
V.Vijitha S.Madhumitha M.Ragul S.Punithavalli K.Rajaganapathy	ADVANCES IN DRUG DESIGN: A REVIEW OF RECENT TRENDS, CHALLENGES AND FUTURE SCOPE	67
Jayaramakani.N Kowsika.M Saraswathi.V Purusothaman.S Tamilarasan.R Suresh.K	ALZHEIMER'S DISEASE	68
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka R.Srinivasan	ANALYTICAL TECHNIQUES IN PHARMACEUTICAL QUALITY CONTROL	69
V.Vijitha S.Madhumitha S.Punithavalli M.Rahul Dr.K.Rajaganapathy	ANTIOBIOTIC RESISTANCE: CHALLENGES AND THE ROLE OF PHARMACISTS	70
Nelya Novotorzhina Shafa Kazimzadeh Jamila Ahmedova Mekhpara Safarova Gahramanova Gariba İngilab İsmayılov	ANTI-SEIZE ADDITIVE FOR SEMI-SYNTHETIC OILS	71-73
Rejhan RAHMAN	THE IMPACT OF ALBANIA'S NATO MEMBERSHIP ON REGIONAL SECURITY	74

VIDHYALAKSHMI.R Dr.K.RAJAGANAPATHY Dr.R.SRINIVASAN R.VIDHYALAKSHMI	FORMULATION DEVELOPMENT OF NOVEL DRUG DELIVERY SYSTEMS: CHALLENGES AND OPPORTUNITIES	75- 86
VIDHYALAKSHMI.R Dr.K.RAJAGANAPATHY Dr.R.SRINIVASAN R.VIDHYALAKSHMI	THE GUT-BRAIN AXIS IN AUTISM SPECTRUM DISORDER: MICROBIOME DYSBIOSIS, PROBIOTICS AND POTENTIAL MECHANISMS OF ACTION	87- 111
Aslıhan TURGUT	INVESTIGATION OF KEY FACTORS AFFECTING SUCCESS IN DISASTER LOGISTICS MANAGEMENT	112- 116
Gönül GÖKÇAY Ferhat AKTUZ	VACCINE REJECTION AND ITS EFFECTS ON MATERNAL AND CHILD HEALTH1	117- 125
Ömer Can ERCE Aydın SEVER Ramazan GÜNDOĞDU Lütfi BEHÇET	INVESTIGATION OF CYTOTOXIC EFFECT OF SOME SALVIA SPECIES COMBINED WITH AURORA-B INHIBITOR ON BREAST CANCER CELL LINE	126- 135
Onur AKYAPI Aydın SEVER Mehmet Kadir ERDOĞAN Lütfi BEHÇET	ANTI-CANCER EFFECT OF SOME SALVIA SPECIES COMBINED WITH RESVERATROL ON BREAST CANCER	136- 148
Beşir ÇAKIR Assoc. Prof. Dr. Duygu AYAR Resc. Assist. Sebahat KUŞLU	CURRENT VACCINATION CALENDARS USED IN COUNTRIES AND NURSING: HOW ARE WE DOING WITH CHILDHOOD VACCINES?	149- 153
Beşir ÇAKIR Assoc. Prof. Dr. Duygu AYAR Resc. Assist. Sebahat KUŞLU	SUPPLEMENTARY NUTRITION IN CHILDREN AND NURSING: WHAT ARE THE CURRENT APPROACHES TO TRANSITION TO SUPPLEMENTARY FOOD?	154-158
Samet KAHYA Murat YAZICI	CREATING A QUARTER VEHICLE MODEL WITH VARIABLE DAMPER COEFFICIENT ON MATLAB TO BE USED IN REGENERATIVE SUSPENSION DESIGN CALCULATIONS	159-160
M. Reşit AKKAYA Yıldız KOÇ Özkan KÖSE	THERMODYNAMIC EVALUATION OF A LNG-COOLED LOW-GRADE HEAT RECOVERY SUPERCRITICAL CO2 CYCLE	161- 169
Mrs.E.Elavarasi Yuvaraj AR J. Jayadurka R.Srinivasan	BIOPRINTING IN THE PHARMACEUTICAL INDUSTRY	170
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka DR.Srinivasan	BIOAVAILABILITY AND BIOEQUIVALENCE STUDIES	171
Yulduz RAMAZANOVA Elmira NAGHIYEVA Malahat ABBASOVA Kamala MAMMADOVA Solmaz AFANDIYEVA Safiyya MELIKOVA	BIOSUSTAINABLE ENGINE OIL FOR MARINE DIESEL ENGINES	172- 175
Mouad LAZRAK Ghita ait BADDI Bouchra CHEBLI Btissam MOURIA	BOKASHI COMPOSTING AS AN EMERGING BIOTECHNOLOGICAL APPROACH FOR WASTE VALORIZATION: A COMPARATIVE STUDY OF SUSTAINABLE BIOFERTILIZER AND BIOPESTICIDE PRODUCTION	176
Birgül BELGIN Sevilay ERDEN	EVIDENCE-BASED PRACTICES TO PREVENT SURGICAL SITE INFECTIONS	177- 185

Mrs. E. ELAVARASI Yuvaraj AR J. JAYADURKA Dr. R. SRINIVASAN	CHICORY PLANT: EXTRACTION, PURIFICATION, AND USES IN HERBAL DRUG TECHNOLOGY	186
Tuğçe KOLAÇ Turgay KOLAÇ Gülsüm YETİŞ KOCA Perihan GÜRBÜZ	CHROSOPHORA TINCTORIA (L.) A. JUSS. COMPARISON OF THE ANTIOXIDANT ACTIVITY OF DIFFERENT PLANT PARTS OF FLOUR AND THE TOTAL AMOUNTS OF PHENOLIC SUBSTANCES	187- 194
Gökçe GÜVEN	CLAUDE DEBUSSY'S PIANO MUSIC	195- 196
Ahmed OSMANE Khadija ZIDAN Moustapha BELMOUDEN	ASSESSING PEARL MILLET'S HEALTH BENEFITS IN SEMI-ARID REGIONS: IMPACT OF TRICKLING FILTER-TREATED WASTEWATER IRRIGATION	197
Ahmed OSMANE Khadija ZIDAN Moustapha BELMOUDEN	PROCESSES FOR OLIVE MILL WASTE WATER TREATMENT	198
Melek ARI Kemal Anıl GÜVENÇ Batuhan EYÜBOĞLU Hüseyin Ardıl KARASUNGUR Gürkan KIZIK Birsen GÜLDEN ÖZDEMİR Yiğit AYDOĞAN	COSMALYZE: AN AI-SUPPORTED COSMETIC ANALYSIS MOBILE APPLICATION	199-211
Casim YAZICI	NUMERICAL EVALUATION OF REINFORCED CONCRETE BEAM–COLUMN CONNECTIONS UNDER MONOTONIC LOADING WITH VARIABLE REINFORCEMENT AND CONCRETE STRENGTHS	212-221
Casim YAZICI	SEISMIC PERFORMANCE PREDICTION OF RC BUILDINGS USING VISUAL SCREENING AND MACHINE LEARNING	222-231
Mrs.E.Elavarasi Yuvaraj AR J. Jayadurka R.Srinivasan	DIABETIC TREATMENT WITH DIABETIC MEDICATION AS ORAL ADMINISTRATION	232-243
Abdessamad DIDI Mustapha KRIM Jawad BOUZID Mohamed BENAICH Hindou BADDIH Zouhair SADOUNE	TOWARDS A LOW-CARBON FUTURE: A COMPARATIVE TECHNO-ECONOMIC EVALUATION OF ENERGY SOURCES FOR SUSTAINABLE AND COST-EFFECTIVE TRANSITIONS	244
Sultan AYTEKİN Gülsen TİRYAKİOĞLU Filiz KOÇOĞLU SAĞLAM Yeliz KINDAP TEPE	AN INVESTIGATION OF DIGITAL ADDICTION IN ADOLESCENTS ACCORDING TO DEMOGRAPHIC VARIABLES	244-252
Büşra Nur Arslan Yağmur Öztürk Filiz KOÇOĞLU SAĞLAM Yeliz KINDAP TEPE	THE EFFECT OF DIGITAL DETOX ON SMARTPHONE ADDICTION AND SMARTPHONE CRAVING: AN INVESTIGATION IN TERMS OF DEMOGRAPHIC CHARACTERISTICS	253-261

R. VIDHYALAKSHMI SARANYA. P PRATHEEBA.G DANISH KHAN C.REJITHA R. SRINIVASAN	UNDERSTANDING THE MECHANISMS OF ALZHEIMER'S DISEASE	262-271
R. VIDHYALAKSHMI SARANYA. P PRATHEEBA.G DANISH KHAN C.REJITHA R. SRINIVASAN	THE IMPACT OF DIABETES ON GLOBAL HEALTH	272-282
Mustafa Yunus GÜMÜŞ	THE SOUND-MEANING RELATIONSHIP IN DIVAN POETRY: ONOMATOPOEIC WORDS	283-284
Bilal DÖRTTEPE Osman BABAYİĞİT	A STUDY ON THE EFFECT OF AIR VELOCITY AND WATER TEMPERATURE ON SUPPLY AIR IN EVAPORATIVE COOLING PROCESS	285-286
Muhammad TAYYAB	ENZYMES AND POULTRY FEED INDUSTRY	287
Elif ÖZGÜLER Serap ŞAHİN	INVESTIGATION OF CYTOTOXIC EFFECT OF TRIMETAZIDINE DIHYDROCHLORIDE on HeLa CANCER CELLS	288-289
Saraswathi.V R. Vidhyalakshmi Kowsika.M Dhanush kumar.S Sastha.K Prashanth.S W.Helen R.Srinivasam	ENVIRONMENTAL STRESS AND PLANT BIOCHEMISTY	290
Divya. K V. Rakshana	EPILEPSY	291-293
Gamze Nur CÜRE Sevda Duygu KOLBAY	POST-EARTHQUAKE DEPLOYMENT OF PREFABRICATED EDUCATIONAL BUILDINGS: ANALYSIS THROUGH THE HATAY KINDERGARTEN PROJECT	294-301
Abeeta HILAL Meha PANT	FROM CEASEFIRE TO CRISIS: THE UNFOLDING OF RECENT VIOLENCE IN GAZA	302
Saraswathi.V R. Vidhyalakshmi Kowsika.M Dhanush kumar.S Sastha.K Prashanth.S W.Helen R.Srinivasam	GENETIC ENGINEERING OF TOMATOES FOR ENHANCED NUTRIENT CONTENT	303
Major Gheorghe GIURGIU med Manole COJOCARU	NATURAL MODULATION OF THE GUT MICROBIOTA IN PATIENTS WITH FOOD ALLERGIES. IMPACT OF ALERGIPLANT	304
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka R.Srinivasan	GREEN CHEMISTRY IN PHARMACEUTICAL SYNTHESIS	305

Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka .R.Srinivasan	HETEROCYCLIC COMPOUNDS IN DRUG DESIGN	306
Divya. K V. Rakshana	HIV (HUMAN IMMUNODEFICIENCY VIRUS)	307
Saraswathi.V R.Vidhyalakshmi Kowsika.M Dhanush kumar.S Sastha.K Prashanth.S Dr.W.Helen R.Srinivasam	IN VITRO-IN VIVO CORRELATION (IVIVC) IN DRUG DEVELOPMENT	311
Dauda, Abdulwaheed Echono Samson	INFLUENCE OF TECHNOLOGY INCUBATION SUPPORT SERVICES ON THE GROWTH AND SUSTAINABILITY OF SMALL-SCALE ENTERPRISES IN KANO STATE, NIGERIA	311-322
İsmail Karakaya İbrahim ARMAN Aycan ÇELİK Utku Can ATILGAN	IN-SILICO EVALUATION OF POTASSIUM SORBATE AS A MULTI-TARGET ANTIMICROBIAL AGENT AGAINST *ENTEROCOCCUS FAECALIS*	323-324
Abubakar, Zainab ALIYU Chadi, Aishatu MUHAMMAD	THE PREDICTION OF TEACHER RELATED VARIABLES ON ACADEMIC ACHIEVEMENT OF COLLEGES OF EDUCATION STUDENTS IN BUSINESS MATHEMATICS IN NORTH-EAST NIGERIA	325
Gülümser DURGUN Sevilay ERDEN	VIRTUAL REALITY IN PERIOPERATIVE NURSING: INNOVATIVE APPROACHES FOR PAIN MANAGEMENT IN OBESE PATIENTS UNDERGOING ROBOTIC SURGERY	326-334
Gülümser DURGUN Sevilay ERDEN	THE ROLE OF NURSING IN ROBOTIC CARDIAC SURGERY: PROCESSES, ADVANTAGES, DISADVANTAGES, AND RECOMMENDATIONS FOR PRACTICES IN TURKEY	335-342
CHANNAN Khadija HILAL Khalid KAJOUNI Ahmed	OPTIMAL CONTROL OF A COCAINE–HEROIN EPIDEMIOLOGICAL MODEL INVOLVING THE PSI-CAPUTO FRACTIONAL TIME-DERIVATIVE	343
Birgül BELGIN Sevilay ERDEN	PRECAUTIONARY PACKAGES USED TO PREVENT SURGICAL SITE INFECTIONS IN PATIENTS UNDERGOING CRANIOTOMY AND THE ROLES OF THE NURSE	344-352
M. M. Fatih KARAHAN	MULTIPLE SCALES LINDSTEDT POINCARE METHOD FOR SOLVING STRONGLY SEPTIC DUFFING EQUATION	353
Imane ALIOUAT Safae ABDESSADKI Rachida MOUSTAKIM Naima CHIKHI Mziwira MOHAMED	PREVALENCE AND ASSOCIATION BETWEEN HYPERURICEMIA, ABDOMINAL OBESITY AND METABOLIC SYNDROME IN ADULT POPULATION LIVING IN TETOUAN NORTHERN MOROCCO	354
Mansouri Asmaa Belabbas Meriem Faiza Benabi Ahmed Kerfouf	BIODIVERSITY OF MACROPHYTES IN THE COASTAL WATER FROM ALGERIAN WEST COAST	355
Murat BAZO Mehmet KÜÇÜKOFLAZ	SHEEP FARMING PROFILE OF THE TRA2 REGION	356-357

S.punithavalli V.Vijitha S.Abinaya R.Vidhyalakshmi R.Saravanan	*MECHANISMS AND MANAGEMENT OF DRUG INDUCED HEPATOTOXIC*	358
JAYARAMAKANI.N KOWSIKA.M SARASWATHI.V PURUSOTHAMAN.S TAMILARASAN.R SURESH.K	MEDICATION SAFETY	359
Mehmet Ali TÜMKAYA Mustafa YÜKSEK	META-MATERIAL BASED CIRCULAR RING RESONATOR	360-364
Mehtougui Mohamed Samir Meliani Habib Arjoum Safia Ahmed Kerfouf	IMPACT OF DESALINATION OF SEA WATER ON A COASTAL ENVIRONMENT FROM ALGERIAN WEST COAST	365
Tanimu BALA Usman HASSAN Ibrahim Bello ABUBAKAR	MITIGATING MISINFORMATION IN NIGERIA USING MACHINE LEARNING AND INFORMATION LITERACY	366
Furkan Şahin Muhammed Mustafa ÇALIŞ	BEHAVIOR OF A 5-STOREY SEISMIC ISOLATED BUILDING UNDER THE EFFECT OF 4 DIFFERENT EARTHQUAKES THAT TOOK PLACE IN OUR COUNTRY	367
Chadi, Aishatu MUHAMMAD Abubakar, Zainab ALIYU	LEARNING ENVIRONMENT AS MODERATOR OF UNIVERSITY STUDENTS ATTITUDE TOWARDS ACHIEVEMENT IN BUSINESS AND SELF-RELIANCE IN THE NORTH-EAST OF NIGERIA	368
Hejab FATIMA Maryam DAWOOD	THE ROLE OF NETWORKING IN JOB OPPORTUNIIES; A CROSS SECTIONAL STUDY	369
Mrs. E. ELAVARASI Yuvaraj AR J. JAYADURKA SRINIVASAN	NOVEL CONCEPTS REGARDING DIABETES AND END-STAGE RENAL DISEASE	370-376
Songül KAYIK Selahattin Barış ÇELEBİ	SOLAR RADIATION PREDICTION WITH DEEP LEARNING BASE TIME SERIES	377-390
Kemal PANÇ Sümeyye SEKMEN	INTEGRATIVE MACHINE LEARNING MODEL LEVERAGING DCE-MRI AND PSA DENSITY FOR ADVANCED RISK STRATIFICATION IN PROSTATE CANCER	391-398
Miray YILMAZ DURMUŞOĞLU İlke Bezen TOZKOPARAN	INNOVATIVE ECO-FRIENDLY TECHNOLOGIES AND ECOLOGICAL FOOTPRINT: HARMONIOUS APPROACHES FOR A SUSTAINABLE FUTURE	399-400
Kemal PANÇ Sümeyye SEKMEN	MULTI-CNN DEEP FEATURE FUSION AND STACKING ENSEMBLE CLASSIFIER FOR BREAST ULTRASOUND LESION CLASSIFICATION	401-407
Kemal PANÇ Sümeyye SEKMEN Hasan GÜNDOĞDU	LIVER AND PANCREATIC FAT FRACTIONS AS PREDICTORS OF DISEASE SEVERITY IN ACUTE PANCREATITIS: AN MR IDEAL-IQ STUDY	408-416
Kemal PANÇ Sümeyye SEKMEN Hasan GÜNDOĞDU	ENHANCING BONE METASTASIS PREDICTION IN PROSTATE CANCER USING QUANTITATIVE MPMRI FEATURES, ISUP GRADE, AND PSA DENSITY: A MACHINE LEARNING APPROACH	417-425

HülyaAKTAŞ	DIFFERENCES BETWEEN LATE PAYMENT INTEREST AND CONTRACTUAL INTEREST AND THEIR PRACTICAL IMPLICATIONS: AN ANALYSIS ON CREDIT CARD DEBT	426-431
HülyaAKTAŞ	PUBLIC GUARANTEE IN THE PROTECTION OF SAVINGS: THE STRATEGIC ROLE OF THE SAVINGS DEPOSIT INSURANCE FUND	432-436
Mehmet GÖL Ahmet YAPICI	FINITE ELEMENT INVESTIGATION OF THE BALLISTIC PERFORMANCE OF BORON CARBIDE CERAMIC BODY ARMOR COVERED WITH KEVLAR 29 FABRIC	437-449
Yücel PEKGENÇ Mehmet DEMİRHAN	SAMPLE SELECTION IN RESEARCH METHODS: THE DIFFERENCE BETWEEN QUANTITATIVE AND QUALITATIVE APPROACHES	450
Ecrin ÇETİN Dilek ARDUZLAR KAĞAN	USE OF LOCAL HERBS IN GASTRONOMY IN SEVEN REGIONS OF TURKEY	451-483
Muhammed AYDIN	SPIRITUAL COUNSELING AND GUIDANCE PRACTICES IN OUR COUNTRY: BASIC QUALIFICATIONS AND COMPETENCIES	484-495
Volkan UCA Gönül GÖKÇAY	THE RELATIONSHIP BETWEEN PARENTS' HEALTH BELIEFS, ANTIBIOTICS PERCEPTIONS AND VACCINE ATTITUDES	496-497
Nurhilal BURAK	THE IMPACT OF SALUTOGENIC DESIGN ON SENSORY INTEGRATION IN CHILDREN'S SPACES	498-499
Taner BİLGİN Seda Nur ÜSTÜN	ADMINISTRATIVE DIVISION AND LOCAL ADMINISTRATION STRUCTURE OF BILECIK BETWEEN 1930-1945	500-504
Hüseyin KALIN Gencay SARIIŞIK	PRIORITIZATION OF IT INVESTMENT PROJECTS IN THE ELECTRICITY DISTRIBUTION SECTOR USING MULTI-CRITERIA DECISION-MAKING METHODS: AN APPLICATION OF AHP, PROMETHEE, AND VIKOR	505-506
İslam POLAT Gencay SARIIŞIK	A MULTI-CRITERIA DECISION-MAKING APPROACH FOR ERP SOFTWARE SELECTION IN THE ELECTRICITY DISTRIBUTION SECTOR: A COMPARATIVE ANALYSIS OF AHP, TOPSIS, AND VIKOR	507-515
Melisa DOYMAZ Dilek ARDUZLAR KAĞAN	TRADITIONAL AND NEARLY FORGOTTEN TASTES OF THE CENTRAL ANATOLIA REGION	516-532
PUNIPARTHI SUNITHA M.K.VIJIYALAKSHMI	PHARMACOVIGILANCE IN THE ERA OF PERSONALIZED MEDICINE: OPPORTUNITIES AND LIMITATIONS	533-542
Vini. K. R. SANKAR Nissamudeen K. M.	PHOTONIC APPLICATIONS OF YTTRIUMOXIDE BASED NANAOPHOSPHORS	543
Merve İCAT Gülay ALTUN UĞRAŞ Sevilay ERDEN	THE USE OF ROBOTIC SURGERY IN PLASTIC, RECONSTRUCTIVE AND AESTHETIC SURGERY AND NURSING APPROACHES	544-548
Hassane MOURTAKIB	STATE OF THE ART ON NANO-ENHANCED PHASE CHANGE MATERIALS FOR SOLAR THERMAL ENERGY STORAGE	549
NAZDAN Samsul BAKRI Indra Gumay FEBRYANO TUGIYONO	PRACTICE OF FLOATING NET CAGE CULTIVATION IN LAMPUNG BAY, LAMPUNG PROVINCE, INDONESIA	550-554

Tahir QURESHI Mohammad Owais FAROOQUI Dewa SAFI	PRE-EMPTIVE SELF DEFENCE AND THE UN CHARTER: A LEGAL ANALYSIS	555
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka R.Srinivasan	QSAR (QUANTITATIVE STRUCTURE-ACTIVITY RELATIONSHIP) IN DRUG DEVELOPMENT	556
R. RAGAVI	FRAGRANCE PRODUCTION FROM WASTE MATERIALS BY *PSEUDOMONAS PUTIDA* THROUGH MICROBIAL PROCESSES	557
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka R.Srinivasan	RATIONAL USE OF MEDICINES: ROLE OF THE PHARMACIST	557
K. POOJA M. K. VIJAYALAKSHMI	REVIEW ON ANTICOAGULANT THERAPY MANAGEMENT	559-567
V.VIJITHA S. MADHUMITHA M. RAGUL S. PUNITHAVALLI K. RAJAGANAPATHY	REVOLUTIONIZING PHARMACY WITH ARTIFICIAL INTELLIGENCE: APPLICATIONS AND CHALLENGES	568
Kalsoom TARIQ Hashim KHAN Bela INAYAT	ROLE OF ASYMMETRICAL DIMETHYL ARGININE IN CARDIOVASCULAR DIABETOLOGY	569
S.punithavalli V.Vijitha S.Abinaya R.Vidhyalakshmi R.Saravanan	ROLE OF PHARMACOVIGILANCE IN ENSURE DRUG SAFETY	570
Noor ALLAHHAM Mustafa ÇAKIR	MACHINE LEARNING IN HEALTH PREDICTIONS: TRANSFORMING DATA TO VALUE	571-581
Samed ŞİMŞEK Tuğçe VAROL	BIOLOGICAL EVALUATION OF *Chenopodium foliosum*: FOCUSING ON ANTIOXIDANT AND ANTICANCER ACTIVITIES	582-583
Serdar VOLKAN Erkan GÜLER	INVESTIGATION OF ENRICHMENT CONDITIONS OF ÇUKURALAN REGION GOLD ORE BY LEACHING METHOD	584-592
Emre ERGEN Mustafa PEHLİVAN	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF SILICIUM OXIDE ADDED ULTRA EVER DRY® COATINGS ON THE WETTABILITY PERFORMANCE OF STAINLESS-STEEL SURFACES	593-599
Ensar Abdullah GÖKALP Oya ÇEPNİ ÖNALAN	EFFECTS OF STRESS FACTORS ON EMPLOYEES AND COPING METHODS	600-606
Subhashish Dey	APPLICATION OF MACHINE LEARNING FOR CRACKDETECTION ON CONCRETE STRUCTURES USING CNN ARCHITECTURE	607
Subhashish Dey	EFFECT OF CBR RESULTS FOR FLY ASH PURIFIED CLAYEY SOIL MATERIALS	608
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka R.Srinivasan	SUSTAINED AND CONTROLLED RELEASE FORMULATIONS	609

Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka .R.Srinivasan	SYNTHESIS AND SAR OF ANTIHYPERTENSIVE AGENTS	610
Serkan SAYAR	SIBLING RIVALRY IN TANAH: ETHNO-THEOLOGICAL FOUNDATIONS OF COLLECTIVE IDENTITY	611-612
Serkan SAYAR	ANTI-ZIONISM IN THE JEWISH TRADITION: A THEOLOGICAL ASSESSMENT IN THE CONTEXT OF THE THREE OATHS	613-614
Shashwath M. Shyam D. Vishaal S. Vishnu L. Banu Prakash S.	TEMPERATURE MANAGEMENT AND SAFETY ENHANCEMENT IN EV BATTERIES	615
Verora VUTHAJ Anesa VELIU Meritor ZHDRELLA Ilir MAZREKU	THE IMPACT OF DICHLOROMETHANE (DCM) AND IT'S TOXIC EFFECTS ON *MUS MUSCULUS*	616
M. K. VIJAYALAKSHMI Puniparthi SUNITHA K. POOJA	UNDERSTANDING HYDROPS: CAUSES, DIAGNOSIS, AND MANAGEMENT ACROSS LIFE STAGES	617-620
Nargiz AİTUGANOVA	ECONOMIC ANALYSIS OF WHEAT PRODUCTION IN NORTHERN KAZAKHSTAN: PRODUCTIVITY, EXPORTS, AND INTERNATIONAL COMPARISON	621
Mrs.E.Elavarasi Yuvaraj AR J.Jayadurka R.Srinivasan	CHICORY PLANT: EXTRACTION, PURIFICATION, AND USES IN HERBAL DRUG TECHNOLOGY	622
Adel DELIOU KhmissiBELKAID Abdelkader FIDJAH Meriem DEHBI Mohamed CHAOUR	ANALYSIS OF TENSILE CHARACTERISTICS IN EPOXY COMPOSITES: ASSESSING TWARMAT AND WOVEN GLASS FIBER REINFORCEMENTS	623
Izuogu, C.U Okonwe, P.N Njoku, L.C Olaolu, M.O brahim-Olesin, S Umeh, N.E Agou, G.D Iroegbu, S.C	ACCESS AND USE OF INFORMATION AND COMMUNICATION TECHNOLOGY AMONG RICE FARMERS IN ISHIELU, EBONYI STATE, NIGERIA	624-629
Mrs.E.Elavarasi Yuvaraj AR J. Jayadurka R.Srinivasan	ACETYLCHOLINE, MOLECULAR CHARACTERISTICS, AND APPLICATIONS	630
Volkan UCA Gönül GÖKÇAY	THE RELATIONSHIP BETWEEN PARENTS' HEALTH BELIEFS, ANTIBIOTICS PERCEPTIONS AND VACCINE ATTITUDE	631-632
Mitat Uysal Aynur Uysal Elif Erçelik	SUPPORT VECTOR MACHINES AND THEIR OPTIMIZATION USING SMO, MBO, AND PSO: A COMPARATIVE STUDY	633-634
Merve İCAT Sevilay ERDEN	THE LATEST TECHNOLOGY IN PLASTIC RECONSTRUCTIVE AND AESTHETIC SURGERY: ARTIFICIAL INTELLIGENCE AND NURSING APPROACHES	635-639

SICAK-NEMLİ İKLİM KUŞAĞINDA YER ALAN GELENEKSEL YÖRESEL MİMARİ VE ÇAĞDAŞ BÖLGESEL TASARIM UYGULAMALARI ÜZERİNDEN ENERJİ ETKİN TASARIM İLKELERİNİN İNCELENMESİ

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ÖZET
Bu çalışma, Ege Bölgesi ile Türkiye'nin sıcak-nemli iklim kuşağında yer alan farklı yerleşimlerde, yapı kabuğu tasarımının ve malzeme tercihinin kullanıcı konforu üzerindeki etkilerini kapsamlı bir şekilde değerlendirmeyi ve bu etkilerin sürdürülebilir tasarım yaklaşımları bağlamında nasıl optimize edilebileceğini ortaya koymayı amaçlamaktadır. Yüksek sıcaklık, uzun güneşlenme süreleri, yıl boyunca değişken bağıl nem oranları ve zaman zaman artan rüzgar etkisinin belirleyici olduğu bu iklim koşullarında, yapı kabuğu tasarımına ilişkin alınan kararlar (yapı yönlenmesi, gölgeleme stratejileri, çatı biçimi ve eğimi, cephe malzemesi seçimi, pencere yerleşimi ve oranları) iç mekânın termal, görsel ve hatta akustik konfor koşullarını doğrudan etkileyen kritik unsurlar olarak ön plana çıkmaktadır. Bu kapsamda, çalışmada hem geleneksel yöresel mimari örnekler hem de çağdaş bölgesel tasarım yaklaşımları üzerinden seçilen konut ölçeğindeki örnekler karşılaştırmalı olarak incelenmiş, farklı yapı kabuğu çözümlemelerinin enerji verimliliği, kullanıcı konforu, yaşam kalitesi ve sürdürülebilirlik hedefleri üzerindeki katkısı detaylı biçimde analiz edilmiştir. Elde edilen bulgular, Ege Bölgesi'nde ısı kazançlarını azaltmaya yönelik geçirimsiz dış yüzeylerin, etkili gölgeleme elemanlarının, doğal hava akışını destekleyen pencere ve açıklık düzenlemelerinin ve çapraz havalandırma stratejilerinin başarılı sonuçlar verdiğini göstermektedir. Sıcak-nemli iklim koşullarında ise, doğal havalandırmayı destekleyen açıklık tasarımlarının, buhar geçirgenliği yüksek nefes alabilir malzeme tercihlerinin ve güneşin etkisini minimize eden gölgeleme çözümlerinin ön planda olduğu saptanmıştır. Çalışma, iklime duyarlı yapı kabuğu tasarımının yalnızca enerji tüketimini azaltmakla kalmayıp, aynı zamanda kullanıcı sağlığı ve mekânsal konfor üzerinde de stratejik bir rol oynadığını vurgulamaktadır.
Anahtar Kelimeler: Yapı kabuğu, enerji etkin tasarım, iklim, yerel mimari, sürdürülebilir mimari.

AN EXAMINATION OF ENERGY EFFICIENT DESIGN PRINCIPLES THROUGH TRADITIONAL VERNACULAR ARCHITECTURE AND CONTEMPORARY REGIONAL DESIGN PRACTICES IN THE HOT-HUMID CLIMATE ZONE

ABSTRACT
This study aims to comprehensively evaluate the effects of building envelope design and material choice on occupant comfort in different settlements located in the Aegean Region and the hot-humid climate zone of Turkey, and to reveal how these effects can be optimized in the context of sustainable design approaches. In these climatic conditions characterized by high temperatures, long periods of insolation, variable relative humidity throughout the year, and occasional wind effects, decisions taken regarding the design of the building envelope (building orientation, shading strategies, roof shape and slope, façade material selection, window placement and proportions) stand out as critical elements that directly affect the thermal, visual

and even acoustic comfort conditions of the interior space. In this context, the study comparatively examines both traditional vernacular architectural examples and contemporary regional design approaches, and analyzes in detail the contribution of different building envelope solutions on energy efficiency, user comfort, quality of life and sustainability goals. The findings show that in the Aegean Region, impermeable exterior surfaces, effective shading elements, window and opening arrangements that support natural air flow, and cross ventilation strategies to reduce heat gains yield successful results. In hot-humid climates, openings that support natural ventilation, breathable materials with high vapor permeability and shading solutions that minimize the effect of the sun are found to be at the forefront. The study emphasizes that climate-sensitive building envelope design not only reduces energy consumption, but also plays a strategic role in user health and spatial comfort.
Keywords: Building envelope, energy efficient design, climate, vernacular architecture, sustainable architecture.

GİRİŞ

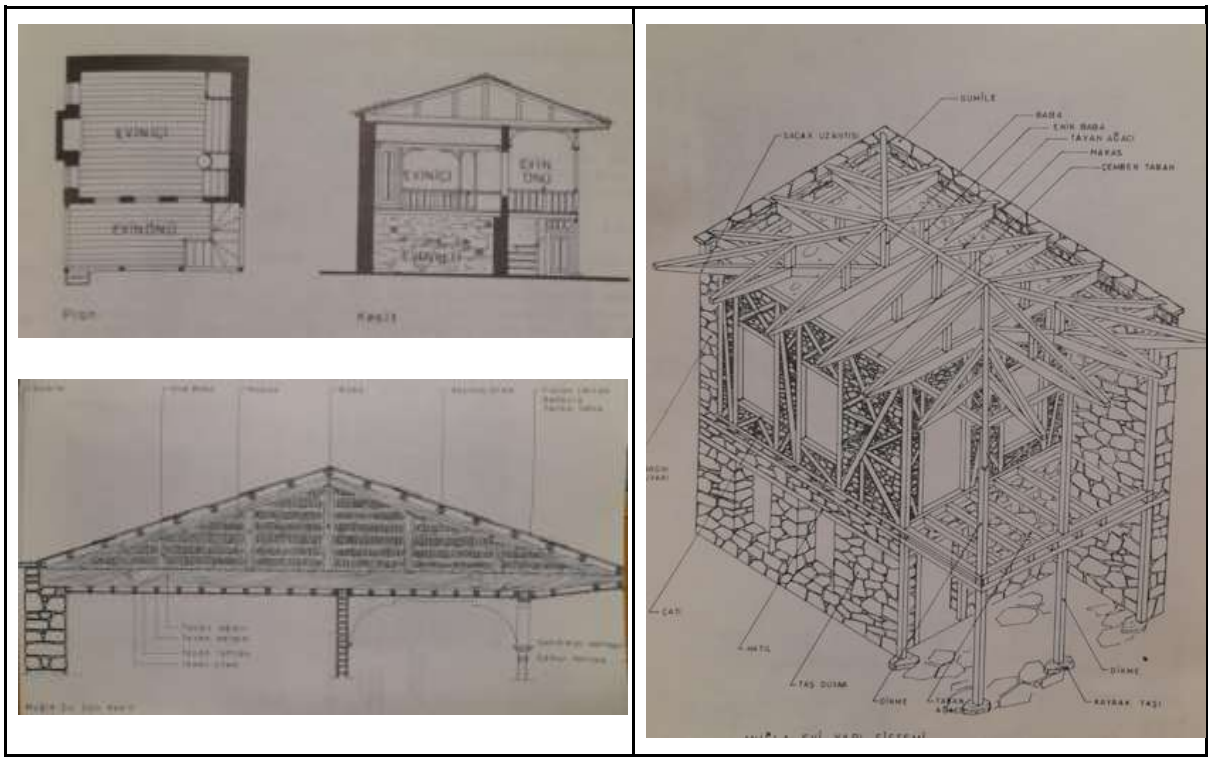
Dünyanın hali hazırda sınırlı olan enerji kaynaklarının hızlı bir şekilde tükeniyor oluşu sürdürülebilir bir gelecek inşa etmek için tüketimin olduğu her alanda önemli adımlar atılmasını gerektirmektedir. Bu kapsamda yapı kabuğu, termofiziksel özellikleri ile enerji ve kaynak tüketiminde etkilidir. Enerjinin korunması, daha az tüketilmesi, verimli kullanılabilmesi amacıyla enerji etkin kabuk kuruluşu ve iklimle dengeli tasarım günümüzde daha da önemli bir noktaya gelmiştir. Bu arayışın, geçmiş yüzyıllardaki ilksel izleri yöresel mimari üzerinden takip edilebilmektedir.

Yerel mimari, geçmişin bir kalıntısı değil, modern dünyanın sorunlarına çözüm sunabilecek bir yapı biçimidir (Oliver, 2006). Çağdaş yapım teknikleri ile yere ve koşullarına özgü yapım yönteminin belirlenmesi güncel tasarım sorunsalıdır. Bölgesel iklim koşulları gibi bölgesel tasarım yaklaşımı da yere özgü çeşitlilik içermektedir. Bölgesel tasarım, bir yapıyı bulunduğu yerin fiziksel, doğal ve kültürel bağlamına adapte ederek, o yerin kimliğini ve ruhunu yansıtan; modern teknolojilerle geleneksel değerleri birleştiren, duyarlı bir mimari anlayıştır (Kuyrukçu, 2018). Kenneth Frampton'ın "Eleştirel Bölgeselcilik" yaklaşımı bağlamında iklim ve enerji etkinliğini bölgesel mimari tasarımın ayrılmaz bir parçası olarak ele almıştır. Küreselleşme ile birlikte mimarlıkta 'yer'den kopuk kimliksiz ve çevresiyle uyumsuz yapıların ve kentlerin ortaya çıkması öncelikli sorundur. Bir yapının 'yer'e ait olabilmesi için mimari tasarımın bir bölgeye özgü doğal, kültürel ve sosyal bağlamlarla uyumlu bir şekilde gelişmesi önem kazanmıştır. Çağdaş yapı malzemelerinin ve teknolojilerinin yerel bağlamla nasıl bütünleştirilebileceği, yerel olanı taklit etmeyip, yorumlayarak ihtiyaçlara nasıl karşılık oluşturulabileceği bölgesel tasarımın öncelikli arayışıdır. Bu değerlerin çeşitliliğini araştırmak amacıyla, Türkiye'nin Ege bölgesinden seçilen yer ile uyumlu yöresel mimari ve bölgesel çağdaş yapı örnekleri incelenerek bölgesel mimaride enerji etkin tasarım verileri analiz edilmiştir.

ARAŞTIRMA VE BULGULAR

Sıcak nemli iklim bölgelerinde yaz ayları genellikle kuru ve sıcak, kış ayları ise ılık ve yağışlı geçmektedir. Bu tür iklimlerde, yazın aşırı sıcaklık ve kışın soğuk iklim koşullarından korunmak için çeşitli önlemler alınmalıdır. Sıcak-nemli bölgelerde doğal havalandırma ve gölgeleme stratejileri ön plana çıkmaktadır. Kış aylarında, güneş ışığından yararlanılarak iç mekanların ısınması sağlanmalı; yaz aylarında ise serinletici hava akımlarından faydalanarak iç mekanlar soğutulmalıdır. Bu tür tasarımlar, binaların iç mekanlarının doğal olarak soğutulmasını ve ısınmasını sağlarken, enerji tüketimini de önemli ölçüde azaltır (Santamouris,

2013). Bu bağlamda, sıcak-nemli iklim bölgelerinde yapılan geleneksel mimari uygulamalar, modern yapı tasarımında önemli bir ilham kaynağı olmaktadır. Ancak günümüzde birçok bina, doğal havalandırma ve gölgeleme gibi pasif iklimlendirme stratejileri göz ardı edilerek inşa edilmektedir. Bunun sonucunda, yüksek enerji tüketimi ile çalışan soğutma sistemlerine duyulan ihtiyaç artmaktadır. Oysa doğru malzeme kullanımı, geniş saçaklar, geçirgen cephe sistemleri ve iç avlu gibi tasarım unsurları, bu bölgelerdeki yapıların hem konfor koşullarını iyileştirebilmekte hem de enerji verimliliğini artırabilmektedir.



Şekil 1. Yöresel Muğla Konutunda yapı kabuğu kuruluşu (Aladağ, 1991)

Yöresel Mimaride Yapı Kabuğu Kuruluşu

Geleneksel yöresel yapı analizleri, iklim tiplerinin, yerel malzeme kullanımının ve çevresel koşulların yapı tasarımını nasıl şekillendirdiğini açıkça ortaya koymaktadır. Bu yapılar, bulundukları coğrafi konum ve iklim özellikleri dikkate alınarak, rüzgar yönü, güneşin hareketleri ve diğer çevresel faktörler göz önünde bulundurularak konumlandırılmıştır. Yöresel malzemelerin tercih edilmesi hem ekonomik hem de çevresel sürdürülebilirlik açısından büyük bir öneme sahiptir; çünkü bu malzemeler, yerel iklimle uyumlu olarak, yapının uzun ömürlü ve enerji verimli olmasını sağlamaktadır. Ayrıca, cephe düzenlemeleri, iç mekanın doğal ışık ve hava sirkülasyonu ile etkileşimini organize edecek şekilde tasarlanmış, çatı saçakları ise yağış ve güneşin olumsuz etkilerinden yapıyı korumak amacıyla belirli bir biçimde yerleştirilmiştir. Ege bölgesine göre geleneksel mimaride yapı kabuğunun oluşumu, yerel malzeme dokusu, cephe tipolojisi, bina formu ve plan kurgusu başlıkları altında analiz edilmiştir (Tablo 1).

Tablo 1. Geleneksel konut örneklerinin iklimsel parametrelere göre malzeme seçimi plan kurgusu ve bina formu

İklim	Yerel malzeme dokusu ve cephe tipolojisi	Bina formu ve plan kurgusu
Sıcak-nemli iklim bölgeleri  Antalya (Gökçe, 2022)	-Güneşten korunmak için geniş saçaklar tercih edilmiştir. -Güney cephelerde geniş açıklıklı duvarlar, tercih edilmiştir. -Yapı malzemesi olarak kerpiç, ahşap vb. malzemeler kullanılmıştır. -Cephelerde yansıtıcılık açısından için açık renkli boyalar kullanılmıştır. -Eğimli çatılar kullanılmıştır. -Pencere kepenkleri vb. yapı elemanları kullanılarak rüzgar ve güneş kontrolü sağlanmıştır.	-Bu iklimin görüldüğü bölgelerde zamanın çoğu açık mekanlarda geçtiği için geniş verandalar vardır ve sofalı plan formu kullanılmıştır. -Bina kabuğunda hava akışı ve gölge sağlayan geniş açıklıklar bulunmaktadır. -Nemden kaynaklanan olumsuzluğu gidermek için ısıtma ve soğutma hakim rüzgar yönünde yapılmıştır ve yapı cephelerinde havalandırma için pencere açıklıkları bırakılmıştır. -Çatılarda genellikle açıklıklar bırakılarak ısınan havanın doğal olarak yükselip tahliye edilmesi sağlanmıştır. -Pencereler karşılıklı konumlandırılarak havalandırma sağlanmıştır. -Hava akımını sağlamak için yükseltilmiş döşemeler tercih edilmektedir.

Geçmiş dönem yapılarında, yerel iklim ve coğrafi koşullara uygun olarak avlulu, kare veya dikdörtgen formlar tercih edilmiştir. Aşırı güneş alan cepheler, kış aylarında pasif ısı kazancı sağlamak amacıyla tasarlanmış, rüzgara açık cepheler doğal havalandırma süreçlerini destekleyecek şekilde değerlendirilmiştir. Bu yaklaşım hem enerji verimliliğini artırmak hem de kullanıcı konforunu sağlamak açısından fayda sağlamıştır.

Geleneksel mimarlık, çevresel faktörlere duyarlı tasarım yaklaşımıyla modern teknolojilere referans olmaktadır. Günümüzde bu mirasın sürdürülebilir tasarımlara aktarılması, çevre dostu yerleşim planlarının oluşturulmasında önemli bir rol oynamaktadır. Anadolu'da farklı iklim bölgelerindeki geleneksel yapı örneklerinin incelenmesi, çağdaş çevresel sorunlara çözüm üretebilmek açısından büyük önem taşımaktadır.

Çağdaş Bölgesel Tasarımda Yapı Kabuğu Kuruluşu

İklim koşullarına uyumlu ve çevresel sürdürülebilirlik ilkelerine uygun yapıların tasarımı, ısıl konforun sağlanmasında önemli bir rol oynamaktadır. Bu tür yapılar, yerel iklim koşullarını dikkate alarak tasarlanmakta ve genellikle pasif iklimlendirme, doğal havalandırma ve yerel malzeme kullanımı gibi unsurları içermektedir. Sürdürülebilir yapılar, yerel malzeme kullanımını teşvik eder ve geleneksel yapım teknikleri ile günümüz teknolojilerini harmanlayarak çevreye duyarlı çözümler sunar (Yılmaz, 2014). Bu unsurların bir araya gelmesi, yapının yalnızca çevresel değil, aynı zamanda kültürel ve toplumsal bağlamda da sürdürülebilir olmasını sağlamaktadır.

Geçmiş deneyimler ve günümüz teknolojilerinin birleşimiyle, farklı iklim koşullarına uyum sağlayabilen çağdaş yöresel yapıların tasarımı ve uygulanması mümkün olmuştur. Bu yapıların, farklı iklim bölgelerindeki özellikleri bağlamında incelenmesi ve analiz edilmesi, sürdürülebilir mimarlık anlayışını daha derinlemesine kavrayabilmek için fayda sağlayacaktır. Bu bağlamda Ege bölgesinde bulunan SE evi incelenmiştir.

Ersen Gürsel tarafından projelendirilen ve 2006 yılında tamamlanan yapı, Bodrum/Muğla'da yer almaktadır (Arkitera, 2012).

Ersen Gürsel, mimarlık disiplininde çevresel uyuma büyük önem vermektedir. Özellikle yapılarında yerel malzeme kullanımını, doğal ışık ve hava akımlarını etkin şekilde kullanarak çevre ile uyumlu tasarımlar oluşturmuştur. Bu yaklaşım, sürdürülebilirlik ilkeleriyle bağdaşmakta ve yapının yerel iklim koşullarına en uygun şekilde tasarlanmasını sağlamaktadır. Gürsel'in eserleri, sadece estetik açıdan değil, aynı zamanda çevresel sorumluluk açısından da örnek teşkil etmektedir (İncedemir, 2022).

Bu eserlerden biri olan SE evi, bölgenin iklim koşullarına uyumlu ve çevresel sürdürülebilirlik ilkelerine uygun bir yapı olarak karşımıza çıkmaktadır. Yöresel malzeme kullanımı, çatı tasarımı, doğal havalandırma çözümleri ve güneş ışığını kontrol eden yapısal özellikler, SE Evi'nin geleneksel Bodrum mimarisiyle uyumlu bir yapı olduğunu göstermektedir (Açıkalın, 2016). SE evi üzerinden yerele ait değerler analiz edildiğinde (Şekil 2);



Şekil 2. SE evi yapı kabuğu (EPA mimarlık, 2013)

- Dış duvarlarında hava deliklerinin açıldığı,
- Tek yöne eğimli bir çatı tasarlandığı ve çatı malzemesi olarak yöresel malzemelerin kullanıldığı,
- Güneye bakan cephede pencere üstlerinde yöresel malzemeler kullanılarak saçaklar oluşturulduğu,
- Pencereler için yöresel malzemeler kullanılarak kepenkler tasarlandığı,
- Arsada bulunan dut ağaçlarının korunarak doğal peyzajın kullanıldığı,
- Dış cephe boya renginin açık renk tercih edildiği,
- Avlusuz ve kareye yakın bir kütle formu oluşturulduğu görülmektedir.

Tüm bu özellikler içerisinde yapı kabuğunu oluşturan ve yerele ait olan tasarım kararları, mekan içerisinde ısıl konforu nasıl etkilediği ile ilgili tablo (Tablo 2);

Tablo 2. SE evi çevresel ve mekânsal uyum analiz tablosu

Isıl konfor için geliştirilen çözümler	Havalandırma için geliştirilen çözümler
Dış duvarlarda hava deliklerinin açılması	
Alt ve üst kısımdaki hava delikleri, serin havanın girişini ve sıcak havanın tahliyesini sağlayarak yaz aylarında iç mekânın serin kalmasına katkıda bulunmuştur.	Hava delikleri, nemin dışarı atılmasına ve kuru havanın içeri alınmasına yardımcı olmuş, nemin neden olduğu ısıl rahatsızlıkları önlemiştir.
Tek yöne eğimli ahşap çatı ve üstünün kiremitle kaplanması	
Çatı eğimi ve kiremit malzeme, güneş ışığını yansıtarak aşırı ısınmayı önlemiş ve ısıyı dengeleyerek iç mekân konforunu sağlamıştır.	Ahşap, çevredeki nemi emme ve salma özelliğine sahiptir. Bu özellik, iç mekanın nem dengesini düzenlemeye yardımcı olmuştur.
Pencereler için saçak tasarlanması	
Saçaklar, yazın pencerelere gölge sağlayarak aşırı ısınmayı önlemiş; kışın ise düşük açılı güneş ışığını engellemeyerek iç mekânın ısınmasına katkıda bulunmuştur.	Saçaklar, pencereyi nemden koruyarak yapı ömrünü uzatır, ısı yalıtımını güçlendirir ve enerji verimliliğini artırır.
Pencereler için ahşap kepenk uygulaması	
Kepenkler, yazın güneş ışığını engelleyerek serinlik sağlarken, kışın ısı kaybını azaltıp ek yalıtım katmanı oluşturarak iç mekân konforunu artırmıştır.	Ahşap, çevredeki nemi emme ve salma özelliğine sahiptir. Bu özellik, iç mekanın nem dengesini düzenlemeye yardımcı olmuştur.

Çağdaş yöresel yapıların tasarımında, yerel iklim koşullarına ve çevresel faktörlere duyarlılık ön planda tutulmuştur. Özellikle, yapının bulunduğu coğrafi konumun güneş, rüzgar ve nem gibi faktörleri göz önünde bulundurularak, mekanik sistemlere duyulan ihtiyaç minimuma indirilmiştir. Doğal havalandırma, güneş enerjisinden yararlanma ve yağışa karşı koruma gibi unsurlar, çağdaş tasarımlarda etkin bir şekilde uygulanmışlardır. Kabuk tasarımı, ışık ve hava sirkülasyonu gibi doğal faktörleri en verimli şekilde kullanacak şekilde düzenlenmiştir. Bu yapılar, dış çevreyle organik bir ilişki kurarak, hem estetik hem de işlevsel anlamda kullanıcı konforunu ön planda tutmaktadırlar. Örneğin, geniş pencereler, doğal ışığın içeri girmesine olanak tanırken, dış mekanla bağlantıyı güçlendirmektedirler. Çatı düzenlemeleri ve cephe

düzenlemeleri ise güneşin olumsuz etkilerinden korunma sağlarken, iç mekanın doğal ısınma süreçlerinden faydalanmasını sağlamaktadırlar.

SONUÇ

Yapılan analizler doğrultusunda, pasif ısınma ve soğutma stratejilerinin yanı sıra doğal havalandırma sistemlerinin entegre edilmesi, enerji tüketimine yol açacak klima gibi mekanik sistemlere olan ihtiyacı ortadan kaldıracaktır. Ayrıca, topoğrafik özelliklerin ve yerel malzemelerin etkin bir şekilde değerlendirilmesi, yapı kabuğunun oluşturulması sürecinde kazı çalışmalarını ve ilave malzeme maliyetlerini minimize edebilecektir. İklimle uyumlu yapı kabuğu tasarımlarının teşvik edilmesi, enerji tüketiminin azaltılması ve bölgesel kimliği koruyan sürdürülebilir mimari çözümler üretilmesi açısından kritik bir adım olacaktır. Böylece, yerin ruhunu koruyan, enerji etkin ve çevresel sürdürülebilirliği destekleyen mimari yaklaşımlar geliştirilerek, hem ekolojik hem de kültürel anlamda değer taşıyan yapılar inşa edilebilecektir.

Sonuç olarak, yapı kabuğunun tasarımında iklim verilerine duyarlı, yerel malzemelerle desteklenmiş ve enerji etkin çözümler geliştirmek, mimarlık disiplininde sürdürülebilir bir gelecek inşa etmenin temel taşlarından biridir. Geleneksel yapıların çevresel verilerle kurduğu dengeyi, çağdaş tekniklerle harmanlayarak mimari tasarıma entegre etmek, hem enerji tasarrufunu hem de kullanıcı konforunu artıracaktır. Bu bağlamda, yapı kabuğunun enerji etkinliğini artırmaya yönelik yeni nesil tasarım yaklaşımlarının benimsenmesi, iklim değişikliğiyle mücadelede önemli bir rol oynayacaktır. Bu çalışma, mimari tasarım sürecinde iklim ve yer faktörlerini göz önünde bulundurmanın önemini vurgulayarak, gelecekteki araştırmalara ve uygulamalara ışık tutmayı amaçlamaktadır.

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STUDYING THE IMPACT OF MILITARY SCHOOLS AND MILITARY UNITS ON THE DEVELOPMENT OF SPORTS IN IRAN DURING THE QAJAR PERIOD

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Abstract
The Qajar period (1789-1925) witnessed profound changes in the social and cultural structure of Iran, one of the most important of which was the attention to sports and physical education. Military schools and military detachments, as educational and social institutions, played a key role in the development of sports during this period. These schools promoted sports and physical activities with the aim of military education and training efficient forces. Military schools, by emphasizing martial arts such as shooting, wrestling, and fencing, not only strengthened military skills but also helped to strengthen collective spirit and nationalism. Military detachments, as social institutions, also helped to promote sports culture in society by holding sports competitions and sports performances. This research aims to examine the impact of military schools and military detachments on the development of sports in Iran during the Qajar period with a descriptive-analytical approach. Therefore, it seeks to answer these questions: 1- How did the system schools and military units help develop sports during the Qajar period? 2- What effect did the holding of sports competitions by military units have on the general culture of society? The research findings indicate that the system schools, through sports training and physical exercises, improved the level of physical fitness and military skills among Iranian youth. By holding sports events, military units played an important role in promoting sports culture and creating a sense of nationalism in Iranian society.
Keywords: Impact, schools, military units, sports development, Iran, Qajar period.

THE CLINICAL SIGNIFICANCE OF NORMAL PHYSIOLOGICAL BLOOD PARAMETERS IN HEALTH ASSESSMENT

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ABSTRACT
Blood parameters are vital indicators of physiological and pathological processes in the human body. Normal physiological values serve as reference ranges that guide clinical interpretation of laboratory results, **aiding** in the diagnosis, monitoring, and management of various diseases. These parameters, including hemoglobin concentration, white blood cell count, platelet count, glucose levels, electrolytes, renal and liver function markers, provide crucial insights into the functional status of different organ systems. This study aims to highlight the importance of maintaining and understanding normal ranges of key blood parameters in clinical practice. It also explores how deviations from these normal values can signal early signs of systemic diseases such as infections, anemia, metabolic disorders, organ dysfunction, and hematological abnormalities. The research emphasizes the variability of normal ranges based on age, sex, physiological state, and geographical or ethnic differences, underscoring the need for context-specific interpretation. Accurate interpretation of blood test results depends not only on identifying abnormalities but also on understanding what constitutes "normal." Misinterpretation of these values can lead to misdiagnosis, delayed treatment, or unnecessary interventions. Therefore, this paper advocates for increased awareness among healthcare professionals and students regarding the physiological significance of these reference values. In conclusion, normal blood parameter values are foundational to evidence-based medicine. Recognizing their role enhances diagnostic accuracy, supports early detection of diseases, and promotes better clinical outcomes.
KEY WORDS: Blood parameters, Health assessment, clinical Outcomes, Laboratory results

CORRELATION STUDY ON ETIOLOGICAL FACTORS OF HEART DISEASE IN DIABETIC PATIENTS IN LAHORE, PAKISTAN

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ABSTRACT:
Diabetes is a chronic disorder and inability to process and regulate blood glucose levels. This disorder may arise from excessive secretion of insulin by pancreas in our body. Type I diabetes is a chronic autoimmune disease characterized by deficiency of insulin, resulting in an increase in blood glucose level in body. This dysfunction includes autoimmune destruction of beta cells in pancreas leads to complete lack of insulin production. Type 2 diabetes is most prevalent metabolic disorder characterized by inadequate insulin production and impaired response of tissues to insulin. Global burden of diabetes mellitus represents a significant public health challenge. Heart disease is a serious health condition that affects millions of people. Heart diseases include coronary artery disease (CAD), myocardial infarction, angina, heart failure, congenital heart disease, Atrial fibrillation and heart valve disorder. Etiological factors of heart disease are modifiable factors, conventional factors, environmental factors, non- traditional factors and psychological factors that collectively contribute to diabetes prevalence. Modifiable factors include high blood pressure, obesity and metabolic syndrome while conventional factors include age, gender and family history. Complications related to diabetes like liver cirrhosis, alcohol related liver disease and renal disease also promote cardiovascular disorders. Different risk factors show different level of correlation with each other. Age limit, duration of diabetes and high level of cholesterol has significant level of positive correlation. Moreover, high levels of cholesterol in diabetic patients correlate with normal systolic blood pressure which is also an indication of prevalence of heart disease in diabetic patients. Treatment and preventions focus on stress management, lifestyle interventions and balanced diet.
Key Words: Diabetic Heart Disease, Cardiovascular complications, Etiological Factors, Correlation Study

THE IMPACT OF LIVER CIRRHOSIS ON THE PROGRESSION AND COMPLICATIONS OF DIABETES MELLITUS

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Background: Liver cirrhosis and diabetes mellitus are two chronic conditions that frequently coexist and interact in complex ways. The liver plays a central role in glucose metabolism, and cirrhosis significantly alters hepatic function, insulin sensitivity, and glucose homeostasis. This interaction often results in a specific form of diabetes known as hepatogenous diabetes, complicating the management and prognosis of both conditions.
Objective: This study aims to explore the impact of liver cirrhosis on the onset, progression, and complications of diabetes mellitus. It also examines the bidirectional relationship between hepatic dysfunction and glycemic control, focusing on how cirrhosis influences diabetic complications such as cardiovascular disease, nephropathy, and neuropathy.
Methods: A comprehensive review and clinical data analysis were conducted on patients with coexisting liver cirrhosis and diabetes. Key indicators such as glycemic variability, insulin resistance, and complication rates were compared with diabetic patients without liver disease.
Results: Patients with cirrhosis exhibited higher rates of glycemic instability, increased insulin resistance, and more severe complications, particularly in renal and cardiovascular systems. Cirrhotic patients also faced challenges in diabetes management due to altered drug metabolism and reduced tolerance to standard therapies.
Conclusion: Liver cirrhosis significantly exacerbates the pathophysiology and complications of diabetes mellitus. Early detection and integrated management of both conditions are essential to improve clinical outcomes and reduce morbidity. Further studies are warranted to develop optimized treatment protocols for this high-risk population.
Key Words: Liver cirrhosis, DM, Complications, glycemic control

AN OVERVIEW OF CAD; ETIOLOGIC FACTORS & SURGICAL MANAGEMENTS

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ABSTRACT:
The most leading cause of death is CAD. CAD is a disease of coronary artery characterized by calcium or fat deposition, vascular spasm and clot formation. Arthrosclerosis leads to different cardiovascular diseases which include cardiac muscular damage, hypertrophy, ischemic heart disease and other cardiac abnormalities. CAD is usually related to ischemic heart disease, coronary heart disease, myocardial infarction, angina pectoris and congested heart failure. ECG, MRI, Echo, angioplasty, X-ray, PET, CT scan and cardiac markers are different diagnostic workouts. This article is to review different etiological factors of CAD. These factors are modifiable, non-modifiable, environmental factors, conventional, or traditional, psychological and disease related conditions. Modifiable factors are age, high blood pressure, diabetes mellitus, lack of ordinary activity, obesity and cholesterol rich diet. Non- modifiable factors are family history, age and gender. Environmental factors are tobacco, air pollutants, inhaled gases and pesticides. Moreover, psychological factors include depression, anxiety and stress, social isolation and social inactivity. Non-pharmacological therapy includes lifestyle modifications and precautionary measures. Smoking cessation, low cholesterol diet and exercise are lifestyle modifications to prevent the risk of CAD. Pharmacological therapy for CAD includes different agents i.e. anti-platelet agents, anti-coagulating agents, thrombolytic agents, beta blockers, ACE antagonists and lipid lowering agents. When pharmacological therapy fails to treat a patient, then the second option is surgical management. This article also reviews the surgical managements of CAD. Surgical managements for CAD patients involve angioplasty and CABG. Angioplasty is an alternate of CABG because CABG is more complicated surgical procedure than angioplasty.
Key Words: CAD, Etiological Factors, CABG, Angioplasty

FORMULATION AND EVALUATION OF OTF OF CETIRIZINE FOR RAPID SYSTEMIC ACTION

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ABSTRACT:
Allergy has become one of the most common chronic disorder worldwide, affecting nearly 40% of the global population Hypersensitivity reactions are the root cause of allergies, autoimmune diseases, and transplant rejections. Cetirizine, a second-generation H1 histamine blocker, is widely used to manage allergy-related conditions, particularly hay fever and skin welts in patients. Oral thin films (OTFs) are a pharmaceutical dosage form designed to rapidly dissolve within seconds when placed in the oral cavity. One of the main advantages of oral films is that they may be provided without the need for distilled water, preparing oral thin films convenient to use anywhere and whenever. Oral thin films have low disintegration duration and a high dissolution period, which results in a quick onset of action. The solvent casting method is used to prepared films by initially dissolving the excipients; the mixture was stirred for 15 minutes to achieve a clear solution. The films were dried in a hot air oven at a temperature not exceeding 50°C. Once dried, they were gently peeled from the glass plates. The pre-formulation and post-formulation studies, including Organoleptic analysis, solubility testing, stability assessment, drug content analysis, and microscopic examination were conducted. Each OTF was packaged in silver-coloured aluminium foil to protect it from moisture, heat, and light, with twenty films placed in a box, meeting all necessary packaging requirements. Oral thin films are better than conventional dosage forms because of flexibility, rapid onset of action, improved bioavailability, and increased patient compliance. Oral thin films are customizable, according to specific patient need.

Keywords: Autoimmune disease, OTF, Solvent Casting method, H1 blocker

TÜRKİYE'DE ERKEN DÖNEM BABALIK DENEYİMLERİNE ODAKLANAN LİSANSÜSTÜ TEZLERİN SİSTEMATİK İNCELEMESİ (0–2 YAŞ GRUBU)

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Özet
Bu araştırmanın amacı, Türkiye'de 0-2 yaş grubunda çocuğu bulunan babaların babalık rollerine ilişkin olarak 2014-2024 yılları arasında yapılmış ve YÖKTEZ veri tabanında yayımlanmış lisansüstü tezleri incelemektir. Araştırma, betimsel analiz yöntemi kullanılarak yürütülmüş; çalışma grubu, ölçüt örnekleme yöntemiyle belirlenen toplam 29 lisansüstü tezden oluşmuştur. Analiz sonucunda; tezlerin büyük çoğunluğunun yüksek lisans düzeyinde olduğu, özellikle hemşirelik alanında yoğunlaştığı ve neredeyse tüm çalışmaların baba-bebek bağlanması teması etrafında şekillendiği görülmüştür. Bunun yanı sıra, en sık ele alınan konular arasında babalara yönelik bebek bakımı ve beslenmesine ilişkin verilen eğitimlerin etkililiği yer almaktadır. İncelenen çalışmaların çoğunun nicel araştırma desenine sahip olduğu; özellikle deneysel ve betimsel yöntemlerin tercih edildiği belirlenmiştir. Çalışmalarda genellikle 50 ila 99 arasında değişen örneklem büyüklükleriyle veri toplandığı ve son yıllarda bu alandaki akademik ilgide artış yaşandığı gözlemlenmiştir. Ayrıca, baba-bebek bağlanmasını ölçmek amacıyla en yaygın olarak kullanılan veri toplama aracı "Baba-Bebek Bağlanma Ölçeği" olmuştur. Genel olarak bulgular, babalık rolleri üzerine yapılan lisansüstü çalışmaların odak noktasının baba-bebek bağlanması olduğunu; bu bağlamda, babalara yönelik bebek bakım ve beslenmesine ilişkin programların sıklıkla uygulandığını ortaya koymaktadır.
Anahtar Kelimeler: Baba, Babalık Rolleri, Bebek, Lisansüstü Tezler.

SYSTEMATIC REVIEW OF GRADUATE THESES FOCUSING ON EARLY FATHERHOOD EXPERIENCES IN TURKEY (0-2 AGE GROUP)

Abstract
The aim of this study is to examine the postgraduate theses published in the YÖKTEZ database between 2014 and 2024 on the fathering roles of fathers with children in the 0-2 age group in Turkey. The study was conducted using the descriptive analysis method; the study group consisted of a total of 29 postgraduate theses determined by criterion sampling method. As a result of the analysis, it was seen that the majority of the theses were at the master's level, especially in the field of nursing, and almost all studies were shaped around the theme of father-infant attachment. In addition, among the most frequently addressed topics was the effectiveness of trainings on infant care and feeding for fathers. It was determined that most of the studies examined had a quantitative research design; especially experimental and descriptive methods were preferred. It was observed that the studies generally collected data with sample sizes ranging from 50 to 99 and that there has been an increase in academic interest in this field in recent years. In addition, the most commonly used data collection tool to measure father-infant attachment was the "Father-Infant Attachment Scale". In general, the findings reveal that the focus of graduate studies on fathering roles is father-infant attachment; in this context, programs on infant care and feeding for fathers are frequently implemented.

Keywords: Father, Fatherhood Roles, Graduate Theses, Infant.

CROHN HASTALIĞINDA VEDOLİZUMAB VE USTEKİNUMAB TEDAVİLERİNİN ETKİNLİĞİ: TEK MERKEZ DENEYİMİ

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ÖZET
Ustekinumab ve Vedolizumab, Crohn hastalığı tedavisinde kullanılan etkili ve güvenli yeni ajanlardandır. Bu çalışmada birimimizde takip ve tedavi edilen Crohn (CH) hastalıklarında Vedolizumab ve Ustekinumab'ın etkinliği, devamlılığı ve güvenirliğini değerlendirmek amaçlanmıştır. Çalışmaya gastroenteroloji polikliniğimizde takip ve tedavi edilen İBH hastaları alındı. Vedolizumab/Ustekinumab'ın Türkiye'de onaylanıp kullanılmaya başlandığı tarihten Mart 2025 tarihine kadar bu ilaçları kullanan 18 yaş üstü Crohn hastaları değerlendirildi. Çalışmaya 15 Vedolizumab ve 20 Ustekinumab kullanan toplam 35 Crohn hastası alındı. Yaş, cinsiyet, sigara, eşlik eden hastalıklar, hastalık tutulumu, davranışı her iki grupta benzerdi. Hastalık yılı Vedolizumab grubunda (8,4±3,6'e karşılık 7,6±5,8) anlamlı şekilde daha uzundu (p=0,01). Hastalık şiddeti Vedolizumab hasta gurubunda (ağır hasta %70,3'a karşılık %55,2, başlangıç kolonoskopi ve Harvey-Bradshaw Index (HBİ) skorları) belirgin olarak daha yüksekti (p=001). Fistül, apse, bağırsak dışı belirti sıklıkları her iki hasta gurubunda benzerdi. Tedaviyle 52. haftadaki biyokimyasal belirteçlerden bakılan WBC, trombosit, hemoglobin, albumin, CRP, Sedimantasyon düzeylerinde, iki grupta benzer ve anlamlı şekilde düzelme saptandı(p< 0.01) .İki grupta da hastalığının şiddetini belirlemek için bakılan Harvey-Bradshaw Index skorlarında belirgin düzelme izlenmekle birlikte erken, orta ve geç dönemde düzelme Ustekinumab gurubunda daha düşüktü (p=0,001 ve p=0,03). Klinik remisyon oranları sırasıyla %47'ya karşılık %62 (p=0,002), kalıcı yanıt oranı %38,2 ve %45,1 idi (p=0,003). 14. haftada yanıt oranları Vedolizumab için %61 iken Ustekinumab gurubunda %70 (p=0,003) olarak saptandı. 52. haftada yanıt oranları ise sırasıyla %55.2 ve %56,1 olarak saptandı.(p=0,01).Kullanım süresi Vedolizumab'ta ortalama 20 ay, Ustekinumab'ta 16 ay (p=0,0001) idi (p=0,01). Steroidsiz remisyon 14. Haftada %47 ve %59 (p=0,018), 52. haftada %56 ve %53 olarak saptandı. Sonuç olarak çalışmamızda Crohn hastalarında sık olarak kullanılan biyolojik ajanlardan Anti-TNFlerin etkisiz olduğu durumlarda Vedolizumab ve Ustekinumab'ın gibi yeni ajanların günümüz klinik pratiğinde etkin ve sürdürülebilir tedaviler olduğu, güvenlik profillerinin benzer olduğu saptandı.
Anahtar Kelimeler: Crohn,Vedolizumab,Ustekinumab

EVALUATION OF THE EFFICACY VEDOLIZUMAB AND USTEKINUMAB IN THE TREATMENT OF CROHN'S DISEASE: A SINGLE CENTER COHORT STUDY

ABSTRACT
Vedolizumab and Ustekinumab are emerging biological therapies with promising safety and efficacy profiles in Crohn's disease (CD), particularly in anti-TNF refractory cases. This study aimed to evaluate of clinical outcomes, treatment durability, and safety of these agents in patients with CD managed in a tertiary gastroenterology clinic. Adult patients with CD who received Vedolizumab or Ustekinumab from the date of their approval in Türkiye until March

2025 were retrospectively evaluated. Clinical data, disease activity (Harvey-Bradshaw Index [HBI]), biochemical markers, and treatment response at weeks 14 and 52 were analyzed.A total of 35 patients were included in the study (Vedolizumab, n=15; Ustekinumab, n=20). Baseline demographics and disease characteristics were similar, although disease duration (p=0.01) and severity (p=0.001) were significantly higher in the Vedolizumab group. Both therapies led to significant improvements in biochemical markers by week 52 (p<0.01). HBI scores improved in both groups; however, early and sustained responses were higher in the Vedolizumab group (p=0.001 and p=0.03). Clinical remission at week 52 was observed in 47% (Vedolizumab) vs. 62% (Ustekinumab) (p=0.002). Sustained response rates were 38.2% vs. 45.1%, respectively (p=0.003). Steroid-free remission at weeks 14 and 52 were comparable. Mean treatment duration was longer in the Vedolizumab group (20 vs. 16 months, p=0.01). In conclusion ,Vedolizumab and Ustekinumab are both effective and safe in managing Crohn's disease in real-world settings. Vedolizumab may offer more durable responses in patients with more severe disease profiles. Both agents represent viable options for patients unresponsive to anti-TNF therapy.
Keywords: Crohn, Vedolizumab, Ustekinumab

EFFECT OF SULFURIC ACID ON OXIDATIVE STRESS AND ACTIVITY IN HELIX POMATIA

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Abstract
Objective: This study aimed to investigate the effects of sulfuric acid exposure on oxidative stress and motor activity in Helix pomatia over a 7-day period.
Materials and Methods: Two groups of Helix pomatia were used: a control group (this group was not exposed to sulfuric acid) and an experimental group (this group was exposed to sulfuric acid). The experimental group received food containing sulfuric acid at concentrations ranging from 1% to 5%, prepared by diluting the acid in 100 mL of distilled water (e.g., 1 mL acid in 100 mL water for a 1% solution). The control group received the same food without acid. Both groups were monitored daily for motor activity, health status, and behavioral changes. At the end of the 7-day exposure period, biochemical tests were conducted to evaluate oxidative stress through indicators such as lipid peroxidation and antioxidant enzyme activity.
Results: After 7 days, snails in the experimental group showed a significant decline in motor activity and body weight compared to the control group. Additionally, visible pigmentation changes and reduced mobility were observed. Biochemical analysis indicated elevated levels of oxidative stress markers, pointing to potential cellular damage and impaired physiological function. The combined behavioral and biochemical results suggest that sulfuric acid disrupts the metabolic and nervous systems of exposed snails.
Conclusion: Short-term exposure to sulfuric acid significantly affects the health of Helix pomatia, leading to reduced activity, weight loss, and increased oxidative stress. These findings highlight the potential ecological risks of acid pollutants and stress the importance of further studies on their long-term impact on terrestrial invertebrates.
Keywords: sulfuric acid toxicity, oxidative stress, Helix pomatia, snail behavior, environmental impact

INVESTIGATION OF THE PARTICLE SWARM OPTIMIZATION METHOD IN MAXIMUM POWER POINT TRACKING OF PHOTOVOLTAIC SYSTEMS

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ABSTRACT

The advantages of renewable solar energy systems include ease of maintenance, fewer mechanical components, and access to an infinite, clean energy source. However, the high installation costs of solar energy systems and the reduction in efficiency under varying atmospheric conditions are notable disadvantages. To increase the efficiency of the energy produced by photovoltaic (PV) panels, Maximum Power Point Tracking (MPPT) must be implemented. In this study, a Maximum Power Point Tracking algorithm using the Particle Swarm Optimization (PSO) method was developed in MATLAB, and corresponding Simulink circuit models were created. Under constant temperature and varying irradiance levels, performance metrics such as rise time to the maximum power point, convergence speed, stability, power efficiency, and oscillation level at the maximum power point (MPP) were observed. The advantages and disadvantages of the PSO algorithm were identified. Additionally, the simulation results of the PSO method in MATLAB were analyzed graphically.

Keywards : Photovoltaic (PV), Maximum Power Point Track (MPPT), Maximum power point (MPP), Particle swarm optimization (PSO),

Introduction

With the increase in industrialization around the world, energy demand has also risen. Due to the potential depletion of fossil fuels in the near future and the harmful gases they emit, there is a growing need for clean energy sources. Because renewable energy sources are inexhaustible and clean, the demand for these resources is increasing. One of the main advantages of solar power plants is that they require little to no maintenance and the sun is an infinite source of energy. However, the still high costs and low efficiency of these systems are among their disadvantages. Thus, renewable energy sources have emerged as alternatives to conventional energy sources (Özgenç & Altaş, 2019).

Photovoltaic (PV) technologies used to generate electricity from photons coming from the sun are essentially used to harness solar energy and convert it into electrical energy through an electronic process (Sarah, 2020). Since the energy production of PV panels is not linear, changes in environmental conditions such as solar irradiance and temperature can affect

maximum power generation. However, due to changing atmospheric conditions, it is not always possible to obtain maximum power from PV panels. Therefore, many algorithms have been developed to track the Maximum Power Point (MPP).

Traditional methods such as fractional open-circuit voltage and short-circuit current cannot track the Maximum Power Point (MPP) under changing atmospheric conditions. These algorithms tend to oscillate around the MPP and have a long convergence time. Their efficiency decreases under varying atmospheric conditions. To track the MPP more effectively under such conditions, researchers have developed advanced algorithms (Yakubu et al., 2023a).

Conventional methods like Perturb and Observe and Incremental Conductance are widely used due to their simple structures. However, these methods result in greater energy losses (Abdullah et al., 2020).Advancements in microcontroller technologies have led to the emergence of more advanced methods such as fuzzy logic, particle swarm optimization, artificial neural networks, Adaptive Neuro-Fuzzy Inference Systems (ANFIS), hybrid models, ant-bee colony algorithms, and more.

As can be seen from the literature, various traditional MPP tracking (MPPT) techniques include:

- Fractional Open-Circuit Voltage (FOCV) (Sarvi & Azadian, 2021)
- Fractional Short-Circuit Current (FSCC) (Atri et al., 2020)
- Curve Fitting (CF) (Atri et al., 2020)
- Hill Climbing (HC) (Chtouki et al., 2018)

Incremental Conductance (IC) (Khosravi et al., 2017), and similar methods, have also been widely studied. The main disadvantage of FOCV (Fractional Open-Circuit Voltage) and FSCC (Fractional Short-Circuit Current) methods is their low accuracy; therefore, they are generally preferred in low-power applications. While popular techniques such as Perturb and Observe (P&O), Incremental Conductance (IC), and Curve Fitting (CF) perform well under constant irradiance conditions, they are not effective under variable irradiance and shading conditions.

Moreover, these methods suffer from several issues, including:

- Poor convergence
- High oscillation in steady-state
- Slow tracking of the Maximum Power Point (MPP) (Dahiya, 2018)

To achieve better steady-state performance and dynamic response, intelligence-based MPPT methods such as Artificial Neural Networks (ANN), Fuzzy Logic, and Adaptive Neuro-Fuzzy Inference Systems (ANFIS) are utilized (Kacimi et al., 2020; Kanimozhi & Rabi, 2016; Bataineh, 2019). Genetic Algorithms, combinations of Perturb and Observe with Incremental Conductance, Particle Swarm Optimization with Gravitational Search Algorithm, and many other algorithms have been proposed. However, each has a different level of complexity depending on the application area.

Effective implementation of these algorithms ensures accurate tracking of the maximum power point and enhances the efficiency of solar panels.(Hayder et al., 2022). Modern algorithms differ in terms of efficiency, circuit complexity, and convergence speed. To achieve better results, traditional methods can be combined with alternative approaches to track the Maximum Power Point (MPP) under varying conditions (Dagal et al., 2022; Ali et al., 2022; Gong et al., 2022). With these combinations, the performance of solar panels has been improved, erroneous responses within the model have been eliminated, and reliable performance has been ensured even under changing atmospheric conditions (Manna et al., 2022; Badoud et al., 2021).In the particle swarm optimization (PSO) algorithm used in our study, two example studies from the literature were examined regarding how these parameters are selected and how they vary depending on the application context. To reduce oscillations, a fixed and low inertia weight ($w = 0.4$) was selected, and the cognitive/social coefficients were set as $c_1 = 1.2$ and $c_2 = 1.6$, thereby achieving a balance between convergence and stable tracking performance (Chaieb &

Sakly, 2018). In system identification problems, inertia weight w was varied in the range [0.5, 0.8], $c_1 = c_2 = 2$, and the swarm size was examined between 20–60; overall, a moderately sized swarm (≈30 particles) and w ≈ 0.7 were shown to offer a balanced trade-off between search performance and computational cost (Lin & Xu, 2014). In this study, under constant temperature and varying irradiance levels, performance parameters such as convergence speed, stability, complexity, cost, and oscillation at the maximum power point were analyzed for Maximum Power Point Tracking (MPPT) using the Particle Swarm Optimization (PSO) algorithm in the MATLAB/Simulink environment.

In the selection of parameters for the PSO algorithm, the swarm size was kept small to reduce computational load. Keeping the inertia weight (w) low reduced the oscillation amplitude at the maximum power level and accelerated local search. For the selection of cognitive and social coefficients (c_1, c_2), choosing a smaller value for c_1 and a slightly larger value for c_2 improved the convergence speed in tracking the maximum power point and enhanced tracking stability. The selection of parameters in this manner demonstrated that the PSO algorithm is a more effective method for maximum power point tracking. Additionally, this method was analyzed in terms of factors such as cost and complexity, and the results obtained from Simulink outputs were evaluated and presented in tabular form.

2.Materials and Methods

2.1 Photovoltaic Cell Equivalent Circuit

Photovoltaic (PV) cells represent the main component of a PV power system, consisting of two or more doped silicon wafers. A single cell generates a relatively small amount of power, approximately one watt (Kenneth et al., 2014). This amount is insufficient to meet load requirements. Therefore, a group of solar cells is connected in series and parallel through a common bus to achieve the desired power level, forming what is called a PV module.

Moreover, multiple PV modules are arranged in series to form a string, increasing the voltage to the required level. To increase the output current, PV strings are connected in parallel to form a PV array. At night, the solar cell is inactive and behaves like a P-N junction diode (Mahdi et al., 2010). According to the Schottky diode equation, the single-diode model represents the simplest and most commonly used PV model (González et al., 2005). This model is used to describe the output characteristic curves. Figure 1 shows the single-diode PV cell model, which consists of a diode and current source connected in parallel, along with series resistances. The diode represents the behavior of the P–N junction of the cell; the series resistance accounts for internal losses within the cell and its adjacent cells; and the parallel resistance represents the effect of ground leakage current.

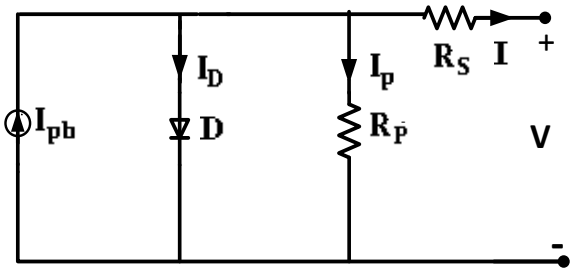


Figure1:

The single-diode equivalent circuit of the photovoltaic panel

The output current I is expressed as follows..(prakash, and Singh.,2016)

$$I = I_{ph} - I_d - I_p \quad (1)$$

The structural diode current IdI_dId of the PV cell is given in Equation 3.

$$I_d = I_0 \left[e^{\left(\frac{q(V_{pv}+IR_s)}{aKT} \right)} - 1 \right] \quad (3)$$

The current flowing through the parallel resistance in the equivalent circuit of the PV cell is expressed in Equation 4 as follows:

$$I_p = \frac{V + IR_S}{R_P} \quad (4)$$

Iph is the photocurrent generated when the photovoltaic (PV) cell is exposed to sunlight. The photocurrent varies linearly with solar irradiance at a given temperature. IdI_dId is the current of the reverse-biased diode connected in parallel and introduces a nonlinear response in the PV cell. The current flowing through the shunt resistance is denoted by Ish. By substituting the expressions for Ish and Id into Equation 1, the PV current is derived in Equation 5 (Prakash & Singh, 2016; Tsai et al., 2008).

$$I = I_{ph} - I_0 \left[e^{\left(\frac{q(V_{pv}+IR_s)}{aKT} \right)} - 1 \right] - \frac{V + IR_s}{R_P} \quad (5)$$

To increase the electricity generation capacity of solar PV systems, solar cells are connected in combinations of series and parallel. If NpN_pNp represents the number of cells connected in parallel and Ns represents the number of cells connected in series, the relationship between output current and voltage is expressed as follows (Prakash & Singh, 2016; Chenni et al., 2007):

$$I = N_P I_{Ph} - N_P I_0 \left(e^{\frac{q\left(\frac{V_{pv}}{N_S} + \frac{IR_S}{N_P}\right)}{akT}} - 1 \right) - \frac{V_{pv}\left(\frac{N_P}{N_S}\right) + IR_S}{R_P} \quad (6)$$

Here, q is the electron charge, k is the Boltzmann constant (1.38 × 10−23 J/K), and T is the temperature of the p-n junction. Iph is the photo-generated current, I0 is the saturation current, Id is the diode current, qqq is the electron charge (1.6 × 10−19C), Vpv is the output voltage of the PV module, Rs is the series resistance, Rp is the parallel resistance, aaa is the diode ideality factor, and K is the Boltzmann constant (1.38 × 10−23 J/K).

2.3.DC–DCBoostConverter

PV panels generate maximum power under normal climatic conditions. However, when environmental conditions change, fluctuations in irradiance and temperature cause the power output of the panels to deviate from the maximum power point. To track the maximum power point, DC–DC converters have been developed. The basic principle of MPPT is to extract the maximum possible power from the sun and supply the load through a DC-to-DC converter that steps the current and voltage up or down to the desired level (Gosumbonggot et al., 2018). In this study, a boost-type DC–DC converter was used to track the maximum power point. The block diagram of the PV panel and MPPT system is shown in Figure 2.

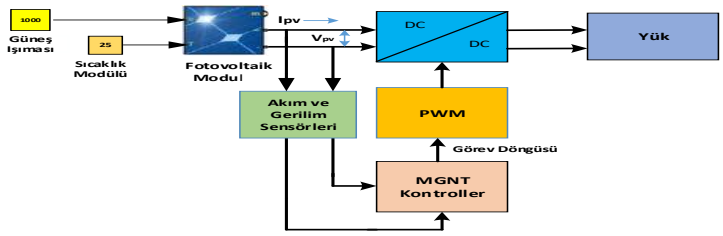


Figure 2:

MGNT' li PV Sisteminin Blok Şeması

The circuit diagram of the boost-type DC–DC converter used in the system is shown in Figure 3. The converter consists of boost circuit components including an IGBT as the switching element, a diode, an inductor, a capacitor, and a resistive load. The duty cycle, expressed in the equation below, is a function of the input. The relationship between the input voltage and the converter output voltage is given as follows:

$$V_{0ut} = \frac{V_{in}}{(1-D)} \qquad (7)$$

Vout is the output voltage, Vin is the input voltage, and D is the duty cycle of the converter. To boost the output voltage, the value of D must be less than 1.

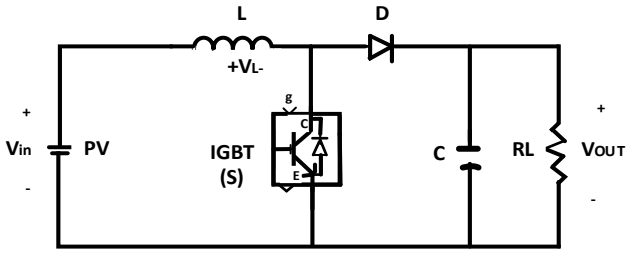


Figure 3:

The circuit diagram of the boost DC-DC converter

2.5. Particle Swarm Optimization (PSO) Algorithm

A simple technique used for solving nonlinear optimization problems is Particle Swarm Optimization (PSO). It is inspired by the behavior of bird flocks, fish schools, or the interaction of bees searching for food. The PSO algorithm has been developed and widely used in various fields of science and engineering for optimization and application design. Generally speaking, PSO operates based on two main principles: one is learning from historical data, and the other is transmitting current information among swarm agents (Gavhane et al., 2017).

PSO technology involves a number of particles. In this technique, each particle proposes a solution to find the optimal one by updating its data obtained during the exploration process. These particles move around the search space based on a simple mathematical relationship (Sarvi et al., 2015). The main objective of PSO is to track the Maximum Power Point (MPP) and adjust the duty cycle of the DC-DC converter to obtain the maximum power permitted by the load. A photovoltaic (PV) system inherently has a maximum power point. However, under partial shading conditions, the system may have multiple power points, and the desired operation is to find the Global Maximum Power Point (GMPP). The PSO algorithm initializes the particles in terms of iterations, duty cycle ranges, and weights. Based on the initial particle, the algorithm calculates the required duty cycle to drive the DC-DC converter by measuring the resulting PV voltage, current, and power.

If the resulting power (fitness) is better for an individual particle, the duty cycle is updated as the best position. These operations are repeated for all particles until the GMPP is reached (Saad et al., 2021). This situation will be demonstrated in the simulation results. Figure 4 shows the PSO flowchart for tracking the MPP. The parameter values used in the particle swarm

optimization algorithm are presented in Table 1. The position and velocity of the particles are updated according to equations (7) and (8).

In this study, the particle swarm position is taken as the duty cycle, and the fitness function is the output power of the PV system. The particle position di is updated using the following equations (Rezk et al., 2017).

$$d_i^{k+1} = d_i^k + v_i^{k+1} \quad (8)$$

v_i is the step size in the (k+1) iteration

$$v_i^{k+1} = wv_i^k + c_1 r_1 \left(P_{best} - d_i^k\right) + c_2 r_2 \left(G_{best} - d_i^k\right) \quad (9)$$

r_1 and r_2: Random values in the range [0, 1];

w: Inertia weight;

c_1 and c_2: Acceleration coefficients;

G_best: The best position in the entire population;

P_best: The best position of the particle;

In PSO-based MPPT (Maximum Power Point Tracking) applications in PV systems, one of the most critical design decisions is the selection and tuning of PSO parameters such as swarm size, inertia weight (w), and individual/social cognitive coefficients (c_1, c_2). These parameters directly affect the algorithm's local and global search capabilities, convergence speed, oscillation magnitude, stability, and computational burden of the application.

When selecting parameters, reducing the swarm size lowers the computational load and accelerates local search but may limit global search capability. A larger inertia weight (w) supports global exploration but increases oscillations, while a smaller w enhances local search and reduces oscillation. The coefficients c_1 and c_2 determine the influence of individual and collective learning, respectively, defining the extent to which particles are influenced by their own best experience and the best experience of the swarm.

In this study, the swarm size was kept small in order to reduce the computational load during parameter selection. A smaller inertia weight (w) helps accelerate local search by reducing the oscillation amplitude around the maximum power level. Setting a lower value for the cognitive coefficient (c_1) and a slightly higher value for the social coefficient (c_2) improves the convergence speed in locating the maximum power point and enhances the tracking stability. The detailed values of each selected parameter are presented in Table 1.

Table 1. Particle Swarm Optimization Algorithm Parameters and Their Values

PSO Parameters	Symbols	Values
Particle Swarm Size	N	4
Number of Iterations	Counter	300
Maximum Duty Cycle	$\mathbf{D_{max}}$	0.9
Minimum Duty Cycle	$\mathbf{D_{min}}$	0.1
Inertia Coefficient	W	0.4
Cognitive Coefficient	$\mathbf{C_1}$	1.2
Social Coefficient	$\mathbf{C_2}$	2.0

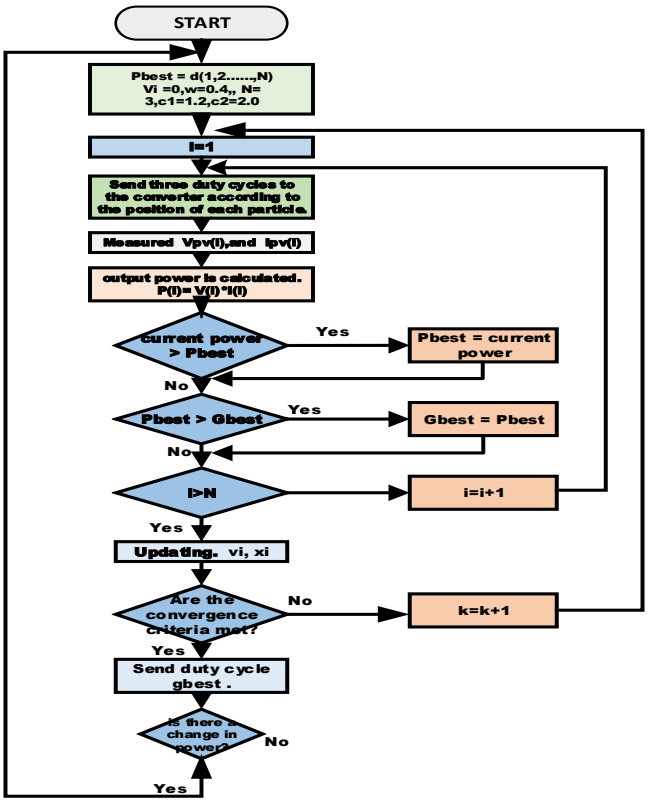


Figure 4. Flow chart of the PSO algorithm

3. SIMULATION IMPLEMENTATION AND RESULTS

3.1. Matlab Simulink Circuit Model

In this study, Matlab/Simulink was used to evaluate data such as the rise time, stability, robustness, and convergence speed of the proposed system. A single PV panel was used in the simulation environment. The specifications of the parameters belonging to the PV panel are shown in Table 2.

Table 2. Parameters and Magnitude Values of the PV Panel

PV Panel Parameters	Symbols	Magnitude Values
Maximum Power	P_{mak}	219.876 W
Open-circuit voltage	V_{oc}	36.06 V
Short-circuit current	I_{sc}	7.95 A
Maxiimum power point voltag e	V_{mp}	30.12 V
Maximum power point current	Imp	7.3 A

The boost DC-DC converter circuit and the particle swarm optimization algorithm were designed in the Matlab environment. The S-function was used in the particle swarm optimization algorithm. The PSO method was examined under varying irradiation conditions. The Matlab Simulink circuit model design of the PSO algorithm for the PV system is shown in Figure 5.

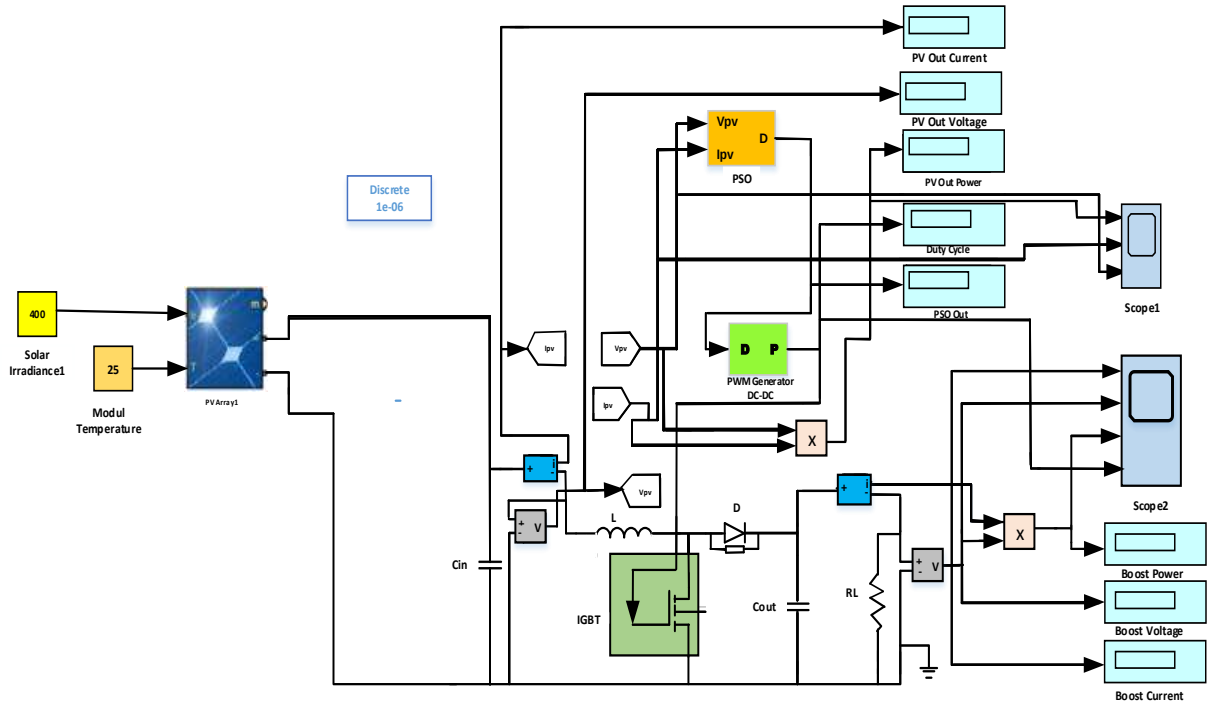


Figure 5:
PSO Matlab/Simulink Circuit Equivalent Diagram

For the PSO method, the output current, voltage, and power graphs under constant temperature of 25°C and varying irradiation conditions of 400 W/m², 600 W/m², 800 W/m², and 1000 W/m² are shown in Figure 6 (a), (b), (c), and (d).

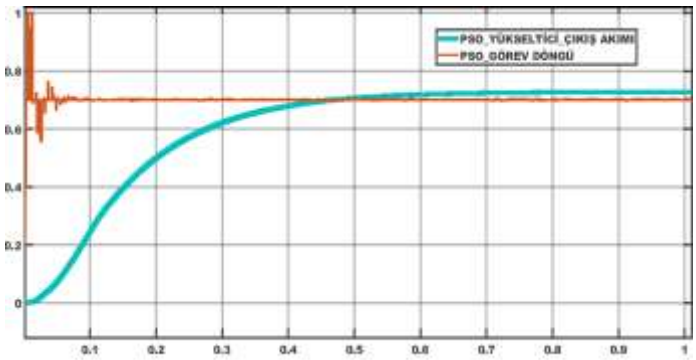
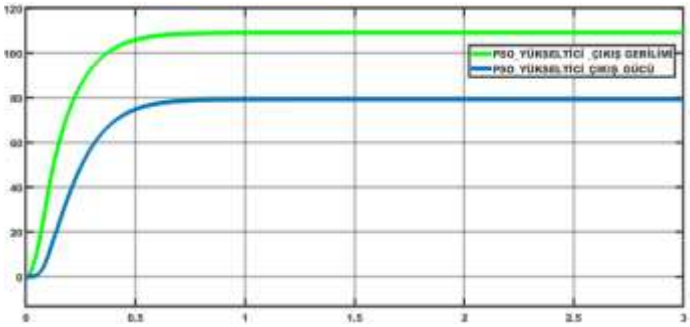
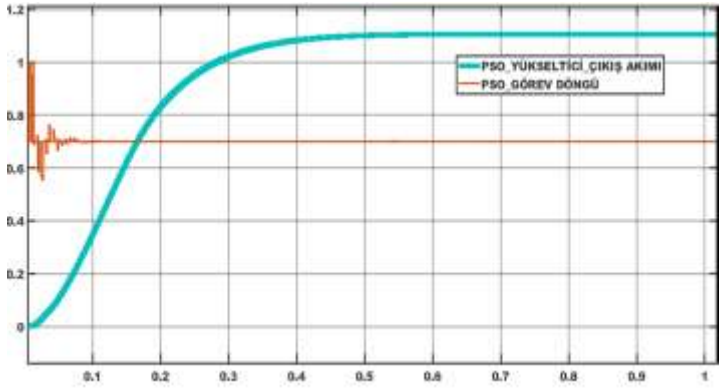


Figure 6:
a. Boost converter output current and duty cycle ratio graph at 400 W/m² irradiation using PSO



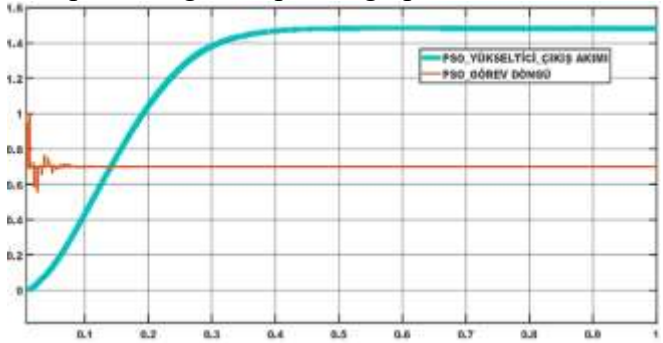
b. Boost converter output voltage and power graph at 400 W/m² irradiation using PSO



c. Boost converter output current and duty cycle ratio graph at 600 W/m² irradiation using PSO



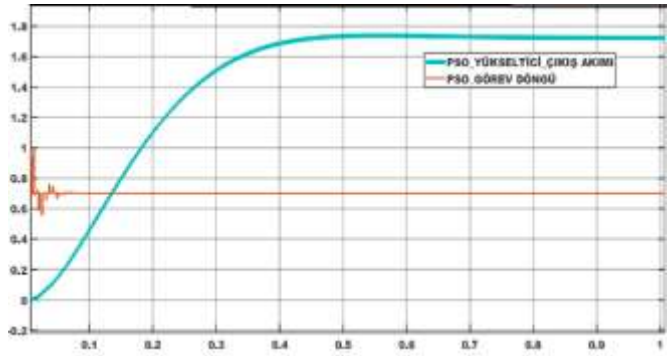
d. Boost converter output voltage and power graph at600 W/m² irradiation using PSO



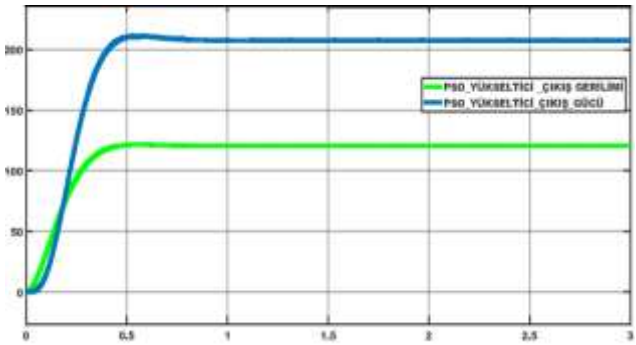
e. Boost converter output current and duty cycle ratio graph at 800 W/m² irradiation using PSO



f. Boost converter output voltage and power graph at 800 W/m² irradiation using PSO



g. Boost converter output current and duty cycle ratio graph at 1000 W/m² irradiation using PSO



g. Boost converter output current and duty cycle ratio graph at 1000 W/m² irradiation using PSO

Under both methods, at a constant temperature of 25°C and varying irradiation levels of 400 W/m², 600 W/m², 800 W/m², and 1000 W/m², the Matlab simulation results demonstrate that PSO reaches the maximum power point more quickly and has superior efficiency compared to the other method. PSO shows no oscillation around the maximum point and is able to track the maximum power point in a stable manner.

When the irradiation is 400 W/m², PSO achieves an efficiency of 95.02% with a rise time of 0.738 seconds. At 600 W/m², the efficiency is 96.69% with a rise time of 0.525 seconds. At an irradiation level of 800 W/m², PSO reaches 96.99% efficiency and a rise time of 0.561 seconds. When the irradiation level is 1000 W/m², the efficiency is 96.14% with a rise time of 0.555 seconds.As can be seen from the analysis of these simulation results, PSO demonstrates superior performance. The PSO method has been analyzed in terms of variables such as rise time, convergence speed, efficiency, stability, and settling time. When evaluated based on these parameters, it is evident that the PSO method is superior. The data related to this method are presented in Table 3.

Table 3. Measured Values of PSO and P&O in Matlab Simulink

Temp Const	irriadinece (w/m2)	Method	Power (Watt)	Verim %	Voltage (Vollt)	Current (Amp)	Time (sn)
25 °C	**400**	**PSO**	82.3	95.02	118.2	0.695	0.738
	600	**PSO**	126.7	96.69	118	1.073	0.525
	800	**PSO**	170	96.99	116.6	1.483	0.561
	1000	**PSO**	211.4	96.14	121.6	1.733	0.555

CONCLUSION

This study presents an analysis of the simulation results regarding the performance of a PV system using the PSO algorithm technique, specifically in terms of MPPT tracking efficiency, convergence speed, stability, and the level of oscillation around the maximum power point.
Evaluating the data in Table 3, the simulation results show that the PSO method is capable of accurately tracking the MPP under constant temperature and varying irradiation conditions. It offers better advantages such as higher tracking efficiency and faster convergence to the desired solution.However, a disadvantage of the PSO algorithm is its high computational load, which requires more powerful microcontrollers and larger memory capacity. This increases cost and contributes to more complex control loop coding and system complexity.
The selection of PSO parameters has a significant impact on optimization performance. Based on the analysis of the data in Table 3, PSO demonstrates superior performance in terms of efficiency, rise time, and convergence speed. Under changing environmental conditions, the PSO algorithm can effectively track the MPP without causing oscillations around the maximum power level.Despite its complexity and implementation challenges, the PSO algorithm maintains stable operation around the maximum power point without oscillations.

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COMPARATIVE REVIEW OF THE ROLES OF NATURAL POZZOLANA, BARIUM COMPOUNDS, SODIUM SILICATE, AND POLYPROPYLENE FIBERS IN MITIGATING SULFATE-INDUCED DISTRESS IN LIME-STABILIZED SOILS

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Abstract: Sulfate-bearing clay soils pose a serious challenge in geotechnical engineering due to the formation of expansive ettringite ($C_6A\hat{S}_3H_{32}$) when treated with calcium-based stabilizers in sulfate-rich environments. This review synthesizes current advances in hybrid stabilization techniques that combine lime (CaO), natural pozzolana (rich in amorphous silica (SiO_2), sodium silicate (Na_2SiO_3), barium compounds ($BaCO_3$, $BaCl_2$, $Ba(OH)_2$), and polypropylene fibers (PF). These components act synergistically to enhance soil stability and durability through a range of chemical and physical mechanisms. Lime hydration initiates the stabilization process [Eq. (1): $CaO + H_2O \rightarrow Ca(OH)_2$]. This high pH environment promotes dissolution of reactive aluminosilicates in the soil, triggering pozzolanic reactions that yield cementitious products [Eq. (2): $SiO_2 + Ca(OH)_2 + H_2O \rightarrow C–S–H$], and [Eq. (3): $Al_2O_3 + Ca(OH)_2 + H_2O \rightarrow C–A–H$]. Sulfate sources such as gypsum ($CaSO_4 \cdot 2H_2O$) and thenardite (Na_2SO_4) dissolve to release sulfate ions [Eq. (4): $Na_2SO_4 \rightarrow 2Na^+ + SO_4^{2-}$], and Eq. (5): $CaSO_4 \cdot 2H_2O \rightarrow Ca^{2+} + SO_4^{2-} + 2H_2O$]. These can react with calcium and aluminate species to form ettringite [Eq. (6): $3Ca^{2+} + 2Al(OH)_4^- + 3SO_4^{2-} + 32H_2O \rightarrow C_6A\hat{S}_3H_{32}$]. To mitigate this expansive mineral, barium additives act by immobilizing sulfate [Eq. (7): $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4 \downarrow$], [Eq. (8): $Ba(OH)_2 \rightarrow Ba^{2+} + 2OH^-$], [Eq. (9): $BaCl_2 \rightarrow Ba^{2+} + 2Cl^-$], and [Eq. (10): $BaCO_3 + H_2O + CO_2 \rightarrow Ba^{2+} + CO_3^{2-} + H_2O$]. Sodium silicate enhances the matrix through multiple reactions [Eq. (11): $Na_2SiO_3 + H_2O \rightarrow SiO_2 + 2NaOH$], and [Eq. (12): $SiO_2 + Ca(OH)_2 + H_2O \rightarrow C–S–H$]. The generated NaOH further increases pH, supporting clay dissolution and accelerating cementitious gel formation, which densifies the soil and limits sulfate transport. Though chemically inert, polypropylene fibers (PF) serve a mechanical function by bridging micro-cracks, enhancing post-peak strength, and resisting deformation caused by swelling. Studies by Gadouri et al. confirm that these multi-component systems significantly reduce swelling and improve strength and durability in sulfate-rich soils. Overall, this review highlights the effectiveness of combining pozzolanic, ion-exchange, and mechanical strategies to suppress ettringite formation, strengthen soil matrices, and ensure long-term performance. The formulation presents a promising, sustainable approach for the stabilization of problematic sulfate-bearing clays in infrastructure development.

Keywords: Lime stabilization, Natural pozzolana, Sulfate-bearing clays, Ettringite formation, Barium, Sodium silicate, Polypropylene fibers, C–S–H/C–A–H formation, Expansive soils, Hybrid soil stabilization

WOMEN IN POWER: POLITICAL PARTICIPATION AND EMPOWERMENT DURING THE ABBASID CALIPHATE

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Abstract
The Islamic golden age of thinking, culture, and government was during the Abbasid Caliphate (750–1258 CE). At this time, creative thinking, different legal schools, and mixed cultures appeared, while women's contributions to politics and society were extremely valuable. In the Abbasid court, caliph mothers, Queen Zubaydah, and female concubines were engaged in giving political advice, political activities, supporting scholars, and looking after the poor. They weren't only obscured behind the scenes, but some of these women had a major influence on government decisions, successors, and reforms.
Abbasid period women were analyzed to confirm that they took part in politics, society, and culture and truly played important roles in power centres. In conclusion, this research establishes that women were politically empowered in the Abbasid Caliphate, and this fact can show the potential for women in leadership today.
Keywords: Islamic golden age, Abbasid Caliphate, Queen Zubaydah

EMPOWERMENT AND PARTICIPATION: WOMEN IN EARLY ISLAMIC PUBLIC ADMINISTRATION

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Abstract
The study looks at how women were empowered in the Islamic government and administration when Islam began. The roles of women are now highlighted in Islamic history, so that it is obvious that women in Islam played an active part in public and governmental matters. Various historical cases, Islamic laws, and proofs from scholars show that women were given more influence in social, legal, and administrative areas at the beginning of the Islamic era. This study is aimed at removing common misunderstandings about women's involvement in Muslim societies nowadays so that more people can understand their leadership and roles from the Islamic viewpoint.
Keywords: Women, Society, Islamic laws, Leadership

GENDER DIFFERENCES IN THE CO-OCCURRENCE OF CELIAC DISEASE AND AUTOIMMUNE THYROIDITIS

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Abstract:
Celiac disease (CD) and autoimmune thyroiditis (AT), two prevalent autoimmune disorders, often coexist due to shared genetic and immunological mechanisms. Notably, both conditions display a marked female predominance, raising critical questions about the influence of gender on disease onset, progression, and clinical outcomes. This paper explores the gender-specific patterns observed in the co-occurrence of CD and autoimmune thyroiditis, particularly focusing on Hashimoto's thyroiditis and, to a lesser extent, Graves' disease.
We delve into the multifactorial reasons behind the heightened prevalence in females, examining hormonal influences such as estrogen's role in modulating immune responses and enhancing susceptibility to autoimmunity. The interaction between sex hormones and cytokine expression is discussed, shedding light on how these biological differences may contribute to a higher autoimmune burden in women. Additionally, genetic predispositions, including X-chromosome-linked immune regulatory genes, are explored as possible contributors.
Clinical data suggest that females with celiac disease are more likely to develop autoimmune thyroiditis compared to males and may present with more pronounced thyroid dysfunction, including subclinical or overt hypothyroidism. Moreover, diagnosis in women is often delayed due to overlapping or atypical symptoms, leading to prolonged exposure to untreated inflammation, nutritional deficiencies, and hormonal imbalance.
This paper advocates for gender-sensitive diagnostic strategies and management approaches, emphasizing the importance of early screening for thyroid dysfunction in female CD patients. Addressing these gender disparities is critical not only for personalized care but also for improving long-term health outcomes in this high-risk group. The findings underscore the need for increased awareness among clinicians about the gendered expression of autoimmune diseases and call for further research into sex-based immune modulation.

Keywords:
- Celiac Disease
- Autoimmune Thyroiditis
- Gender Differences
- Female Predominance
- Hashimoto's Thyroiditis
- Estrogen and Immunity
- Sex Hormones
- Autoimmunity
- Hormonal Influence
- Gender-Specific Screening

Introduction

Autoimmune diseases represent a growing health concern globally, affecting an estimated 5–10% of the population, with a marked tendency to cluster both within individuals and across families. This pattern points to a shared pathophysiological basis driven by genetic predisposition, environmental triggers, and immune system dysregulation. Among the most prevalent autoimmune conditions, celiac disease (CD) and autoimmune thyroiditis (AT)—particularly Hashimoto's thyroiditis and to a lesser extent Graves' disease—exhibit a well-documented co-occurrence. Celiac disease is a chronic, immune-mediated enteropathy precipitated by gluten consumption in genetically susceptible individuals, characterized by intestinal inflammation, villous atrophy, and nutrient malabsorption. Autoimmune thyroiditis involves an immune attack on thyroid tissue, leading to progressive thyroid dysfunction, most commonly hypothyroidism in the case of Hashimoto's thyroiditis.

What is particularly striking about both disorders is their disproportionate prevalence in females, suggesting that sex-based biological, hormonal, and genetic factors contribute to heightened susceptibility in women. Epidemiological studies consistently show that women are two to ten times more likely than men to be affected by autoimmune conditions, and this gender bias becomes even more pronounced when two autoimmune diseases coexist. The clinical implications of this co-occurrence are significant—ranging from atypical symptom presentation to diagnostic delays, overlapping nutritional and hormonal imbalances, and a compounded disease burden. In this context, investigating the gender-specific patterns of co-occurrence, progression, and outcomes in CD and AT is not only timely but also vital for the development of personalized, gender-responsive diagnostic and therapeutic strategies. A nuanced understanding of how gender influences immune function and autoimmune disease expression is essential to bridge existing gaps in care and improve long-term outcomes for affected individuals—especially women, who remain the most vulnerable yet often underdiagnosed subgroup.

2. Shared Pathophysiology of CD and AT

A growing body of evidence supports the notion that celiac disease (CD) and autoimmune thyroiditis (AT) share a common immunological and genetic foundation, which helps explain their frequent co-occurrence. Genetically, both conditions are strongly associated with human leukocyte antigen (HLA) class II molecules, particularly HLA-DQ2 and HLA-DQ8. These molecules play a critical role in antigen presentation and immune regulation, and their presence significantly increases susceptibility to both CD and AT. In fact, up to 95% of individuals with CD express HLA-DQ2, while a substantial proportion of patients with autoimmune thyroid diseases also carry these alleles, indicating a shared genetic predisposition.

From an immunological standpoint, dysregulated T-cell responses are central to the pathogenesis of both disorders. In CD, ingestion of gluten leads to the activation of CD4+ T cells in the small intestinal mucosa, promoting the release of pro-inflammatory cytokines such as interferon-gamma (IFN-γ) and interleukin-15 (IL-15), which drive villous atrophy and tissue damage. Similarly, in AT—especially Hashimoto's thyroiditis—autoreactive T lymphocytes infiltrate the thyroid gland, initiating a chronic inflammatory response that ultimately impairs thyroid function. Autoantibodies are another hallmark feature in both diseases: anti-tissue transglutaminase (anti-tTG) and anti-endomysial antibodies (EMA) in CD, and anti-thyroid peroxidase (anti-TPO) and anti-thyroglobulin antibodies in AT serve as diagnostic and mechanistic indicators of immune-mediated tissue destruction.

An additional layer of pathophysiological overlap lies in intestinal permeability and molecular mimicry. In individuals with CD, chronic inflammation and gluten-induced mucosal damage increase the permeability of the intestinal barrier—a phenomenon often referred to as "leaky gut." This allows luminal antigens and microbial products to translocate into systemic circulation, potentially triggering autoimmune responses in distant organs, including the

thyroid gland. Moreover, molecular mimicry, in which structural similarities between gluten-derived peptides and self-antigens lead to cross-reactive immune responses, is thought to contribute to the initiation and perpetuation of thyroid autoimmunity in CD patients.

Together, these interconnected mechanisms—shared genetics, immune dysregulation, heightened gut permeability, and molecular mimicry—create a biologically plausible basis for the co-occurrence of CD and AT. Importantly, these same pathways may be differentially influenced by sex hormones and X-linked immune genes, helping to explain the gender differences observed in the prevalence, severity, and timing of these autoimmune diseases. Understanding this shared pathophysiology is essential for developing integrated, gender-sensitive screening and treatment approaches.

3. Gender Disparities in Autoimmune Disease Prevalence

Autoimmune diseases are among the most gender-biased health conditions, with a consistent and marked predominance in females. Epidemiological studies reveal that women account for nearly 80% of all autoimmune disease diagnoses, with female-to-male ratios ranging from 2:1 to as high as 10:1, depending on the specific disorder. This disparity is particularly pronounced in the context of celiac disease (CD) and autoimmune thyroiditis (AT). While CD affects approximately 1% of the global population, women are 2 to 3 times more likely to be diagnosed than men. In the case of Hashimoto's thyroiditis, the skew is even more dramatic, with a female-to-male ratio of roughly 10:1, making it one of the most female-predominant autoimmune diseases known.

The biological basis for these gender disparities is multifactorial, involving a complex interplay of hormonal, genetic, and epigenetic influences that collectively enhance immune responsiveness in females. Estrogen, the primary female sex hormone, has been shown to amplify humoral immunity by promoting B-cell activation and antibody production, thereby increasing the likelihood of autoimmune responses. Estrogen also modulates cytokine expression, often shifting the immune response toward a Th2-dominant profile, which is associated with many antibody-mediated autoimmune diseases. In contrast, testosterone—the predominant male hormone—tends to exert an immunosuppressive effect, which may partially explain the lower prevalence of autoimmunity in males.

In addition to hormonal factors, genetic influences, particularly those linked to the X chromosome, play a substantial role. The X chromosome harbors numerous immune-related genes, such as those involved in T-cell regulation and cytokine signaling. Females possess two X chromosomes, and incomplete X-inactivation or skewed inactivation patterns may result in overexpression of these immune-regulatory genes, contributing to heightened autoimmunity risk. Epigenetic modifications, including DNA methylation and histone acetylation, which differ by sex and hormonal milieu, further shape immune system behavior in a gender-specific manner.

These biological differences not only influence disease susceptibility but may also impact clinical presentation, disease severity, and treatment response, making it imperative to recognize gender as a critical factor in the pathophysiology and management of autoimmune diseases. In the context of co-occurring CD and AT, this gender bias underscores the importance of proactive screening, earlier intervention, and personalized care strategies for women, who are both disproportionately affected and at greater risk for diagnostic delay.

Table 1: Gender-Based Differences in Prevalence and Factors in CD and AT

Aspect	Females	Males
Prevalence of CD	2–3 times more likely to be diagnosed	Less frequently diagnosed; often under-recognized
Prevalence of AT (Hashimoto's)	~10:1 female-to-male ratio	Rare; often presents later with milder symptoms
Hormonal Influence	Estrogen enhances immune activation and antibody production	Testosterone tends to suppress immune response
Genetic Factors	Two X chromosomes → increased risk via X-linked immune genes	Single X chromosome; lower expression of immune genes
Immune Reactivity	Stronger humoral response; more autoantibodies	Weaker adaptive immune response
Disease Presentation	More symptomatic; includes fatigue, anemia, menstrual issues	Often asymptomatic or subclinical
Risk of Multiple Autoimmune Disorders	Higher; often coexist with other autoimmune diseases	Lower risk of polyautoimmunity

4. Hormonal Influences and Immune Modulation

Sex hormones, particularly estrogen, play a pivotal role in modulating immune responses and are a key factor in the heightened prevalence of autoimmune diseases among females. Estrogen exerts profound immunomodulatory effects, often enhancing immune activity in ways that can predispose women to autoimmunity. It has been shown to stimulate B-cell activation and antibody production, which are central mechanisms in the pathogenesis of both celiac disease (CD) and autoimmune thyroiditis (AT). Elevated estrogen levels also promote the expression of pro-inflammatory cytokines, such as interleukin-6 (IL-6) and interferon-gamma (IFN-γ), which drive chronic inflammation and tissue-specific autoimmunity. Furthermore, estrogen influences thymic selection, a process crucial for eliminating autoreactive T cells. Alterations in this process may impair immune tolerance, allowing self-reactive lymphocytes to persist and attack host tissues.

In the context of CD, estrogen may interact with the gut mucosa and intestinal barrier function, influencing intestinal permeability and potentially facilitating the translocation of gluten peptides and microbial antigens into systemic circulation. This "leaky gut" phenomenon can trigger systemic immune activation, including the development of thyroid-directed autoimmunity. Hormonal fluctuations during key life stages—such as puberty, pregnancy, postpartum, and menopause—further underscore the role of hormones in modulating disease activity. For instance, pregnancy is often associated with a temporary suppression of autoimmune symptoms due to immunotolerance mechanisms, while the postpartum period

may trigger disease flare-ups. Similarly, menopause, characterized by a decline in estrogen levels, can alter immune homeostasis and exacerbate autoimmune conditions.

These patterns suggest a hormone-driven modulation of immune tolerance and disease progression, which is especially relevant in understanding why autoimmune diseases like CD and AT are more prevalent and often more severe in women. Recognizing the impact of sex hormones on immune regulation is therefore crucial for tailoring gender-specific diagnostic and therapeutic strategies.

Table 2: Hormonal Effects on Immune Modulation in Autoimmunity

Hormonal Factor	**Mechanism**	**Impact on Autoimmunity**	**Relevance to CD & AT**
Estrogen	Enhances B-cell activation and antibody production	Increases autoantibody-mediated responses	Promotes anti-tTG (CD) and anti-TPO (AT) antibody formation
	Upregulates cytokines (e.g., IL-6, IFN-γ)	Drives inflammation and tissue-specific immune responses	Contributes to villous atrophy (CD) and thyroid tissue damage (AT)
	Modifies thymic selection	Alters central immune tolerance; autoreactive T cells may escape	Leads to heightened risk of multiple autoimmunities
	Affects gut mucosa and permeability	Facilitates antigen translocation and immune activation	May trigger thyroid autoimmunity in CD patients
Hormonal Fluctuations	Puberty, pregnancy, postpartum, menopause alter estrogen levels	May cause disease onset, remission, or flare-ups	Fluctuations influence CD and AT symptom severity
Progesterone (secondary)	Generally immunosuppressive; shifts response to Th2 dominance	May balance estrogen's pro-inflammatory effects	Role less clear, but may contribute to pregnancy-related changes

5. Genetic and X-Linked Factors

Genetic factors—particularly those linked to the X chromosome—play a critical role in the observed gender disparity in autoimmune diseases such as celiac disease (CD) and autoimmune thyroiditis (AT). Women possess two X chromosomes, each of which carries a significant number of immune-related genes involved in T-cell regulation, cytokine signaling, and antigen presentation. To maintain genetic balance, one X chromosome in females is normally inactivated through a process called X-inactivation. However, this process is not always random or complete. Skewed X-inactivation—where one X chromosome is preferentially silenced—can result in the overexpression of immune-regulating genes, thereby increasing susceptibility to autoimmunity.

In addition, several X-linked genetic polymorphisms have been identified in genes that regulate immune homeostasis. Notable among these are FOXP3 (a transcription factor crucial for regulatory T-cell function), IRAK1 (involved in Toll-like receptor signaling), and TLR7 (which promotes type I interferon production). Variations in these genes can lead to enhanced immune activation and breakdown of self-tolerance, both of which are fundamental to the development of autoimmune diseases. These polymorphisms are more likely to be expressed or doubly expressed in females due to their dual X chromosome makeup, thus compounding the risk.

Another emerging area of interest is microchimerism, a phenomenon where fetal cells from pregnancy persist in the maternal circulation and tissues for decades. While microchimerism may contribute to immune tolerance in some contexts, it is also hypothesized to act as a chronic immune stimulant in others, possibly triggering autoimmune responses. This could partly explain why many women develop or experience exacerbations of autoimmune diseases like CD and AT in the postpartum period or later in life.

Taken together, these genetic and epigenetic mechanisms—including X-chromosome-linked polymorphisms, skewed inactivation, and microchimerism—work in tandem with hormonal influences to create a heightened state of immune vigilance in females. While this may offer protective benefits against infections, it also increases the risk of autoimmune pathologies. Understanding these mechanisms is essential for developing gender-informed diagnostic and therapeutic interventions that address the unique immunogenetic landscape of women.

6. Clinical Presentation and Diagnostic Delays in Females

The clinical manifestation of coexisting celiac disease (CD) and autoimmune thyroiditis (AT) in females is often complex, subtle, and easily misinterpreted—contributing significantly to delayed diagnosis and under-treatment. Women with CD are more likely than men to develop autoimmune thyroid disorders, especially Hashimoto's thyroiditis, which may initially present with subclinical or overt hypothyroidism. However, the symptoms that women report—such as chronic fatigue, mood disturbances (including anxiety and depression), hair thinning, menstrual irregularities, bloating, or unexplained weight changes—are frequently dismissed or attributed to lifestyle stressors, hormonal fluctuations, or gynecological issues. Moreover, malabsorption syndromes, which are hallmarks of untreated CD, can lead to iron-deficiency anemia, vitamin D deficiency, and other micronutrient imbalances, further mimicking or masking the symptoms of thyroid dysfunction.

This overlap of non-specific and multisystemic symptoms not only complicates the diagnostic process but also often delays appropriate testing and referral to specialists. In many cases, gastrointestinal symptoms may be mild or absent in females with CD, leading to a missed diagnosis until advanced complications, such as osteoporosis, infertility, or persistent metabolic disturbances, begin to emerge. The delay in recognizing and managing this dual autoimmune burden allows chronic inflammation to persist unchecked, causing progressive tissue damage, worsened nutritional status, and a decline in overall health-related quality of life.

Importantly, this delay is not merely clinical—it is also systemic, reflecting long-standing gender biases in healthcare where women's symptoms are more likely to be downplayed, misattributed, or inadequately investigated. As a result, many women endure prolonged suffering and undergo multiple consultations before receiving a definitive diagnosis. Addressing this issue requires not only clinical vigilance and interdisciplinary awareness but also the implementation of gender-sensitive screening protocols, particularly for women presenting with unexplained hypothyroidism, fatigue, or reproductive concerns. Earlier recognition and management of coexisting CD and AT could significantly reduce long-term complications and improve outcomes in this high-risk female population.

Clinical Implications and Recommendations

- The co-occurrence of celiac disease (CD) and autoimmune thyroiditis (AT), particularly in women, presents a compelling case for proactive, gender-sensitive clinical intervention. Given the high likelihood of one condition predisposing to the other, especially among female patients, routine thyroid screening—including thyroid-stimulating hormone (TSH)levels and anti-thyroid peroxidase (TPO) antibodies—should be standard practice in newly diagnosed CD patients. Early detection of thyroid dysfunction, even in its subclinical stages, can prevent progression to overt hypothyroidism and reduce the risk of associated complications like infertility, depression, and osteoporosis.
- Beyond isolated testing, there is a pressing need for integrative diagnostic approaches that draw on expertise from gastroenterology, endocrinology, and gynecology. Women presenting with menstrual irregularities, chronic fatigue, anemia, or mood disturbances should be evaluated for potential underlying autoimmune disorders, especially when standard explanations are insufficient. A holistic assessment that considers gastrointestinal health, endocrine function, and reproductive status can unmask latent co-morbidities and lead to more accurate, timely diagnoses.
- Effective management also requires gender-sensitive treatment strategies. In women, this means not only addressing the autoimmune condition itself but also monitoring hormonal fluctuations, optimizing micronutrient levels, and considering the interplay between diet, endocrine health, and reproductive function. For instance, iron and vitamin D supplementation, gluten-free diet adherence, and thyroid hormone replacement must be closely coordinated to prevent adverse interactions and promote comprehensive recovery.
- Equally important is the need to enhance awareness among primary care providers, endocrinologists, and gastroenterologists regarding the gendered expression of autoimmune diseases. Education and training programs should emphasize that women may present with non-classical or overlapping symptoms, and that a high index of suspicion is necessary for early diagnosis. Encouraging collaborative care models and cross-specialty communication can help bridge diagnostic gaps and foster a more patient-centered, inclusive approach to autoimmune care.

Conclusion

The intersection of celiac disease (CD) and autoimmune thyroiditis (AT) serves as a compelling lens through which to examine the broader challenges of gender disparities in autoimmune disorders. Women are not only more frequently affected by both conditions but also often face delayed diagnoses, under-recognition of symptoms, and fragmented care across medical disciplines. These issues are not merely incidental—they reflect deeper systemic gaps in how sex-based differences in immune function, clinical presentation, and disease progression are understood and addressed in both research and practice. The consistent underrepresentation of women in clinical trials and the historical framing of autoimmune disease as gender-neutral have led to critical blind spots in diagnosis, management, and patient outcomes.

Understanding the biological underpinnings—from hormonal and genetic influences to immune regulation and organ-specific vulnerability—is essential for correcting these gaps. Likewise, recognizing the clinical manifestations that are unique to or more severe in women enables healthcare providers to design more responsive and equitable treatment pathways. By implementing gender-sensitive screening protocols, promoting interdisciplinary collaboration, and tailoring interventions based on sex-specific immune responses, clinicians can markedly improve early detection and reduce the burden of long-term complications. Moreover, ensuring that educational curricula, clinical guidelines, and policy frameworks are informed by a sex-based understanding of autoimmunity is a crucial step toward advancing health equity.

Future research must delve deeper into the sex-specific pathways of immune regulation, including the roles of estrogen, X-linked gene expression, and microchimerism, to pave the way for truly personalized autoimmune care. As our understanding of gender-based immunology evolves, so too must our commitment to closing the diagnostic and therapeutic gap that women disproportionately endure. Ultimately, addressing these disparities is not only a scientific imperative but also a moral and clinical one—vital to ensuring that all patients, regardless of gender, receive timely, accurate, and compassionate care.

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CIRCULAR CHEMISTRY: DESIGNING WASTE-FREE REACTIONS FOR A SUSTAINABLE FUTURE

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Abstract
As the global demand for materials and chemicals continues to rise, traditional linear models of chemical production—based on resource extraction, usage, and disposal—are becoming increasingly unsustainable. Circular chemistry offers a transformative approach by reimagining chemical design and manufacturing processes to minimize waste, maximize resource efficiency, and close the loop on material life cycles. This concept integrates the principles of green chemistry, systems thinking, and sustainability science to create processes that are not only efficient but also environmentally benign and economically viable.
This presentation will delve into the core strategies of circular chemistry, including the use of renewable feedstocks, solvent-free or aqueous-based reactions, biocatalysis, and recyclable or biodegradable products. Emphasis will be placed on CO_2 capture and valorization, waste-to-chemical conversion, and catalyst recycling, highlighting how these technologies can turn industrial waste streams into valuable inputs. Case studies from the pharmaceutical, materials, and agrochemical industries will be used to demonstrate real-world applications and measurable environmental benefits.
In addition to technological innovations, the abstract will explore the challenges of implementation—such as regulatory barriers, economic scalability, and knowledge gaps—and propose pathways for integrating circular chemistry into mainstream practice. The role of interdisciplinary collaboration between chemists, engineers, policymakers, and industry stakeholders will be discussed as a critical factor for success.
By shifting the focus from efficiency alone to circularity and regeneration, circular chemistry holds immense potential to drive the next wave of sustainable innovation. It not only supports the achievement of global climate goals but also fosters resilience in a resource-constrained and environmentally vulnerable world.

Keywords:
Circular chemistry, Green chemistry, Waste-free reactions, CO_2 valorization, Sustainable development, Renewable feedstocks, Biocatalysis, Catalyst recycling, Environmental chemistry, Closed-loop systems

Introduction

The chemical industry serves as the backbone of modern civilization, underpinning a wide range of sectors including healthcare, agriculture, energy, consumer goods, and construction. From life-saving pharmaceuticals and advanced materials to fertilizers and fuels, chemicals are indispensable to economic development and human well-being. However, the same industry that drives innovation and productivity also significantly contributes to environmental degradation. According to the International Energy Agency (IEA), the chemical sector is one of the largest industrial energy consumers and is responsible for approximately 10% of global industrial CO_2 emissions.
Traditionally, chemical manufacturing has operated under a linear economic model, often characterized by the “take–make–dispose” paradigm. Raw materials—typically derived from

finite fossil resources—are extracted, processed into products, and ultimately discarded as waste after use. This model, while historically effective in supporting rapid industrial growth, is increasingly unsustainable in the face of modern challenges, including climate change, ecological imbalance, pollution, and resource scarcity.

Moreover, the linear system fails to account for externalized environmental costs such as water contamination, air pollution, and the persistence of non-biodegradable chemicals in ecosystems. These impacts are particularly acute in regions where environmental regulations are weak, and industrial waste management is inadequate. As a result, the chemical industry faces mounting pressure from policymakers, investors, scientists, and consumers to shift toward more sustainable, circular practices.

Circular chemistry emerges as a timely and transformative approach that reimagines the design, production, and lifecycle management of chemicals. It is inspired by the broader concept of the circular economy, which aims to decouple economic growth from resource consumption by closing material loops and regenerating natural systems. Circular chemistry applies this framework to molecular science by integrating the principles of green chemistry, systems thinking, and life cycle assessment (LCA) into the innovation process.

Unlike conventional approaches that prioritize yield and profitability alone, circular chemistry emphasizes:

- **Resource efficiency**: Designing processes that use fewer inputs and generate minimal waste.
- **Toxicity reduction**: Eliminating or substituting hazardous substances.
- **Material circularity**: Enabling the reuse, recycling, or safe degradation of products after use.
- **Energy conservation**: Utilizing low-energy pathways such as biocatalysis and renewable energy sources.
- **Regenerative inputs**: Sourcing raw materials from renewable biological or captured waste streams.

At its core, circular chemistry promotes the idea that waste is not an endpoint, but a design flaw. By rethinking chemistry through this lens, scientists and industries can contribute not only to environmental protection but also to economic resilience, supply chain stability, and technological innovation.

As global environmental and economic systems become increasingly intertwined, the adoption of circular chemistry is no longer optional—it is imperative for long-term sustainability. The remainder of this article will explore the strategies, technologies, applications, and barriers associated with implementing circular chemistry in real-world contexts, demonstrating how this approach can redefine the future of the chemical industry.

2. Principles of Circular Chemistry

Circular chemistry is a holistic framework that seeks to transform the linear, waste-intensive nature of traditional chemical production into a closed-loop system that prioritizes sustainability, safety, and regeneration. At its foundation lie three core principles, each of which addresses a different facet of the chemical lifecycle:

1. Designing Out Waste and Pollution

At the heart of circular chemistry is the principle of proactive design—engineering chemical processes and products in a way that minimizes or eliminates waste and harmful emissions from the outset, rather than dealing with them post-production. This involves:

- Optimizing reaction conditions to increase yield and selectivity while reducing byproducts.
- Using catalytic rather than stoichiometric reagents to avoid excess reagents and side reactions.

- Avoiding persistent or toxic intermediates and end-products that cannot be broken down in nature.
- Incorporating real-time monitoring and feedback mechanisms to control environmental impacts during manufacturing.

By focusing on *"benign by design"* approaches, chemists can drastically reduce the environmental footprint of chemical production and downstream usage.

Keeping Materials in Use

A fundamental tenet of circular chemistry is extending the useful life of molecules, materials, and components through strategies such as:

- Recycling solvents, reagents, and catalysts within industrial processes.
- Creating reversible chemical bonds that allow for the breakdown and reassembly of polymers and other complex materials.
- Designing molecules for disassembly, making it easier to separate and recover valuable components after use.
- Using secondary raw materials, such as recovered plastics or industrial waste, as feedstocks in new processes.

This principle promotes material circularity, ensuring that chemicals are retained in the system for as long as possible, thereby reducing dependency on virgin resources and lowering the burden on landfills and incinerators.

Regenerating Natural Systems

While traditional chemistry often extracts resources without returning anything to the environment, circular chemistry actively works to regenerate natural systems by:

- Prioritizing renewable feedstocks, such as lignocellulosic biomass, algae, and waste-derived carbon sources.
- Developing biodegradable and compostable materials that reintegrate into ecological cycles after use.
- Using green solvents and reagents that minimize ecological toxicity and enhance biodegradability.
- Capturing and utilizing CO_2, methane, or other greenhouse gases as chemical building blocks.

This regenerative approach not only lessens environmental damage but can also restore ecological balance by integrating production with the cycles of nature—supporting soil health, biodiversity, and carbon neutrality.

Alignment with the 12 Principles of Green Chemistry

The concept of circular chemistry is deeply interconnected with the 12 Principles of Green Chemistry, formulated by Paul Anastas and John Warner. These principles provide a scientific foundation for designing safer, more efficient, and environmentally responsible chemical processes. Key overlapping principles include:

- Prevention (designing processes to avoid waste)
- Atom economy (maximizing the incorporation of all materials into the final product)
- Less hazardous synthesis (avoiding toxic intermediates and products)
- Energy efficiency (favoring ambient temperature and pressure conditions)
- Use of renewable feedstocks
- Design for degradation (ensuring products break down into innocuous substances)
- Safer solvents and auxiliaries

Circular chemistry not only embraces these principles but also builds upon them by embedding systems-level thinking—looking beyond individual reactions to consider entire material and energy cycles.

Implementing circular chemistry in practice requires the adoption of innovative strategies and enabling technologies that facilitate waste minimization, resource regeneration, and closed-

loop material cycles. The following subsections detail the essential tools and methodologies being deployed to transition the chemical industry from a linear to a circular model.

Renewable Feedstocks

One of the foundational principles of circular chemistry is the substitution of non-renewable, fossil-based feedstocks with renewable, bio-based alternatives. Sources such as agricultural residues, lignocellulosic biomass, food waste, forestry by-products, algae, and even waste CO_2 are now being tapped as green raw materials.

Renewable feedstocks have several advantages:

- Lower carbon footprint compared to petrochemicals.
- Biodegradability that enhances end-of-life environmental compatibility.
- Regional availability, which promotes local economies and reduces supply chain vulnerabilities.

For example, polylactic acid (PLA), a biodegradable plastic derived from corn starch or sugarcane, is increasingly used in packaging and medical applications. Similarly, bioethanol and biodiesel derived from sugarcane or jatropha are replacing fossil fuels in various sectors.

Ongoing research focuses on enhancing the conversion efficiency of biomass into platform chemicals like furfural, levulinic acid, succinic acid, and 5-HMF, which can be used to synthesize a wide array of polymers and fine chemicals.

Solvent-Free and Aqueous-Based Reactions

Solvents are responsible for a significant portion of waste and toxicity in chemical manufacturing. Many traditional solvents are volatile organic compounds (VOCs) that pose environmental and occupational hazards. Thus, a key goal of circular chemistry is to reduce or eliminate solvent use altogether, or replace them with safer, greener alternatives.

Solvent-free reactions

These are reactions carried out in the absence of any solvent, typically using neat reactants and sometimes aided by mechanochemical methods (e.g., ball milling). These processes offer:

- Reduced waste.
- Lower energy requirements.
- Simplified product separation and purification.

Water as a green solvent

Water, due to its abundance, non-toxicity, and non-flammability, is considered the ideal green solvent. Reactions in aqueous media, including micellar catalysis and hydrolysis, are gaining popularity across synthetic chemistry and industrial processes.

For instance, micellar catalysis using surfactants in water can mimic enzyme-like environments and improve solubility and selectivity in complex organic reactions.

3.3 Biocatalysis

Biocatalysis involves using enzymes or whole-cell microorganisms to carry out chemical transformations. These biological catalysts offer numerous advantages over conventional chemical catalysts:

- High regio-, chemo-, and stereoselectivity, which simplifies downstream processing.
- Operability at mild temperatures and neutral pH, reducing energy input and risk of side reactions.
- Compatibility with aqueous systems, supporting green solvent goals.

Applications of biocatalysis span pharmaceutical synthesis (e.g., statins, β-lactam antibiotics), agrochemical processing, and food chemistry. For example, lipases, oxidoreductases, and hydrolases are widely used in industry for transesterification, oxidation, and hydrolysis reactions.

Advancements in protein engineering and directed evolution are making biocatalysts even more robust and tunable, allowing them to function under industrial conditions and catalyze previously inaccessible reactions.

Catalyst Recycling

Catalysts—particularly precious metals like platinum, palladium, and rhodium—play an essential role in chemical synthesis, but they are often expensive, toxic, and difficult to separate after reactions. Circular chemistry encourages the recovery, regeneration, and reuse of catalysts to improve economic and environmental outcomes.

Strategies include:

- Heterogenization of homogeneous catalysts, enabling easy separation and reuse.
- Immobilization of enzymes or metal complexes on solid supports like silica or polymers.
- Magnetic nanoparticle-supported catalysts that can be recovered using magnets.
- Closed-loop recycling processes in which catalysts are continuously reused with minimal degradation.

Recycling catalysts not only reduces operational costs but also minimizes heavy metal contamination, a significant source of soil and water pollution.

CO_2 Capture and Valorization

Carbon dioxide is the most abundant anthropogenic greenhouse gas, and conventional mitigation strategies have largely focused on capture and storage (CCS). However, carbon capture and utilization (CCU) offers a more circular approach by converting CO_2 into valuable chemicals and fuels.

Key valorization pathways include:

- Chemical transformation of CO_2 into urea, methanol, cyclic carbonates, and polycarbonates.
- Electrochemical reduction of CO_2 to formic acid, syngas, or ethylene using renewable electricity.
- Photocatalytic or enzymatic fixation of CO_2 into organic compounds.
- Mineralization, where CO_2 reacts with metal oxides to form stable carbonates (useful in construction).

For example, Novomer has developed a process to synthesize polycarbonate polyols from CO_2 and epoxides, used in making foams and coatings. These valorization techniques help close the carbon loop, turning an environmental liability into a resource.

Waste-to-Chemical Conversion

One of the most impactful strategies in circular chemistry is the transformation of various waste streams into high-value chemicals. This involves converting:

- Municipal solid waste (e.g., plastics, food scraps)
- Agricultural waste (e.g., crop residues, manure)
- Industrial effluents (e.g., sludge, chemical waste)

into biofuels, bioplastics, fertilizers, and specialty chemicals.

Core technologies include:

- **Gasification**: Converts biomass or plastic waste into syngas ($CO + H_2$), which can be used to produce methanol or synthetic fuels.
- **Pyrolysis**: Thermal decomposition of organic material in the absence of oxygen to generate bio-oil and char.
- **Hydrothermal liquefaction**: Converts wet biomass into biocrude under high pressure and temperature.
- **Anaerobic digestion**: Microbial breakdown of organic matter to produce biogas ($CH_4 + CO_2$).

These processes offer dual benefits: waste reduction and sustainable chemical production, supporting both climate goals and circular economy mandates.

These core strategies and technologies collectively enable the transition from a waste-producing, resource-depleting industry to a closed-loop, regenerative chemical system. When

implemented together, they have the power to redefine how we make, use, and reuse chemicals, ensuring environmental resilience and industrial competitiveness in the decades to come.

Circular chemistry is not merely a theoretical construct—it is already being actively implemented across various industries. These applications illustrate how circular strategies can reduce environmental footprints, improve efficiency, and generate long-term value. Below are notable examples from the pharmaceutical, agrochemical, and materials industries.

Table 1: Core Strategies in Circular Chemistry – Objectives and Applications

Strategy	Objective	Example/Industry Use
Renewable Feedstocks	Replace fossil-based raw materials with biomass or other sustainable sources	PLA bioplastics from corn starch; bioethanol from sugarcane
Solvent-Free / Aqueous Reactions	Minimize or eliminate toxic solvents to reduce chemical waste	Micellar catalysis in water; solventless esterification
Biocatalysis	Use enzymes/microorganisms to enable clean, selective reactions	Enzyme-catalyzed synthesis of statins in pharmaceuticals
Catalyst Recycling	Recover and reuse precious or toxic catalysts	Immobilized metal catalysts; magnetic nanoparticle-supported systems
CO_2 Valorization	Transform CO_2 from pollutant to feedstock	Polycarbonates from CO_2 and epoxides; methanol production
Waste-to-Chemical Conversion	Convert waste into useful products like fuels or fertilizers	Pyrolysis of plastic waste; anaerobic digestion for biogas

Pharmaceutical Industry

The pharmaceutical sector is known for its complex, multi-step synthesis processes that frequently involve hazardous reagents, toxic solvents, and significant waste generation. Traditional processes often have high environmental factors (E-factors), indicating poor resource efficiency.

Circular chemistry has led to a shift toward more sustainable pharmaceutical manufacturing practices, including:

- Optimizing the atom economy and minimizing waste.
- Replacing toxic solvents with recyclable or aqueous-based alternatives.
- Employing biocatalysis for high selectivity and mild reaction conditions.
- Implementing continuous flow and process intensification methods.

Example: Pfizer's Green Synthesis of Pregabali

Pfizer developed a biocatalytic route for the synthesis of Pregabalin, significantly reducing the number of steps, solvent usage, and byproduct formation. The method utilized an enzyme-catalyzed transamination, performed under aqueous conditions with minimal environmental

impact. This green approach demonstrated how circular strategies can enhance both process sustainability and cost-effectiveness.
Other pharmaceutical companies such as GlaxoSmithKline and Merck are also incorporating green chemistry metrics into their development pipelines, showing that circular chemistry can coexist with innovation and profitability.

Agrochemical Industry

Agrochemicals play a vital role in food production, yet their excessive and inefficient use contributes to pollution, soil degradation, and biodiversity loss. Traditional fertilizers and pesticides are often derived from petroleum-based sources and may persist in the environment long after application.
Circular chemistry is driving innovation through:

- Development of biodegradable and bio-based pesticides and herbicides.
- Formulation of controlled-release fertilizers (CRFs) using eco-friendly polymers.
- Use of agricultural waste to generate soil conditioners and nutrient-rich compost.
- Recycling of nutrient streams from livestock and crop residues.

Example: Biodegradable Controlled-Release Fertilizers

Emerging CRFs use biodegradable polymers such as polylactic acid or starch-based coatings to slowly release nutrients in sync with plant uptake. This reduces nutrient runoff, increases efficiency, and minimizes environmental damage. These fertilizers align with circular principles by both extending nutrient use and regenerating soil health.
The integration of bio-based agrochemicals and precision agriculture techniques supports a sustainable, closed-loop approach to farming.

Materials Industry

The materials industry, especially the plastics and textiles sectors, faces significant challenges regarding resource consumption and post-consumer waste. A large proportion of plastics still come from virgin fossil fuels and end up in landfills or oceans due to limited recyclability.
Circular chemistry provides alternatives through:

- Development of bio-based polymers that degrade safely at end-of-life.
- Chemical recycling techniques that allow for the breakdown and reformation of polymers.
- Design of materials for disassembly, separation, and reuse.
- Innovations in sorting and depolymerization of mixed plastic streams.

Example: Circular Polymers in Industry

Coca-Cola has launched its PlantBottle™ initiative, incorporating up to 30% bio-based polyethylene terephthalate (PET), which is fully recyclable. Meanwhile, Adidas has introduced shoes manufactured entirely from ocean plastic waste and is piloting closed-loop textile systems where old garments are broken down into monomers and repolymerized into new products.
Chemical manufacturers are also investing in processes that allow plastic materials to be chemically recycled into their original building blocks, making infinite recycling technically possible.
These industrial case studies demonstrate that circular chemistry is not only feasible but also strategically advantageous. By redesigning inputs, processes, and product life cycles, these industries are moving toward systems that are both economically viable and environmentally regenerative.

Challenges and Barriers

While circular chemistry holds immense promise for creating a more sustainable and regenerative chemical industry, its implementation at scale remains limited by a range of systemic, economic, regulatory, and cultural barriers. These challenges reflect both structural limitations within current industrial and academic ecosystems and the broader inertia associated with transitioning from entrenched linear models. Addressing these obstacles is essential for the mainstreaming of circular chemistry.

Regulatory Hurdles

One of the most significant impediments to the adoption of circular chemistry lies in outdated or restrictive regulatory frameworks. Many national and international regulations were formulated to govern traditional, linear chemical processes and are often ill-suited to accommodate innovative circular solutions, such as:

- Use of waste-derived or bio-based feedstocks.
- Application of genetically engineered microorganisms in biocatalysis.
- Chemical recycling methods that produce new substances from post-consumer waste.

For instance, regulatory uncertainty around waste-to-chemical processes may categorize recycled or upcycled materials as waste rather than raw materials, triggering strict handling and disposal requirements. This creates compliance burdens that discourage innovation.

To foster circular chemistry, regulations need to evolve to:

- Recognize non-traditional feedstocks as safe and viable.
- Support green process certifications.
- Provide guidance and incentives for lifecycle assessment (LCA) and circular design practices.

Economic Scalability

Transitioning from conventional chemical production to circular processes often requires substantial upfront investments in new technologies, infrastructure, and training. The perceived or actual lack of short-term profitability can be a major deterrent for businesses, particularly in highly cost-sensitive sectors.

Specific economic challenges include:

- High capital expenditure for setting up closed-loop manufacturing systems.
- Limited access to green venture funding, especially in developing regions.
- Uncertainty in returns on investment (ROI) due to the nascent market for circular products.

Additionally, economies of scale for circular technologies have not yet been fully realized. Many circular solutions remain viable only at pilot or small-scale levels, making their adoption financially risky for large-scale manufacturers.

A coordinated approach involving public-private partnerships, subsidies, and carbon pricing mechanisms is essential to make circular chemistry economically competitive.

Lack of Awareness and Education

A major barrier to the growth of circular chemistry is the knowledge and skills gap that exists across the scientific and industrial landscape. Many chemists and engineers are trained within linear, efficiency-oriented paradigms, with limited exposure to sustainability frameworks or systems thinking.

Key issues include:

- Limited integration of circular chemistry into university curricula and technical training.
- Misconceptions about the feasibility, reliability, or performance of circular products.
- A lack of access to practical case studies or industry benchmarks demonstrating circular chemistry’s success.

Increasing awareness will require:

- Curriculum reform in science, engineering, and business education.
- Knowledge exchange platforms between academia, industry, and policymakers.
- Widespread dissemination of success stories and best practices from early adopters.

Interdisciplinary Disconnect

Circular chemistry is inherently interdisciplinary—it operates at the intersection of chemistry, engineering, environmental science, economics, and policy. However, existing institutional structures often operate in silos, resulting in:

- Fragmented research efforts with limited collaboration between departments or sectors.
- Disconnect between scientific innovation and commercial application.
- Inadequate coordination between industry priorities and regulatory or environmental goals.

To overcome this disconnect, it is vital to build cross-disciplinary coalitions involving:

- Chemists and process engineers.
- Economists and supply chain managers.
- Environmental scientists and lifecycle analysts.
- Policy makers and regulatory agencies.

Such collaborations can accelerate the design and scaling of circular solutions, while ensuring that they are both scientifically sound and economically practical.

Pathways Forward

The transition to a circular chemical economy is not only desirable but necessary for a sustainable future. However, it will not occur organically without targeted interventions, systemic reforms, and coordinated action across sectors. To scale the principles and practices of circular chemistry beyond isolated case studies and pilot projects, the following strategic pathways must be prioritized:

Policy Incentives and Regulatory Reform

Governments play a pivotal role in creating the enabling environment necessary for circular chemistry to flourish. Current policy frameworks often reinforce linear production models through subsidies for fossil-based industries and outdated regulations. To shift this dynamic, governments should:

- Offer tax incentives, subsidies, and grants for companies adopting green and circular processes.
- Implement extended producer responsibility (EPR) schemes to encourage design for reuse, recycling, and safe degradation.
- Introduce green procurement standards that prioritize circular and bio-based products in public spending.
- Establish performance-based environmental regulations that reward reduction in waste, emissions, and energy consumption.

Additionally, harmonizing regulations across borders will support global chemical trade while ensuring environmental accountability.

Academic-Industrial Collaboration

While academic research drives innovation, its translation into real-world applications often faces significant delays due to lack of communication, resources, or industrial alignment. To bridge this gap:

- Joint research programs should be established to co-develop scalable technologies in areas such as waste-to-chemical conversion, biocatalysis, and green solvents.
- Universities and chemical companies can form consortia and innovation hubs to facilitate technology transfer and pilot testing.

- Shared testbeds, demonstration plants, and incubation centers can accelerate the commercialization of circular technologies.

These partnerships also enhance feedback loops, allowing scientists to refine their innovations based on real-world industrial constraints and needs.

Curriculum Reform and Education

The widespread adoption of circular chemistry requires a paradigm shift in how chemistry is taught and practiced. Traditional curricula often focus on reaction efficiency and yield optimization without sufficient emphasis on environmental and societal impacts. To address this:

- Sustainability, systems thinking, and lifecycle analysis must be integrated into undergraduate and postgraduate chemistry education.
- Interdisciplinary programs should be developed at the interface of chemistry, environmental science, engineering, and economics.
- Students should be trained in design thinking, ethical responsibility, and regulatory literacy relevant to circular production.

Equipping the next generation of chemists and engineers with these skills is crucial to embedding circularity as a norm rather than an exception in the chemical sciences.

Consumer Engagement and Market Pull

Consumers have a growing influence in driving the demand for sustainable products. By fostering transparency, education, and accessibility, companies can encourage informed choices and shift markets toward circular goods. To support this:

- Companies should implement clear product labeling, detailing the origin, recyclability, and environmental footprint of chemicals and materials.
- Public awareness campaigns can educate consumers about the impact of chemical products and the benefits of circular alternatives.
- Certification schemes such as Cradle to Cradle, Green Seal, or EcoLabel can offer credibility and guidance in purchasing decisions.

Building consumer trust and preference for circular products will not only accelerate adoption but also incentivize manufacturers to reimagine their supply chains and product designs.

Conclusion

Circular chemistry is not merely a scientific advancement but a strategic necessity in a world increasingly strained by climate change, environmental degradation, and finite resources. As traditional linear models of chemical production prove unsustainable, circular chemistry offers a regenerative alternative by redesigning processes to mimic nature's closed-loop systems. It enables the development of economically viable and environmentally restorative technologies through the use of renewable feedstocks, green solvents, biodegradable products, and waste-to-resource conversions. Yet, transitioning from a linear to a circular mindset requires more than technological innovation—it demands systemic change, collective action, and interdisciplinary collaboration among chemists, engineers, policymakers, educators, and consumers. Embedding sustainability into the core of chemical science and industry will not only reduce environmental harm but also reshape our relationship with materials and production. Ultimately, embracing circular chemistry is essential to building a resilient, equitable, and sustainable future for both people and the planet.

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AN INTERROGATION OF CLIMATE CHANGE AND THE LEGAL FRAMEWORK FOR ENVIRONMENTAL PROTECTION IN NIGERIA

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Abstract

Climate change poses significant global threats, exacerbated by human activities such as fossil fuel consumption, deforestation, and gas flaring. Nigeria's vulnerability to climate change is heightened due to its heavy reliance on natural resources and limited adaptive capacity. This study examines Nigeria's legal frameworks, including the 1999 Constitution, the Climate Change Act 2021, and the National Environmental Standards and Regulations Enforcement Agency (NESREA) Act 2007. It evaluates their effectiveness in safeguarding the environment and protecting the rights of indigenous people. The findings indicate the need for constitutional amendments to render environmental protection justiciable, state-level climate legislation, and a liberal approach to *locus standi* to enhance access to justice. The research underscores the importance of robust legal mechanisms in mitigating climate change impacts and fostering sustainable development in Nigeria.

Keywords: Climate Change, Legal Framework, Environmental Protection, Sustainable Development, Nigeria

Introduction

Climate change is a global issue that directly impacts human lives and significantly damages property, primarily resulting from atmospheric pollution and excessive greenhouse gases (GHGs)[1]. Human activities, notably the use of fossil fuels, deforestation, and gas flaring, have led to an accumulation of GHGs in the earth's atmosphere, increasing both surface air and subsurface ocean temperatures[2]. This phenomenon poses substantial economic, cultural, and political threats, particularly concerning ecological vulnerability, deforestation, pollution, and degradation[3].

Scientific consensus confirms that human activities significantly influence the global climate system, leading to global warming. The release of GHGs and the depletion of the ozone layer are clear indicators of human-induced climate change[4]. The impacts of climate change are already evident, with scientific evidence suggesting that these effects will intensify,

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disproportionately affecting poor and developing countries, including small island nations, while the primary responsibility lies with wealthy and industrialized nations[5].

In Nigeria, anthropogenic activities such as fossil fuel use, deforestation, and gas flaring are major contributors to climate change[6]. Natural forces, including continental drift, volcanoes, ocean currents, and earth's tilt, also influence climate change. The consequences include altered rainfall and wind patterns and rising temperatures, leading to natural disasters like floods, droughts, and desertification[7].

Despite advances in technical innovation, energy security, and economic development, the environmental consequences are severe, with extreme degradation and deterioration affecting our reliance on natural resources. We face polluted water courses, infertile soil, drought, and flooding due to global warming and climate change. This highlights the unsustainability of conventional development[8].

The law plays a crucial role in protecting society and maintaining balance in human affairs. It helps prevent climate change by ensuring that daily activities adapt to nature without causing harm. Additionally, climate change may impact other legal areas, such as accounting, taxation, corporate social responsibility (CSR), and corporate transactions, presenting opportunities for legal professionals to address these challenges[9].

This study examines Nigeria's legal frameworks for environmental protection in the context of climate change. It seeks to determine whether these frameworks effectively safeguard the rights and lands of indigenous peoples and, if not, how they can be improved.

Conceptualization of Concepts

i. Climate Change

Climate change, like many other social science concepts, lacks a universally accepted definition. However, it can be broadly understood as significant long-term changes in the patterns of climate variables. For this research, the definition provided by the Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Report will be adopted. The IPCC defines climate change as a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may result from natural internal processes or external forces, or from persistent anthropogenic changes in the composition of the atmosphere or in land use[10].

This definition emphasizes that climate change includes variations in temperature, humidity, atmospheric pressure, wind, rainfall, atmospheric particle count, and other meteorological elements over a long period. The key factor in determining a significant shift in climate is the duration of these changes. As noted by Agbo, climate change is a long-term shift in the patterns of a specific place, measured by changes in the behavior of climate elements such as temperature, wind patterns, and precipitation, resulting in changes in ecosystems and socio-economic activities.[11]

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From the perspective of human activities, climate change is defined as a pattern of change affecting global or regional climates, measured by factors such as average temperature and rainfall, or an alteration in the frequency of extreme weather conditions.[12] Therefore, climate change can be conceptualized as a gradual shift in climatic variations over a long period due to both human and industrial or technological activities, which harm the ozone layer and eventually affect the ecosystem. This results in heat waves, rising sea levels, poor rainfall, changing wind patterns, and other concomitant effects.

ii. Environmental Protection

Environmental protection is the practice of safeguarding natural resources and ecosystems from harm or destruction. It involves implementing strategies and policies to protect the environment, reduce pollution, and conserve natural resources for the benefit of present and future generations. Environmental protection is essential for ensuring the sustainability of the planet and preventing irreversible damage to the natural world.[13]

The concept includes several interconnected elements: conservation, preservation, pollution control, and sustainable development. Conservation involves the responsible use and management of natural resources, while preservation focuses on protecting and maintaining natural ecosystems, habitats, and biodiversity.[14] Pollution control strategies aim to reduce the release of harmful substances into the environment, affecting air, water, and soil quality.[15] Sustainable development seeks to meet the needs of the present generation without compromising the ability of future generations to meet their own needs.[16]

Historically, environmental protection focused primarily on conservation and preservation efforts, such as establishing national parks and protected areas. However, as environmental issues have become more complex and widespread, the scope of environmental protection has expanded to include a range of strategies and policies aimed at reducing pollution and promoting sustainable development.[17]

Environmental protection is crucial for maintaining the health and well-being of both ecosystems and human populations. Environmental degradation and pollution have been linked to various health issues, including respiratory problems, cancer, and cardiovascular disease. By reducing exposure to harmful pollutants and promoting cleaner environments, environmental protection can help prevent or mitigate these health risks.[18] Additionally, environmental protection ensures the sustainability of natural resources, such as water, soil, and forests, which are vital for supporting human life and economic activity. Unsustainable practices like deforestation, overfishing, and excessive water use can lead to the depletion and degradation of these resources, posing significant risks to human well-being and economic development.[19]

The concept of environmental protection is closely linked to environmental justice, which refers to the fair distribution of environmental benefits and burdens across different groups and

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[18] Health and the environment, 'World Health Organization (WHO)' <https://www.who.int/news/item/04-04-2022-health-and-the-environment> accessed 4 May 2023.

[19] Ibid.

communities.[20] Environmental protection policies and practices must consider the needs and perspectives of all stakeholders, including marginalized and vulnerable groups.

An Overview of Climate Change Phenomenon in Nigeria

Climate change is a global phenomenon with devastating consequences for the environment, human health, and socio-economic development. Nigeria, like many other developing countries, is particularly vulnerable due to its high dependence on natural resources, low adaptive capacity, and limited resources for mitigation efforts[21]. With a population exceeding 200 million, Nigeria is the most populous country in Africa and the seventh most populous in the world, situated in the West African sub-region with a land area of 923,768 square kilometers.[22] The country hosts diverse ecosystems, including tropical rainforests, savannas, wetlands, and coastal areas, which provide crucial ecosystem services and support millions of livelihoods[23].

The impacts of climate change in Nigeria are already evident across various sectors, including agriculture, health, water resources, energy, and infrastructure. The agriculture sector, employing over 70% of the population, faces significant vulnerabilities due to altered rainfall patterns, increased drought frequency, and flooding. These changes result in reduced crop yields, food insecurity, and increased poverty in rural areas[24]. Additionally, climate change exacerbates health issues, with higher incidences of malaria, waterborne diseases, and respiratory illnesses linked to extreme weather events like floods and heatwaves[25]. Water resource availability and quality are also compromised, posing threats to human health and socio-economic development[26].

The Lake Chad Basin exemplifies the transboundary nature of climate change effects, impacting regional agriculture and biodiversity. In the 1960s, the Lake Chad Basin supported approximately 60 million farmers and fishermen, with Nigeria having the highest number of beneficiaries. However, the lake's surface area has dramatically decreased from about 25,000 km² in the 1960s to less than 2,500 km² by 2017, largely due to climate change, dam construction, and other anthropogenic activities[27]. This reduction has severe implications for food security, regional stability, and biodiversity, contributing to conflicts such as the perennial farmer-herder clashes in Northeast and North-Central Nigeria[28].

The causes of climate change in Nigeria are both natural and human-induced. Natural factors include solar variability and volcanic activities, while human-induced factors involve deforestation, land-use changes, and fossil fuel combustion. Despite low carbon emissions

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[20] What Environmental Justice Means—and Why It Matters', *Goldman Environmental Prize* <https://www.goldmanprize.org/blog/what-environmental-justice-means-and-why-it-matters/> accessed 16 June 2023.

[21] JE Ogbuabor and EI Egwuchukwu, 'The Impact of Climate Change on the Nigerian Economy' (2017) 7(2) *International Journal of Energy Economics and Policy* 217-223.

[22] Wikipedia contributors, 'Nigeria', Wikipedia, The Free Encyclopedia (2024) <https://en.wikipedia.org/wiki/Nigeria> accessed 16 June 2023.

[23] A Hussaini, 'An Overview of the Socio-Economic Impact of Climate Change in Nigeria' (2015) 3(3) *Journal of Human Ecology* 21.

[24] JO Adejuwon, 'Impacts of Climate Change on Agriculture and Food Security in Nigeria: A Review' (2017) 60(3-4) *Journal of Human Ecology* 163.

[25] IF Monday, 'Investigating Effects of Climate Change on Health Risks in Nigeria' (2019) *Environmental Factors Affecting Human Health* < https://www.intechopen.com/chapters/67704> accessed 25 November 2023.

[26] JO Owoeye, AF Fagbamigbe and OO Daramola, 'Climate Change, Water Resources, and Public Health in Nigeria: Impacts and Adaptation Strategies' (2020) 17(22) *International Journal of Environmental Research and Public Health 8376*.

[27] PE Ndimele and others, "Fostering International and Trans-boundary Cooperation in the Management of Lake Chad Fisheries, Wildlife, and Flora: the Role of a Trans-boundary Ramsar Conservation Area" (2024) 37 *Aquatic Living Resources* 6 DOI: 10.1051/alr/2024004.

[28] NE Ebele and NV Emodi, 'Climate Change and Its Impact in Nigerian Economy' (2016) 10 *Journal of Scientific Research and Reports* 1.

compared to developed nations, Nigeria's status as a major oil producer and its heavy reliance on fossil fuels contribute significantly to global greenhouse gas emissions[29]. Over the past few decades, Nigeria has experienced a steady increase in temperature and shifts in rainfall patterns, leading to extreme weather events like floods, droughts, and heatwaves, causing substantial economic losses and human suffering[30].

Given the pressing nature of climate change, Nigeria must take decisive actions to mitigate and adapt to its impacts. This requires coordinated efforts from the government, civil society, and the private sector to implement policies and programs that reduce greenhouse gas emissions, enhance adaptive capacity, and promote sustainable development[31].

Climate Change Adaptation and Mitigation

Changes in climate patterns due to increased levels of greenhouse gases (GHGs) significantly impact human and natural systems. It is essential to mitigate the causes of climate change while adapting to its consequences.

Adaptation involves adjusting to the effects of climate change, including changes in temperature, precipitation patterns, sea level rise, and extreme weather events. Key strategies for adaptation include developing resilient infrastructure, increasing biodiversity, and implementing policies that promote sustainable land use practices. Adaptation measures are necessary because climate change is already significantly impacting vulnerable communities and ecosystems[32].

Building resilience is a crucial adaptation strategy. Resilience refers to the ability of a system to recover from a disturbance. This involves creating systems that can withstand the effects of climate change, such as constructing sea walls to protect against rising sea levels, building structures that can endure extreme weather events, and designing infrastructure to handle increased precipitation[33].

Increasing biodiversity is another vital adaptation strategy. Biodiversity provides essential ecosystem services that support human well-being, such as air and water quality, food and medicine, and cultural and spiritual values. Biodiversity helps ecosystems adapt to climate change by offering services that support species' ability to respond to changing conditions. For example, biodiversity can buffer the impacts of extreme weather events, provide habitat for migratory species, and maintain ecosystem function[34].

Implementing policies that promote sustainable land use practices is a third key adaptation strategy. Sustainable land use practices include reducing deforestation, promoting reforestation, and encouraging sustainable agriculture. These practices help reduce GHG emissions, increase carbon sequestration, and enhance ecosystem resilience. Additionally, sustainable land use practices help maintain and increase ecosystem services, such as biodiversity, water and air quality, and soil health[35].

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[29] A Osuafor and N Nnorom, 'Impact of Climate Change on Food Security in Nigeria' (2014) 3(1) *AFRREV STECH: An International Journal of Science and Technology* 208.

[30] BJ Abiodun, KA Lawal, A Salami and AA Abatan, 'Potential Influences of Global Warming on Future Climate and Extreme Events in Nigeria' (2013) 13 *Regional Environmental Change* 477.

[31] BE Ikumbur and SI Iornumbe, 'The Impacts of Climate Change on Nigerian Ecosystems: A Review' (2019) 3(2) Nigerian *Journal of Environmental Sciences and Technology 267-291.*

[32] E Woodley, "Building Nigeria's Response to Climate Change: Pilot Projects for Community-Based Adaptation in Nigeria" (2011) 19 *Experiences of Climate Change Adaptation in Africa* 297–315 DOI: 10.1007/978-3-642-22315-0_19.

[33] N Onyekuru and R Marchant, 'Nigeria's Response to the Impacts of Climate Change: Developing Resilient and Ethical Adaptation Options' (2012) 25 *Journal of Agricultural and Environmental Ethics* 585.

[34] N Sangotegbe, S Odebode and MP Onikoyi, 'Adaptation Strategies to Climate Change by Food Crop Farmers in Oke-Ogun Area of South Western Nigeria' (2013) 16 *The Journal of Agricultural Extension* 119.

[35] BA Hassan and J Knight, "Adaptation to Climate Change and Variability by Farming Households in North-Central Nigeria" (2023) 15 *Sustainability* 16309 DOI: 10.3390/su152316309.

Mitigation involves reducing GHG emissions to slow or stabilize the rate of climate change. Mitigation strategies focus on reducing emissions from energy production, transportation, industry, and agriculture. Mitigation is necessary because the continued release of GHGs into the atmosphere will exacerbate climate change effects[36].

Transitioning to renewable energy sources is a key mitigation strategy. Renewable energy sources, such as wind, solar, and hydropower, produce energy without releasing GHGs. Transitioning to renewable energy can reduce GHG emissions from the energy sector, which significantly contributes to global emissions[37].

Theoretical Framework

Several theoretical perspectives have been developed to explain climate change and its impacts. These frameworks include ecological, social, and economic theories. This study will explore ecological theoretical perspectives as a framework of analysis and discuss its implications for understanding climate change.

Ecological Theory

The ecological theory of climate change emphasizes the importance of understanding natural processes and ecosystem dynamics. According to this theory, climate change is a natural response to changes in the earth's climate system, such as variations in solar radiation or volcanic eruptions. This theory highlights the role of biogeochemical cycles, such as the carbon cycle, in regulating the earth's climate[38].

However, ecological theory also recognizes that human activities have accelerated the rate of climate change. The burning of fossil fuels and deforestation have led to increased levels of carbon dioxide in the atmosphere, contributing to the warming of the planet. This disruption of natural processes and ecosystems has resulted in changes in precipitation patterns, sea level rise, and loss of biodiversity[39].

Ecological theory provides a comprehensive understanding of how both natural and anthropogenic factors contribute to climate change. It underscores the need for integrated approaches that consider ecological processes and human impacts to effectively address climate change challenges[40].

Legal Framework for the Protection of Climate Change in Nigeria

i. The Constitution of the Federal Republic of Nigeria

The Constitution of the Federal Republic of Nigeria, 1999 (as amended) serves as the highest law in Nigeria.[41] Section 20 of the Constitution states, "The State shall protect and improve the environment and safeguard the water, air and land, forest and wildlife of Nigeria." This provision imposes a responsibility on the government to protect Nigeria from the detrimental impacts of climate change and prevent contributing to its causes. However, Section 20 is placed under Chapter 2 of the Constitution, which has been declared non-justiciable under Section 6(6)(c) of the Constitution. This means that individuals cannot compel the government to enact or implement legislation or policies for climate change regulation and environmental protection through the courts.

Despite these limitations, Nigerian courts have creatively interpreted the rights in Chapter 2 by linking them to the enforceable rights in Chapter 4 of the Constitution. Chapter 4 encompasses

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[36] IC Enete, Officha, AM Ezezue and P Agbonome, 'Adapting Nigeria Cities to Climate Change Using Design Options: A Review' (2012) 2 *British Journal of Applied Science and Technology* 367.

[37] J Ajayi, 'Adaptation Strategies to Climate Change by Farmers in Ekiti State, Nigeria' (2016) 5 *Applied Tropical Agriculture* 1.

[38] W Schlesinger, 'Global Change Ecology' (2006) 21(6) *Trends in Ecology & Evolution* 348.

[39] G Walther, E Post, P Convey, and others, 'Ecological Responses to Recent Climate Change' (2002) 416 *Nature* 389.

[40] W Ingwersen, A Garmestani, MA Gonzalez, J Templeton, 'A Systems Perspective on Responses to Climate Change' (2014) 16 *Clean Technologies and Environmental Policy* 719.

[41] Section 1, Constitution of the Federal Republic of Nigeria, 1999 (as amended), Cap C23 LFN, 2004.

fundamental rights, including the right to life, freedom of movement, human dignity, and personal liberty. Section 46(1) grants individuals the right to seek legal redress if their fundamental rights are violated or likely to be violated. By interpreting these fundamental rights, litigants can argue that the government's failure to protect individuals from the adverse effects of climate change violates their fundamental right to life[42].

A notable example is the case of *Jonah Gbemre v. Shell Petroleum Development Company Nigeria Ltd and others*.[43] The applicant sought declarations that the constitutionally guaranteed fundamental rights to life and dignity include the right to a clean, poison-free, pollution-free, and healthy environment. The Federal High Court in granting the relief sought by the Applicant, made a declaration that the Applicant's constitutionally guaranteed right to life encompassed the right to a 'clean, poison-free, pollution-free, and healthy environment'. The Court based its decision on the right to life enshrined in Chapter 4 of the Constitution, as well as Article 24 of the African Charter, which guarantees the right to a clean environment. Unfortunately, the court's order, instructing Shell and others to cease gas flaring in the plaintiff's community, was disregarded. Additionally, the judge who made the declaration was promptly transferred to a different region of the country, while the case file has since gone missing.[44]

ii. Climate Change Act 2021

The Climate Change Act is a significant statute in Nigeria aimed at addressing climate change. It provides a legal and institutional framework for reducing greenhouse gas emissions and aligns with Nigeria's international climate change commitments. The Act sets a goal of achieving net-zero greenhouse gas emissions between 2050 and 2070[45].

One of the key provisions of the Act is the establishment of the National Council on Climate Change. This corporate body has the authority to make policies and decisions on all matters related to climate change in Nigeria. The Council is responsible for coordinating the implementation of sectoral targets, regulating greenhouse gas emissions, and approving and monitoring the National Climate Action Plan. It also manages the Climate Fund[46]. The Act mandates the federal ministries of environment and land use planning to develop a carbon budget aimed at limiting the global temperature rise to 2°C and making efforts to limit it to 1.5°C above pre-industrial levels. The Council, through its Secretariat, is responsible for developing a national action plan on climate change every five years[47].

The Climate Change Act provides a strong framework for climate action, addressing Nigeria's short, medium, and long-term objectives for climate reduction and adaptation. It places obligations on public and commercial institutions to promote a low-carbon economy and sustainable lifestyles. The Act also emphasizes collaboration with relevant parties, including civil society organizations, thereby creating a solid legal foundation for potential climate-related legal disputes and climate change activism[48]. Although implementation steps remain, the Climate Change Act demonstrates Nigeria's commitment to addressing climate change seriously. It has the potential to serve as a powerful tool for climate change activism and

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[42] MT Ladan, 'A review of Nigeria's 2021 Climate Change Act: Potential for increased climate litigation' IUCN <https://www.iucn.org/news/commission-environmental-economic-and-social-policy/202203/a-review-nigerias-2021-climate-change-act-potential-increased-climate-litigation> accessed 22 May 2023.

[43] Suit No: FHC/B/CS/53/05; (2005) AHRLR 151.

[44] MT Ladan, (n 42).

[45] Section 1(f).

[46] Section 3(1).

[47] T Akaluzia, 'The Nigerian Climate Change Act — Key Highlights' Businessday NG (2022) <https://businessday.ng/opinion/article/the-nigerian-climate-change-act-key-highlights/< accessed 22 May 2023.

[48] Ladan MT, (n 42.)

provide a legal basis for climate litigation in Nigeria. Notably, it is the first comprehensive climate change law in West Africa and one of the few globally and regionally[49].

iii. **The National Environmental Standards and Regulations Enforcement Agency (Establishment) Act, 200**7

The National Environmental Standards and Regulations Enforcement Agency (Establishment) Act, 2007 (NESREA Act) is a crucial environmental legislation in Nigeria that replaced the Federal Environmental Protection Agency Act of 1988.[50] It establishes the National Environmental Standards and Regulations Enforcement Agency (NESREA), which is responsible for enforcing compliance with environmental laws, guidelines, policies, and standards.[51] The agency ensures adherence to international agreements, protocols, conventions, and treaties related to climate change, biodiversity, conservation, desertification, forestry, ozone depletion, and other environmental matters[52].

The NESREA Act grants the agency various powers and responsibilities, including collaborating with relevant authorities to prosecute violators of environmental regulations and establishing programs for setting standards and regulations for pollution prevention, reduction, and elimination. The Act empowers the agency to regulate emissions from various sources, such as vehicles, industries, factories, and power-generating facilities, to combat atmospheric pollution.[53] Section 20 of the NESREA Act specifically authorizes the agency to make regulations on the most appropriate means of reducing emissions to permissible level.

To support the functions of the agency, Section 34 of the NESREA Act empowers the Minister of Environment to make regulations for the effective implementation of the Act. Over the years, the Minister of Environment in Nigeria has issued approximately 24 regulations to fulfill the objectives of the NESREA Act.[54] Some of these regulations applicable to climate change and its impacts include:[55]

- The National Environmental (Control of Vehicular Emissions from Petrol and Diesel Engines) Regulations, 2011
- The National Environmental (Desertification Control and Drought Mitigation) Regulations, 2011
- The National Environmental (Soil Erosion and Flood Control) Regulations, 2011
- The National Environmental (Ozone Layer Protection) Regulations, 2009

Conclusion

While Nigeria has made strides in developing legislation such as the Climate Change Act 2021 and the NESREA Act 2007, significant gaps remain in the effective enforcement and implementation of these laws. The Constitution of Nigeria, with its non-justiciable provisions on environmental protection, further complicates the legal landscape, limiting citizens' ability to seek redress for environmental harm. The study finds that human activities, including fossil fuel consumption, deforestation, and gas flaring, are major contributors to climate change in Nigeria. These activities have led to severe environmental degradation, adversely affecting agriculture, health, water resources, and biodiversity. The existing legal framework, though

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[49] Ibid.

[50] S Mustapha, 'An Appraisal of the Regulatory Role of National Environmental Standards Regulations and Enforcement Agency (NESREA) in Nigeria' (2022) 10(3) *International Journal of Diplomatic, Legal and International Studies* 9-13.

[51] Ibid.

[52] Ibid.

[53] MT Ladan, 'Review of NESREA Act 2007 and Regulations 2009-2011: A New Dawn in Environmental Compliance and Enforcement in Nigeria', (2012) 8(1) *Law, Environment and Development Journal* 116.

[54] Ibid.

[55] Adeoluwa RO, 'Appraisal of the Operationalisation of National environmental Regulations in Nigeria under the National Environmental Standards and Regulations Enforcement Agency' (2018) 9 *Nnamdi Azikiwe University Journal of International Law and Jurisprudence* 199-215.

robust on paper, requires amendments and stronger enforcement mechanisms to address these challenges effectively.

Recommendations

Based on the findings and analysis presented in this research paper, the following recommendations are proposed for combating climate change in Nigeria:

i. A constitutional amendment is necessary to render justiciable the responsibility placed on the state by section 20 of the Constitution to safeguard and enhance the environment, ensuring its safety for human habitation. One approach to achieving this is by incorporating the duty to protect and improve the environment into the fundamental rights provisions outlined in Chapter 4 of the Constitution. By doing so, citizens would have the ability to seek legal recourse through the fundamental rights enforcement procedure rules to enforce this duty. This would enable citizens to seek legal recourse through the fundamental rights enforcement procedure to enforce environmental protection.

ii. To ensure progress in addressing climate change, state governments should proactively enact climate change legislation instead of relying solely on the federal government. This approach would allow states to take action even in the absence of federal climate change legislation. A similar approach has been successful in the United States, where several states have enacted and enforced legislation to limit greenhouse gas emissions and adapt to the negative impacts of climate change. Australia has also seen provincial governments taking the lead in enacting climate change legislation. In Nigeria, this is feasible since environmental matters fall under the concurrent legislative list. This means that both the federal government and state governments have the authority to legislate on environmental issues.

iii. To enhance access to justice, there should be a liberal approach to the *locus standi* requirement, where litigants would not be required to demonstrate personal harm or loss resulting from the failure of an institution or individual to fulfil their duties under the Act or law. Instead, it would suffice to prove that there has been a failure to perform a climate change duty imposed by the legislation. This would allow concerned citizens to bring climate change-related cases on behalf of the wider public interest.

DETERMINANTS OF MEDICATION ADHERENCE: A KEY CHALLENGE IN CHRONIC DISEASE MANAGEMENT

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Abstract
Medication adherence refers to the extent to which patients follow the treatment regimens prescribed by their healthcare providers. It is influenced by a wide range of factors. **Sociodemographic determinants** such as age, education level, marital status, income, and health insurance coverage play a crucial role. **Clinical factors**, including treatment complexity, side effects, disease duration, and comorbidities, also impact adherence. In addition**, health literacy**, the quality of the patient-provider relationship, individual motivation, social support, and access to healthcare services are key contributors. Poor adherence can lead to suboptimal therapeutic outcomes, increased complications, and higher healthcare costs. Understanding these determinants is essential for improving treatment strategies, particularly in the management of chronic conditions such as type 2 diabetes.

Keywords:
Medication adherence; Determinants; Chronic diseases; Type 2 diabetes; Health literacy; Socioeconomic factors; Patient behavior; Primary healthcare

THE EFFECT OF INJECTION ADMINISTRATION OF MERCURY(II) CHLORIDE ON BLOOD PARAMETER,ENZYMES (ALT,AST) AND GLUCOSE IN "MUS MUSCULUS"

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Abstract
Objective: To evaluate the hematological and biochemical effects of intraperitoneal exposure to mercuric chloride ($HgCl_2$) in laboratory mice, with the aim of assessing its systemic toxicity and impact on cellular and metabolic processes.
Materials and methods: This study investigates the hematological and biochemical effects of exposure to mercuric chloride ($HgCl_2$) in laboratory mice. $HgCl_2$ was administered intraperitoneally to six mice (3 males and 3 females) to evaluate its impact on glucose levels, liver enzymes, and hematological parameters. The aim of the study is to provide insights into the systemic toxicity of $HgCl_2$ and its effects on cellular and metabolic processes.
Results: The results showed a marked decrease in white blood cell (WBC) and red blood cell (RBC) counts, suggesting immunosuppression and a potential decline in oxygen transport capacity. Conversely, a significant increase in platelet count was observed, which may indicate the activation of pro-inflammatory responses or compensatory mechanisms. Elevated glucose levels, as revealed by biochemical analysis, highlighted disruptions in metabolic homeostasis, potentially induced by $HgCl_2$-related stress.
Conclusions: Mercuric chloride ($HgCl_2$) exposure leads to significant alterations in hematological and biochemical parameters, indicating systemic toxicity. These changes suggest impaired immune function, disrupted metabolism, and potential organ stress in exposed mice.
Key Words: Mercuric chloride, Hematological parameters, Glucose levels , Red blood cells ,White blood cells

MIXED MHD CONVECTION OF A HYBRID NANOFLUID IN A CUBIC CAVITY UNDER MAGNETIC FIELD: A NUMERICAL APPROACH

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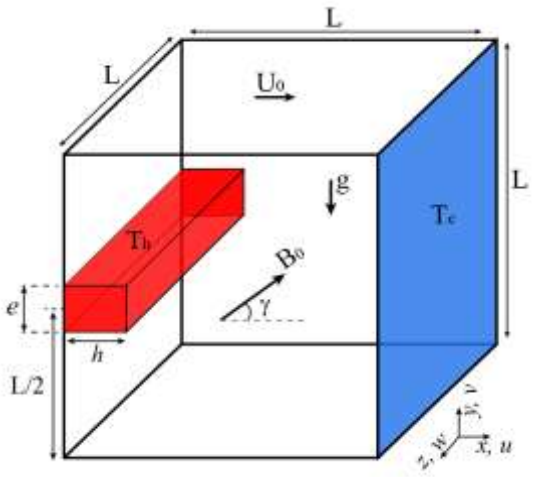
Abstract:

This study conducts a numerical analysis of mixed magneto-hydrodynamic (MHD) convection involving a hybrid nanofluid composed of Cu-Al_2O_3-water within a driven-wall cubic cavity. A heated isothermal block at temperature T_h is mounted on the left wall, while the opposite wall is maintained at a cooler temperature T_c. A magnetic field is applied throughout the domain. The governing equations are solved using the finite volume method, along with the SIMPLE algorithm for pressure-velocity coupling. The investigation explores the effects of several dimensionless parameters: Richardson number from 0.01 to 10, Hartmann number from 0 to 100 and nanoparticle volume fraction from 0 to 0.06. The flow and thermal behaviors are illustrated through streamlines, isotherms, velocity profiles, and average Nusselt number distributions. The findings indicate that increasing Richardson number and volume fraction enhances heat transfer, while a higher Ha value tends to suppress thermal performance.



DESIGNING ENVIRONMENTALLY-FRIENDLY 3D ORGANIC ARCHITECTURE FOR PROTECTIVE SURFACE USING DIP-COATING PROCESS: ELECTROCHEMICAL PERSPECTIVE

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Abstract
The use of organic coatings (OCs) on metallic surfaces, particularly on steel surfaces, is a well-established and effective strategy for enhancing corrosion resistance, especially in aqueous, humid, or harsh environments. In this study, an OCs was developed and applied to carbon steel (CS) alloy substrates using a dip-coating chemical process in an aqueous solution containing HQ functional organic molecules. This treatment led to the formation of a compact and adherent self-assembled layer that chemically interacts with the CS surface, thereby reducing its susceptibility to corrosive agents. The primary function of the OCs is to act as a physical and chemical barrier, preventing direct contact between the CS substrate and aggressive species. Additionally, the flower-like molecular structure of the OCs can be tailored to improve adhesion, hydrophobicity, and chemical resistance, which offer potential for long-term protection in harsh conditions, making it suitable for various industrial applications. The electrochemical stability of the coated and uncoated samples in 3.5 wt% NaCl, 1.0 M HCl, and 1.0 M H_2SO_4 was assessed using Electrochemical Impedance Spectroscopy (EIS) and Potentiodynamic Polarization (PDP) techniques.
Keywords: Carbon steel, Organic coatings, harsh environment, electrochemical performance, and dip-coating.

A QUALITATIVE STUDY OF A NONLINEAR DYNAMICAL SYSTEM WITH GENERALIZED DERIVATIVES

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Abstract:
This study presents a qualitative analysis of a fractional-order dynamical system described by the equations:

$$D^{\alpha}x = y$$
$$D^{\alpha}y = z$$
$$D^{\alpha}z = \mu(2-\mu)x - 2x^3 + x^5 - y - z$$

$\alpha \in [\![0;2]\!]$ and μ as a bifurcation parameter.

The focus is placed on the exploration of chaotic dynamics and the identification of conditions under which a Hopf bifurcation occurs. The analysis begins with a study of the system's stability characteristics as a function of the fractional derivative order α. By varying α, the study examines how the system's stability evolves, leading to different dynamic behaviors, including the onset of chaos.

Tools such as bifurcation diagrams, phase portraits, and Lyapunov exponents are employed to characterize the transition to chaos and the associated dynamical features. Furthermore, the study delves into the phenomenon of Hopf bifurcation, identified through critical values of the bifurcation parameter μ. The emergence of periodic solutions from equilibrium points is discussed, with detailed graphs illustrating how stability regions and bifurcation points evolve with respect to the fractional order α.

The results of this study provide deeper insight into the impact of fractional dynamics on system behavior, highlighting the intricate relationships between chaos, bifurcations, and stability in systems modeled by fractional derivatives.

Keywords:
Dynamical systems, qualitative study, equilibrium points, fixed points, limit points, fractional derivatives

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[3] Mohammed-Salah Abdelouahab ·Nasr-Eddine Hamri · JunweiWang . Hopf bifurcation and chaos in fractional-order modified hybrid optical system - DOI 10.1007/s11071-011-0263-4

ADVANCES IN DRUG DESIGN: A REVIEW OF RECENT TRENDS, CHALLENGES AND FUTURE SCOPE

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ABSTRACT:
Drug design has changed significantly in recent years because to developments in precise delivery systems, new therapeutic modalities, and computational techniques. Target discovery, virtual screening, de novo molecule production, and toxicity prediction are all accelerated by artificial intelligence (AI) and machine learning (ML), which have become potent tools in drug design pipelines. Research shows that deep learning—particularly generative models and geometric graph neural networks—is becoming more popular for protein engineering and structure-based design. In order to interpret model decisions and improve usability and trust, explainable AI techniques are becoming more popular. Geometric deep learning and 3D modeling advancements (like AlphaFold) greatly aid structure-based drug design by facilitating better binding-site recognition, affinity prediction, and scaffold innovation. Combining data-driven and knowledge-based approaches into hybrid paradigms holds the potential of overcoming the drawbacks of each approach alone. Nanoparticles, ADCs, electro-responsive implants, and 3D-printed formulations are examples of intelligent, stimuli-responsive drug delivery systems that have developed into sophisticated structures that provide improved bioavailability and spatiotemporal control. Nevertheless, these developments face real-world obstacles like regulatory barriers, in vivo stability, and manufacturing scalability. A resurgence of PROTACs and targeted covalent inhibitors (TCIs) demonstrates novel therapeutic approaches with distinct pharmacodynamics and high selectivity. Complementary methods, such as organ-on-chip models and dynamic combinatorial chemistry, provide new paths for preclinical validation and ligand discovery. However, the area still faces persistent challenges, such as interpretability and data quality, gaps in the translation between in silico and experimental results, time and cost limits, and changing regulatory frameworks. Robust multi-omics integration, modular delivery systems, integrated AI-experimental procedures, and innovative policymaking will all be necessary to meet these problems. The combination of AI-powered approaches, cutting-edge delivery systems, and flexible regulatory regimes will shape medication design in the future. When combined, these components offer a more effective, accurate, and customized therapeutic environment.

ALZHEIMER'S DISEASE

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Abstract

Many studies are still being conducted on disease-modifying therapeutic approaches for Alzheimer's disease (AD). These days, the only therapies for this illness are symptomatic ones that aim to balance the neurotransmitter disruption: memantine and three cholinesterase inhibitors. Therapeutic medicines are intended to impede the development of the disease by interfering with the pathogenic processes that cause the clinical symptoms, which traditionally include the production of intracellular neurofibrillary tangles and the deposition of extracellular amyloid β plaques. Anti-inflammatory, growth factor-promoting, neuroprotective, metabolically effective, and stem cell therapies all address other underlying pathways. Numerous additional elements, including fresh biomarkers, new neuropsychological outcomes, enrolment of earlier populations during the course of the disease, and creative trial designs, have been incorporated into recent medicines.. A "precision medicine" setting may soon employ distinct agents for each patient, where abnormal biomarkers combined with a specific pattern of neuropsychological and neuroimaging results could dictate a particular course of treatment within a tailored therapeutic framework. We go over possible disease-modifying treatments that are being researched as well as customised treatment plans that may be helpful for AD patients in this overview. The terms

Keyword: Alzheimer's disease, disease-modifying medications, anti-amyloid, anti-Tau, and customised treatment plans

ANALYTICAL TECHNIQUES IN PHARMACEUTICAL QUALITY CONTROL

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ABSTRACT:
Analytical techniques are integral to pharmaceutical quality control, ensuring the safety, efficacy, and consistency of drug products throughout manufacturing and distribution. These techniques enable the identification, quantification, and characterization of active pharmaceutical ingredients (APIs), excipients, impurities, and degradation products. Among the most widely used methods are high-performance liquid chromatography (HPLC), gas chromatography (GC), ultraviolet-visible (UV-Vis) spectroscopy, infrared (IR) spectroscopy, mass spectrometry (MS), and nuclear magnetic resonance (NMR) spectroscopy. Each technique provides unique advantages in analyzing different aspects of drug substances and formulations. For instance, HPLC is essential for impurity profiling and content uniformity, while MS and NMR offer precise structural elucidation. Advanced hyphenated techniques like LC-MS and GC-MS have improved the sensitivity and selectivity of analysis, enabling detection of trace-level contaminants. Additionally, titrimetric and gravimetric methods remain relevant for routine quality assessments due to their simplicity and cost-effectiveness. Quality control laboratories also utilize dissolution testing, stability studies, and particulate matter analysis to evaluate product performance over time. The integration of automated systems and real-time analytical monitoring through Process Analytical Technology (PAT) further enhances manufacturing efficiency and regulatory compliance. Strict adherence to Good Laboratory Practices (GLP) and International Council for Harmonisation (ICH) guidelines ensures data integrity and reliability. As the pharmaceutical industry continues to advance, the role of precise, validated analytical techniques remains critical in upholding product quality, patient safety, and global regulatory standards.
Keywords: Analytical techniques, pharmaceutical quality control, HPLC, drug analysis, process validation

ANTIOBIOTIC RESISTANCE: CHALLENGES AND THE ROLE OF PHARMACISTS

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ABSTRACT:
Overprescribing, patient abuse, and pandemic-related disruptions to stewardship programs are the main causes of antibiotic resistance (AMR), which is becoming a greater global concern. Pharmacists are crucial in addressing this epidemic through public education, antimicrobial stewardship (AS) programs, and antibiotic usage monitoring in their clinical and community responsibilities. Clinical pharmacists assist with de-escalation procedures, formulary management, prospective audits, and guidelines formulation in hospitals. Although there is still little data on the impact of resistance and mortality, a recent systematic review that included 24 trials (2016–2023) showed that pharmacist-led interventions enhanced prescribing appropriateness, decreased antibiotic duration and costs, and shortened hospital admissions. Pharmacist participation in stewardship teams dramatically reduces overall antibiotic prescribing and improves general practitioners' adherence to guidelines, according to meta-analyses. Pharmacists frequently act as the initial point of contact in community settings, particularly in low- and middle-income nations. Their critical significance in One-Health campaigning, public awareness initiatives, and rational antibiotic dispensing is highlighted by narrative evaluations. Targeted educational programs in countries like Saudi Arabia and Pakistan have demonstrated notable gains in pharmacist competence and antibiotic stewardship practices, despite systemic obstacles such inadequate training, time restrictions, and lack of regulation. Organizations like the Society of Infectious Diseases Pharmacists, which support public education and policy worldwide, are prime examples of the underutilized role pharmacists play in antimicrobial stewardship advocacy. However, problems still exist: the strain of the pandemic on healthcare systems reduced the capabilities of AS and increased its overuse. To sum up, pharmacists play a critical role in combating AMR through hospital governance, community involvement, and policy advocacy. Efforts should concentrate on improving AMR training, including pharmacists in stewardship teams, growing community-level initiatives, and fortifying regulatory frameworks in order to have the greatest possible impact.

YARIMSİNTETİK YAĞLARA SİYRİLMƏYƏ QARŞI AŞQAR

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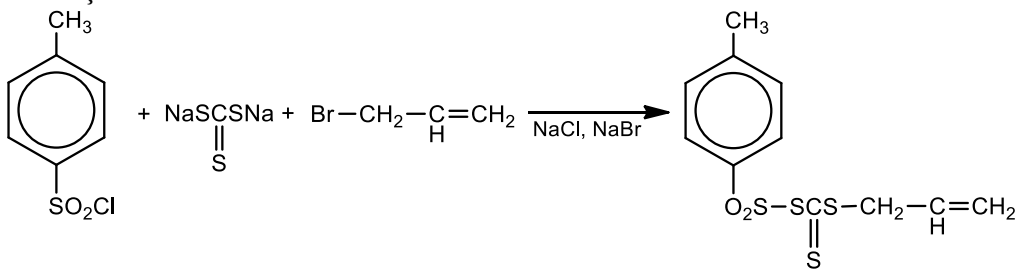
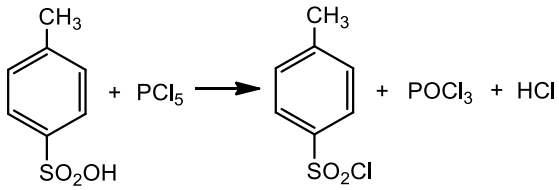
Özət
Müasir nəqliyyat vasitələrinin gücünü nəzərə alaraq, transmissiyaya düşən yüklər çox yüksək ola bilər. Bu baxımdan, transmissiya yağları effektli siyrilməyə qarşı xassələrə malik olmalıdır. Buna geniş temperatur diapazonunda işləyə bilən yarımsintetik yağlardan istifadə etməklə nail olmaq olar, xüsusən də onlar tam sintetik yağlardan əhəmiyyətli dərəcədə ucuzdur.
Bizim tərəfimizdən, ədəbiyyatda məlum olmayan toluolsulfoalliltritiokarbonat sintez edilmiş və siyrilməyə qarşı aşqar kimi tədqiq olunmuşdur. Birləşmə aşağıda verilən sxem üzrə alınmışdır:



Başlanğıc maddə kimi götürülmüş sulfoxlorid məlum üsulla sintez edilmişdir [1].



İkinci başlanğıc maddə – allilbromid əmtəə məhsuludur.
Toluolsulfoalliltritiokarbonatın sintezi 2 mərhələdə aparılır. 1-ci mərhələdə natriumtritiokarbonat alınır, sonra isə ardıcıllıqla hissə-hissə toluolsulfoxlorid və damcı-damcı

allilbromid əlavə edilir, reaksiya 60-65^{0}C-də 5 saat ərzində aparılır. Maddə kristaldır. Tər. – 60^{0}C. Maddənin tərkibi və kimyəvi quruluşu element analizi və İQ spektroskopiya üsulu ilə təsdiq edilmişdir.
Toluolsulfoalliltritiokarbonatın SN-1200 baza yağı və PEE (pentaeritrit efiri) sintetik yağın 1:1 nisbətində götürülmüş tərkibində 2% qatılıqda tədqiq edilmişdir.
Alınan nəticələrdən məlum olmuşdur ki, toluolsulfoalliltritiokarbonat yüksək siyrilməyə qarşı xassələrə malikdir. Bu bir tərəfdən maddənin tərkibində kükürd atomunun çox olması ilə, digər tərəfdən molekulunda allil qrupunun olması ilə izah edilir [2].
Beləliklə, sintez olunmuş toluolsulfoalliltritiokarbonat yarımsintetik transmissiya yağlarının yaradılması üçün təklif oluna bilər.

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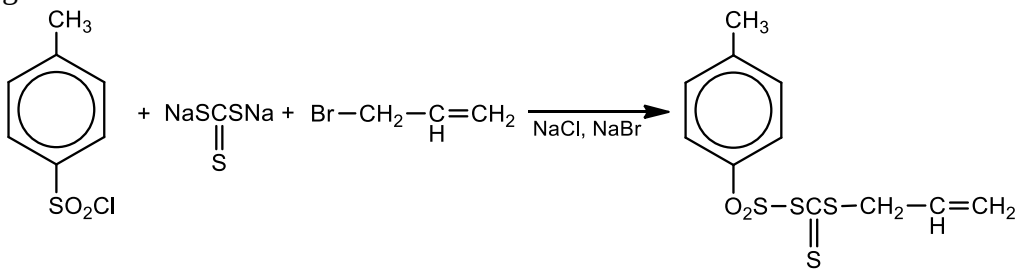
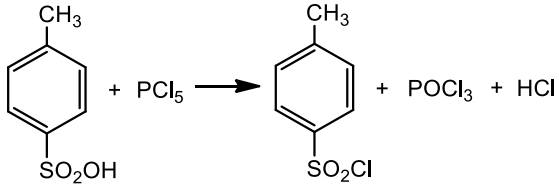
ANTI-SEIZE ADDITIVE FOR SEMI-SYNTHETIC OILS

Abstract

Given the power of modern vehicles, the loads on the transmission can be very high. In this regard, transmission oils must have effective anti-seize properties. This can be achieved by using semi-synthetic oils that can operate in a wide temperature range, especially since they are significantly cheaper than fully synthetic oils.
We have synthesized toluenesulfoallyltrithiocarbonate, which is not known in the literature, and studied it as an anti-seize additive. The compound was obtained according to the scheme given below:



Sulfochloride, taken as the starting material, was synthesized by a known method [1].



The second starting material is allyl bromide, a commodity product.
The synthesis of toluenesulfoallyltrithiocarbonate is carried out in 2 stages. In the 1st stage, sodium trithiocarbonate is obtained, then toluenesulfochloride and allyl bromide are added dropwise in sequence, the reaction is carried out at 60-65^{0}C for 5 hours. The substance is crystalline. Melting point – 60^{0}C. The composition and chemical structure of the substance were confirmed by elemental analysis and IR spectroscopy.

Toluenesulfoallyltrithiocarbonate was studied in a 2% concentration in a 1:1 mixture of SN-1200 base oil and PEE (pentaerythritol ether) synthetic oil.

The results obtained showed that toluenesulfoallyltrithiocarbonate has high anti-seize properties. This is explained, on the one hand, by the large number of sulfur atoms in the substance, and, on the other hand, by the presence of an allyl group in its molecule [2].

Thus, the synthesized toluenesulfoallyltrithiocarbonate can be proposed for the creation of semi-synthetic transmission oils.

ARNAVUTLUK'UN NATO ÜYELİĞİNİN BÖLGESEL GÜVENLİĞE ETKİSİ

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Özet

Bu bildiri, Arnavutluk'un 2009 yılında NATO'ya tam üye olmasının, yalnızca ulusal güvenliğine değil, aynı zamanda Batı Balkanlar'ın istikrarına olan doğrudan etkisini bilimsel bir çerçevede ele almaktadır. Tarihsel olarak kırılgan, etnik gerilimlere açık ve jeopolitik olarak rekabetin yoğun olduğu bir bölgede Arnavutluk'un NATO şemsiyesi altına girmesi, bölgesel caydırıcılığı artırmış ve güven inşa sürecine ivme kazandırmıştır. Bu üyelik, yalnızca askeri bir güvenlik garantisi değil; aynı zamanda kurumsal reformları teşvik eden, şeffaflığı artıran ve demokratikleşmeyi hızlandıran bir yapı olarak değerlendirilmelidir. Arnavutluk'un, Kosova gibi istikrarsızlık potansiyeli taşıyan komşu alanlardaki duruşu, NATO çerçevesinde çok taraflı bir güvenlik anlayışına dönüşmüş; bölgesel güç dengelerini dengeleyen stratejik bir unsur haline gelmiştir. NATO'nun güneydoğu kanadında önemli bir lojistik konuma sahip olan Arnavutluk, ittifakın operasyonel kapasitesine katkı sunmakla kalmamış, aynı zamanda Balkanlar'daki Avrupa-Atlantik entegrasyonunun da katalizörü olmuştur. Bu bildiride, Arnavutluk'un üyeliğini yalnızca sembolik bir katılım değil, bölgesel güvenlik mimarisinde yapısal bir dönüm noktası olarak konumlandırmaktadır.

Anahtar Kelimeler: NATO, Arnavutluk, bölgesel güvenlik, caydırıcılık, stratejik denge, demokratikleşme.

THE IMPACT OF ALBANIA'S NATO MEMBERSHIP ON REGIONAL SECURITY

Abstract

This paper examines the impact of Albania's full accession to NATO in 2009, not only on its national security but also on the broader stability of the Western Balkans, within a rigorous analytical framework. Situated in a historically fragile region characterized by ethnic tensions and intense geopolitical rivalry, Albania's integration under NATO's umbrella has significantly enhanced regional deterrence and accelerated confidence-building processes. lMembership in the Alliance should not be viewed merely as a military security guarantee; it has also served as a catalyst for institutional reforms, greater transparency, and democratic consolidation. Albania's stance on neighboring areas with latent instability—most notably Kosovo—has been reframed through a multilateral security approach under NATO, rendering the country a strategic balancing actor in the regional power dynamics. With its critical logistical position on NATO's southeastern flank, Albania has contributed meaningfully to the operational capacity of the Alliance, while simultaneously acting as a driving force for Euro-Atlantic integration in the Balkans. This paper argues that Albania's membership constitutes not just a symbolic affiliation, but a structural turning point in the architecture of regional security.

Keywords:
NATO, Albania, regional security, deterrence, strategic balance, democratization.

FORMULATION DEVELOPMENT OF NOVEL DRUG DELIVERY SYSTEMS: CHALLENGES AND OPPORTUNITIES

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Abstract
The landscape of pharmaceutical science has witnessed remarkable innovations over recent decades as researchers strive to overcome the limitations of conventional drug delivery. Conventional methods, while foundational, often fall short of ensuring precise targeting, controlled release, and improved bioavailability—factors that are critical for maximizing therapeutic efficacy and minimizing adverse effects. Against this backdrop, formulation development of novel drug delivery systems (NDDS) has emerged as one of the most dynamic and pivotal areas of research and development. This treatise examines the evolution of drug delivery platforms—from conventional oral and parenteral formulations to sophisticated systems such as nanoparticles, liposomes, implants, and microneedle arrays. It also explores the myriad challenges that accompany the design and formulation process, including issues of solubility, stability, scalability, regulatory hurdles, and the intricacies of patient-specific delivery profiles. Equally, the discussion highlights emerging opportunities driven by advanced materials science, nanotechnology, digital tools, and personalized medicine, which promise to redefine how active pharmaceutical ingredients (APIs) are delivered to their site of action.In detailing the latest trends and breakthrough strategies, this review underscores the importance of interdisciplinary collaboration, integrating insights from chemistry, biology, engineering, and regulatory science. The discussion is structured into several key sections: an overview of conventional and novel drug delivery paradigms, formulation considerations and process development, an in-depth look at novel drug delivery approaches, challenges in formulation development, opportunities for technological and process enhancements, and future perspectives for the field. Each section draws upon current research, case studies, and technology roadmaps that inform both early development and clinical applications. Ultimately, this review evokes a forward-looking vision where novel drug delivery systems not only address current therapeutic needs but also open avenues for safer, more effective, and patient-centric treatments.
Keywords: Novel drug delivery systems, formulation development, nanotechnology, controlled release, targeted delivery, regulatory challenges, personalized medicine.

Introduction

Drug delivery represents one of the most critical interfaces in medical treatment, linking potent therapeutic agents with their intended biological targets. Historically, administration routes such as oral, intravenous, and intramuscular injections have dominated therapy; however, these conventional approaches present limitations including poor bioavailability, non-specific distribution, and significant systemic side effects. As our understanding of disease pathology has advanced, so too has the need for formulations capable of targeting specific tissues, ensuring sustained release, and optimizing pharmacokinetics.The evolution of drug delivery has been driven by a convergence of scientific disciplines—with organic and polymer chemistry, materials science, engineering, and medicine coalescing to address these challenges.

The formulation development of novel drug delivery systems (NDDS) can be viewed as an iterative process that begins with understanding the pharmacological properties of the active pharmaceutical ingredient (API) and culminates in a delivery mechanism that maximizes therapeutic impact while minimizing adverse effects.

Over the past several decades, the field has experienced a paradigm shift from the "one-size-fits-all" approach toward more personalized and precision-based strategies. This transition is marked by the development of systems such as nanoparticles, which leverage enhanced permeability and retention effects for tumor targeting; liposomes that offer biocompatibility and controlled release; and implantable devices that provide sustained action for chronic conditions. Each of these innovations represents a testimonial to the relentless pursuit of improved outcomes in patient care.Yet, the road to innovation is paved with challenges. From the physicochemical hurdles intrinsic to APIs—such as solubility or chemical instability—to the complexities associated with scale-up and regulatory compliance, formulation scientists must navigate a labyrinth of technical and logistical obstacles. Moreover, the programmable nature of many modern materials introduces additional layers of complexity regarding manufacturing reproducibility and storage stability.In this review, we illuminate the multifaceted nature of formulation development in NDDS by first contextualizing the scientific rationale for innovation. We elaborate on the technical requirements, material selection, and processing techniques that underpin successful formulations. Furthermore, we explore a series of case studies and success stories that demonstrate how targeted delivery systems can be engineered to overcome traditional barriers. By highlighting both obstacles and opportunities, we demonstrate that while challenges exist, the potential to revolutionize therapeutic efficacy is enormous.

As we journey through this review, the emphasis will be on a balanced analysis—acknowledging the hurdles while remaining optimistic about the opportunities bestowed by advances in nanotechnology, computational modeling, and biomimetics. Our discussion begins with an overview of drug delivery systems, setting the stage for a deeper exploration of the formulation challenges and the promising opportunities that lie ahead.

Overview of Drug Delivery Systems

Historical Context and Traditional Approaches

The development of drug formulations began long before the advent of modern molecular science. Early remedies relied on crude extracts and natural compounds, where the therapeutic agent was often used in its crude form. With the emergence of synthetic drugs in the 20th century, the need for controlled and reproducible formulation strategies became paramount. Traditional drug delivery methods, such as oral tablets and injectables, were developed to offer convenience and simplicity in administration. However, these methods often resulted in rapid drug clearance, limited absorption, and widespread distribution within the body, leading to a high incidence of side effects.Over time, formulation scientists sought ways to optimize therapeutic outcomes by modifying the release kinetics and enhancing the bioavailability of the drug. Techniques such as enteric coating, time-release formulations, and the use of excipients became vital tools in overcoming the limitations posed by the native physicochemical properties of certain drugs. These traditional approaches, while foundational, primarily aimed to address immediate concerns of stabilization and prolonged release rather than targeted therapeutic delivery.

The Emergence of Novel Approaches

The disadvantages of conventional methods have spurred the development of novel drug delivery systems designed to improve the therapeutic index of drug compounds. Modern approaches leverage advancements in nanotechnology, biotechnology, and materials science to create platforms that can deliver drugs precisely where they are needed. For example, nanoparticles and liposomes have been engineered to encapsulate drugs, protect them from

premature degradation, and ensure their release only upon reaching the desired target tissues. This shift toward precision medicine has marked a significant evolution in drug delivery science.Novel drug delivery systems are not merely scaled-down versions of traditional systems but represent a rethinking of the entire drug administration process. By harnessing the unique properties of nanoscale materials, these systems improve targeting through passive mechanisms like the enhanced permeability and retention effect, as well as active targeting via ligands that recognize specific cellular markers. Additionally, implantable pumps, transdermal patches, and microneedle arrays have enriched the therapeutic arsenal—each designed to address specific clinical requirements ranging from chronic disease management to acute emergency interventions.

Understanding the Biological Barriers

One of the central challenges in designing NDDS is the body's intrinsic defense mechanisms. Biological barriers—including the gastrointestinal lining, the blood–brain barrier, and the skin—are naturally designed to protect vital functions from foreign substances. Consequently, formulating a drug delivery system that can navigate and, when necessary, bypass these barriers represents a formidable task. Researchers have developed various strategies to address these barriers: bioadhesive formulations for mucosal routes, receptor-mediated endocytosis for targeted uptake, and stimuli-responsive systems that release the drug in response to changes in pH, temperature, or enzymatic activity.Navigating these barriers requires an in-depth understanding of both the material properties of the drug delivery vehicle and the complex physiological environment into which it is deployed. For instance, a formulation intended for delivery to the central nervous system must overcome strict tight junctions while maintaining biocompatibility and minimal immunogenicity. Equally, oral formulations must contend with harsh conditions in the gastrointestinal tract, where pH variations and enzymatic activity can compromise drug integrity.

Current Trends and Future Directions

Current research in NDDS is increasingly oriented toward the integration of digital tools, smart materials, and artificial intelligence. High-throughput screening methods, computational modeling, and machine learning algorithms are enabling formulation scientists to predict and optimize the behavior of drug delivery systems far more accurately than ever before. Moreover, 3D printing and microfluidic technologies are opening up new possibilities for custom-tailored formulations that meet the specific needs of individual patients—or even specific patient populations.The potential of these approaches is reflected in the growing body of literature demonstrating success across a variety of applications, from oncology to gene therapy. As personalized medicine continues to be a dominant focus of biomedical research, the formulation development process is positioned to take advantage of the confluence of data-driven design and innovative material science. This blend of technology and science promises to transform the drug delivery landscape, offering unprecedented control over therapeutic outcomes.In summary, the evolution from traditional to novel drug delivery systems is characterized by a progression from simple, passive formulations to complex, multifunctional platforms. While the challenges are many, the promise of improved patient outcomes drives the continued innovation and investment in this field. The remainder of this paper delves into the formulation development process, the challenges faced, and the opportunities on the horizon.

Formulation Considerations in Novel Drug Delivery Systems

The formulation development process in NDDS is an intricate endeavor that requires the convergence of multiple scientific disciplines. The journey begins with understanding the unique characteristics of the API and determining the optimal carrier system that can address its limitations while leveraging its therapeutic strengths.

Preformulation Studies and Physicochemical Characterization

Preformulation is the foundation upon which any successful drug delivery system is built. It involves comprehensive physicochemical characterization of the API—parameters such as solubility, pKa, molecular weight, crystallinity, and partition coefficient are meticulously evaluated. These parameters determine how the molecule interacts with various excipients and influences factors like dissolution rate, stability, and permeability.For instance, APIs with poor aqueous solubility may require strategies such as nanoparticle dispersion or the use of solubilizing agents to enhance absorption. Alternatively, drugs that are highly susceptible to degradation might benefit from encapsulation in protective carriers like liposomes or polymeric nanoparticles. The end goal of these studies is to tailor the formulation to maintain the integrity of the API while maximizing its bioavailability and therapeutic concentration at the target site.

Selection and Role of Excipients

Excipients play a critical role in the overall performance of any drug delivery system. They serve as the medium in which the API is delivered, influence the drug's release kinetics, and can even affect the biodistribution of the active compound in the body. In NDDS, the selection of excipients extends beyond traditional polymers and fillers to include novel biomaterials such as biodegradable polymers, stimuli-responsive hydrogels, and lipid-based carriers.The compatibility between excipients and the API is paramount; any chemical interaction that compromises drug stability can lead to reduced efficacy or unforeseen toxicity. Modern formulation development often employs a combination of empirical studies and computational methods to select excipients that not only ensure compatibility but also promote the desired release profile. This strategy allows for the fine-tuning of formulation properties to meet both the physicochemical requirements of the API and the clinical needs of the patient.

Manufacturing Process Considerations

The process by which a formulation is manufactured has profound implications for its clinical performance and scalability. Techniques such as high-pressure homogenization, solvent evaporation, spray drying, and microfluidic formulation have all emerged as effective methods for producing NDDS. Each method presents its own set of variables—including particle size distribution, encapsulation efficiency, and batch-to-batch reproducibility—that must be rigorously controlled.The challenges inherent in scale-up from bench to industrial production cannot be understated. A formulation that performs optimally in a laboratory setting might falter when subjected to the rigors of mass production, where factors such as mixing dynamics, environmental conditions, and equipment variability can influence product quality. Thus, process development is closely intertwined with formulation research, requiring iterative optimization and robust quality control measures to ensure that the final product meets stringent regulatory standards.

Stability and Storage Concerns

Stability is a critical determinant of a formulation's shelf life and clinical efficacy. Novel drug delivery systems often incorporate materials and structures that are highly sensitive to environmental conditions such as temperature, humidity, and light. Stability testing involves a series of accelerated and long-term studies to assess whether the structural integrity, potency, and release properties of the formulation are maintained under various storage conditions.For several advanced NDDS, such as those based on nanotechnology, the aggregation or degradation of nanoparticles can drastically reduce therapeutic effectiveness. Advances in material science have led to the development of surface modification techniques—such as PEGylation or coating with stabilizing agents—that enhance the longevity and stability of these systems. Ensuring robust stability while preserving the biological activity of the API is a critical balance that formulation scientists must achieve.

Targeting and Release Kinetics

Among the most compelling features of NDDS is the ability to engineer systems that release their payload in a controlled and targeted manner. The design of these systems takes into account physiological cues such as pH gradients, temperature, or enzymatic profiles, which can trigger drug release only when the carrier reaches its destination. For instance, tumor microenvironments, which are often characterized by an acidic pH, can be exploited by pH-sensitive polymers to release chemotherapeutic agents directly into cancer cells.Control over release kinetics is accomplished through careful manipulation of formulation variables, including particle size, matrix porosity, and the use of stimuli-responsive materials. By modulating these parameters, researchers can tailor the drug release profile from a rapid burst to a sustained, controlled delivery—each profile being optimal for different therapeutic scenarios. Such precision is essential in avoiding systemic toxicity while ensuring that the drug concentration at the target site remains within the therapeutic window for an adequate period.

In Vitro and In Vivo Evaluation

The formulation development process is incomplete without rigorous in vitro and in vivo testing to evaluate efficacy, release kinetics, biocompatibility, and toxicity. Advanced in vitro models, including cell-based assays and tissue-mimicking constructs, provide initial insights into how the formulation interacts with biological tissues. However, in vivo studies remain indispensable for capturing the complex interactions present in a living system—including metabolism, immune response, and biodistribution.Animal models are commonly used to bridge this gap, although differences between animal physiology and human biology present limitations. Innovative approaches such as organ-on-a-chip technology and sophisticated computational models are beginning to supplement traditional in vivo studies. Such platforms not only reduce reliance on animal testing but also allow for a more detailed mechanistic understanding of drug release, distribution, and clearance.In conclusion, the formulation considerations for NDDS are as complex as they are critical. The journey from preformulation studies through to manufacturing and evaluation requires a thorough understanding of both the API's physicochemical properties and the biological environment in which it is meant to act. Each step is a balancing act—optimizing for stability, targeted delivery, and controlled release while ensuring manufacturability and regulatory compliance. These considerations lay the groundwork for the myriad innovations in novel drug delivery approaches that are discussed in the following section.

Novel Drug Delivery Approaches: Technologies and Strategies

The burgeoning field of novel drug delivery systems is characterized by its diversity. As researchers strive to circumvent the shortcomings of conventional delivery methods, a wide range of innovative platforms has been developed. These platforms often leverage the unique properties of nanomaterials, smart polymers, and bio-inspired designs to achieve unprecedented levels of precision and efficacy in drug delivery.

Nanoparticle-Based Delivery Systems

Nanoparticles have become one of the most extensively studied and clinically promising platforms in modern drug delivery. With sizes typically ranging from 10 to 1000 nanometers, these carriers can encapsulate a variety of APIs, protecting them from degradation while enabling enhanced solubility. The small size of nanoparticles allows them to navigate biological barriers and accumulate preferentially in diseased tissues through mechanisms such as the enhanced permeability and retention (EPR) effect.Polymeric nanoparticles, liposomes, and solid lipid nanoparticles are among the most common variants. Polymeric nanoparticles are formulated using biodegradable polymers such as polylactic acid (PLA) or poly(lactic-co-glycolic acid) (PLGA), which break down into non-toxic byproducts. Liposomes, on the other hand, mimic natural cell membranes in structure and can encapsulate both hydrophilic and hydrophobic drugs. Solid lipid nanoparticles provide the advantage of physical stability and

controlled drug release. Regardless of the specific system, nanoparticles offer the dual benefits of targeted delivery and reduced systemic toxicity, making them particularly attractive for oncologic and central nervous system therapies.

4.2 Liposomal Platforms

Liposomes represent one of the earliest forms of NDDS and remain a cornerstone of modern targeted delivery strategies. Comprised of concentric lipid bilayers, liposomes can encapsulate drugs in their aqueous core or within the hydrophobic layers, depending on the nature of the API. Surface modification through the attachment of polyethylene glycol (PEG) has further enhanced their circulation time by reducing uptake by the reticuloendothelial system, thereby enabling them to circulate longer and deliver their payload more effectively.The versatility of liposomes has led to their successful application in delivering chemotherapeutic agents, vaccines, and even nucleic acids for gene therapy. Innovations in liposome formulation, such as the development of pH-sensitive and ligand-targeted formulations, have improved the specificity and efficacy of these carriers. Despite these advances, challenges such as batch variability and scale-up remain, highlighting the need for further research and standardized manufacturing protocols.

Polymeric Micelles and Dendrimers

Polymeric micelles are formed by the self-assembly of amphiphilic block copolymers in aqueous solutions, creating a core–shell structure that is particularly useful for solubilizing hydrophobic drugs. The hydrophobic core acts as a reservoir for the drug while the hydrophilic shell enhances the system's stability in biological fluids. These micellar systems are characterized by their small size, ease of production, and ability to improve the pharmacokinetic properties of their payloads.Dendrimers, on the other hand, embody a unique class of hyperbranched polymers that offer an incredible degree of control over molecular architecture. Their structurally defined branches allow for high drug loading capacities and the possibility of precise functionalization. The multivalent nature of dendrimers offers exciting possibilities for targeted delivery, as multiple ligands can be attached to the dendrimer surface to mediate binding to specific cellular receptors. However, issues related to toxicity and biodistribution remain active areas of investigation, requiring further optimization before widespread clinical adoption.

Transdermal and Implantable Systems

Transdermal drug delivery systems represent a non-invasive route that circumvents the gastrointestinal tract and first-pass metabolism. These systems, which include patches and microneedle arrays, are designed to penetrate the stratum corneum—the outermost layer of the skin—without causing significant discomfort or damage. Microneedle arrays, in particular, have generated significant interest because they provide a pain-free alternative to injections while enabling controlled drug release. Advances in material science have facilitated the development of dissolvable microneedles that release their payload once inserted, offering a precise and patient-friendly method for vaccine delivery and hormone therapy.Implantable systems offer yet another avenue for sustained drug release. These systems can be designed to release drugs over prolonged periods—sometimes spanning months or even years—thus offering significant advantages for chronic conditions such as diabetes, cancer, or cardiovascular disease. The design and fabrication of implantable devices involve careful consideration of biocompatibility, mechanical stability, and the controlled degradation of the carrier material. In many cases, the implants are engineered to bypass the need for daily administration, improving patient compliance and therapeutic outcomes.

Emerging Technologies: 3D Printing and Microfluidics

In recent years, emerging technologies such as 3D printing and microfluidics have begun to make their mark on the field of drug delivery. 3D printing enables the fabrication of complex geometries and personalized dosage forms that can be tailored to individual patient needs. This

technology is particularly useful in producing implants and scaffolds with intricate internal architectures that control drug release. The promise of on-demand, patient-specific formulations could potentially revolutionize how medicines are produced and delivered in a clinical setting.Microfluidics, the manipulation of fluids in channels with dimensions on the order of micrometers, offers another powerful tool for formulation development. Microfluidic devices allow for the precise control of formulation parameters such as particle size, mixing efficiency, and encapsulation yield. By enabling high-throughput production and real-time monitoring, microfluidics is poised to streamline the production of NDDS, ensuring reproducibility and scalability.

Gene Delivery and Biologic Therapeutics

Beyond small-molecule drugs, NDDS have opened up exciting possibilities in the delivery of biologics, including proteins, peptides, and nucleic acids. Gene therapy, for instance, relies on vehicles that can safely and efficiently transport genetic material into cells without eliciting an immune response. Viral vectors have historically been employed for this purpose; however, their potential for immunogenicity and insertional mutagenesis has led researchers to explore non-viral delivery systems. Nanoparticles, liposomes, and polymeric carriers are actively being developed to meet this need, with promising results in early-stage clinical trials.The development of these platforms requires an even more nuanced understanding of formulation science. Biologic molecules are typically more fragile than small-molecule drugs, necessitating gentler processing techniques and robust stabilization strategies. The integration of targeting ligands, the use of stimuli-responsive carriers, and the optimization of release kinetics are all critical factors that must be harmonized to ensure successful gene delivery and subsequent expression of the therapeutic protein.Overall, the panorama of novel drug delivery approaches is as diverse as it is innovative. Each platform offers unique advantages—and distinct challenges—that contribute to the broader field of formulation science. The promise of these technologies lies in their ability to overcome the limitations of conventional delivery methods, thereby enhancing therapeutic efficacy and patient outcomes.

Challenges in Formulation Development

While the promise of NDDS is vast, the journey from concept to clinical application is fraught with a host of challenges that must be carefully navigated during formulation development. This section outlines the primary hurdles confronting researchers and formulation scientists today.

Physicochemical Limitations and API Challenges

Many active pharmaceutical ingredients (APIs) present inherent challenges related to poor solubility, limited stability, and unfavorable partition coefficients. These physicochemical properties can hinder the absorption, distribution, and, ultimately, the therapeutic efficacy of the drug. For hydrophobic molecules particularly, achieving a formulation that provides adequate solubility while preserving the structural integrity of the API requires innovative approaches such as the development of nanoparticle suspensions or the incorporation of solubilizing excipients.Transforming the physicochemical limitations of an API into an opportunity for enhanced delivery often involves extensive preformulation work. This work isn’t simply about identifying the challenges—it’s also about devising strategies to overcome them. For example, modifying the chemical structure through salt formation or prodrug conversion has proven to be effective in some cases. In addition, encapsulation techniques that protect the API from environmental degradation represent key strategies for addressing the instability of sensitive compounds.

Scale-Up and Manufacturing Issues

A formulation that demonstrates exceptional performance in the controlled environment of a laboratory does not automatically translate into a commercially viable product. Scale-up presents a unique set of process challenges. Variables such as mixing dynamics, shear forces,

and batch-to-batch variability can drastically affect the quality and performance of the final product. Techniques that show promise in a small-scale setting must be rigorously revalidated during pilot production to ensure that the physical characteristics essential to drug delivery—such as particle size, encapsulation efficiency, and release kinetics—remain consistent.The transition from bench to large-scale manufacturing necessitates close collaboration between formulation scientists and process engineers. The development of robust, scalable processes that can accommodate stringent regulatory requirements is essential, yet often challenging, particularly when dealing with cutting-edge materials and techniques that are not yet fully standardized in the industry.

Regulatory and Quality Assurance Hurdles

Developing NDDS is not solely a technical endeavor; it is equally subject to the pressures and constraints imposed by regulatory bodies. The complexity of these systems—often involving novel materials and multifunctional components—can complicate the regulatory review process. Agencies such as the U.S. Food and Drug Administration (FDA) and the European Medicines Agency (EMA) require rigorous data on safety, efficacy, stability, and reproducibility. This requirement often demands additional layers of testing and validation beyond what is necessary for conventional formulations.Compliance with current Good Manufacturing Practices (cGMP) and the need for rigorous quality assurance further complicate the process. These regulatory challenges, while designed to protect patient safety, can introduce significant delays and financial pressures in the development pipeline. The balancing act between innovation and regulatory compliance is a constant theme in the NDDS arena.

Toxicological and Immunogenic Considerations

One of the most critical aspects of developing any drug delivery system is its biocompatibility. Novel materials, which may exhibit exceptional delivery properties in vitro, can become problematic when introduced into the complex milieu of the human body. Nanoparticles, for instance, may trigger unforeseen immune responses or display cytotoxic effects, particularly if their size, surface charge, or chemical composition is not meticulously controlled.The biodistribution and long-term fate of NDDS remain active areas of research. Toxicological assessments must account not only for the immediate effects of the formulation but also for the potential build-up of materials in vital organs or their interactions with the immune system over extended periods. In some cases, even minor modifications in formulation composition can drastically alter the immunogenic profile of the delivery system, underscoring the importance of comprehensive preclinical evaluation.

Cost and Economic Viability

Another important challenge in the formulation development of NDDS is the cost of production. Many novel approaches involve complex synthesis processes and require high-purity materials, both of which can drive up production costs. These economic considerations are not merely academic—they have a direct impact on the access and adoption of new therapies, particularly in low-resource settings.Developing cost-effective manufacturing methods without compromising the quality or performance of the formulation is a critical hurdle. Innovations such as continuous manufacturing and process intensification are being explored to reduce costs, but these approaches also require significant upfront investment and robust process control strategies.

Patient Variability and Personalized Medicine Challenges

Patient heterogeneity presents another layer of complexity in delivering the ideal formulation for every individual. Variations in metabolism, disease state, genetics, and even the microenvironment of a disease site can influence how a drug is absorbed and metabolized. Modern NDDS are increasingly focused on personalized delivery approaches, yet tailoring a delivery system to meet the needs of every patient is an enormously challenging task.The

variability in how individuals respond to both the drug and its carrier means that formulation scientists must incorporate elements of flexibility into their designs. This could mean developing modular systems that can be easily adapted based on patient-specific parameters or integrating smart materials capable of responding to physiological cues. Although promising, these approaches are still in the early phases of development and highlight the need for further research into patient-specific formulation strategies.In summary, while novel drug delivery systems offer remarkable promise, the formulation development process is beset by a spectrum of challenges. From the inherent limitations of APIs and the intricacies of manufacturing scale-up to the complexities of regulatory approval and patient variability, each obstacle necessitates a sophisticated, multi-pronged approach. Addressing these challenges is imperative not only for advancing the field but also for ensuring that the benefits of NDDS can be realized in clinical practice.

Opportunities in Formulation Development

Despite—or perhaps because of—the myriad challenges faced in NDDS formulation development, significant opportunities lie ahead. Each obstacle provides a potential entry point for innovation, driving the development of technologies and approaches that can transform current limitations into advantages.

Advances in Material Science and Nanotechnology

The proliferation of new materials has opened up avenues for designing drug delivery systems that are both highly effective and biocompatible. Advances in nanotechnology have enabled the development of finely tuned nanoparticles with unique physical and chemical properties. Materials such as biodegradable polymers, lipids, and even metal–organic frameworks (MOFs) are being harnessed to create carriers that are not only efficient but also capable of responding to specific physiological stimuli.For example, smart polymers that change conformation or solubility in response to pH or temperature shifts can be used to design systems that release their payload only at the desired site. Such stimuli-responsive systems are particularly promising for cancer therapy, where the tumor microenvironment differs markedly from that of normal tissues. With continuous improvements in the synthesis and functionalization of these materials, there is a growing potential to develop NDDS that combine safety, efficacy, and precision.

Computational Modeling and Artificial Intelligence

The incorporation of computational modeling and artificial intelligence (AI) into formulation development is revolutionizing the field. High-throughput in silico simulations and machine learning algorithms are now capable of predicting the behavior of complex formulations before they are physically produced. These tools aid in the rational design of drug delivery systems by allowing researchers to iterate rapidly through formulation parameters, thereby identifying optimal candidates for further development.AI-driven approaches can analyze vast datasets—from experimental outcomes to molecular dynamics simulations—to uncover patterns that might be missed by traditional methods. Such data-driven strategies not only expedite the formulation process but also enhance reproducibility and quality control. In the near future, the integration of AI with advanced analytical techniques may enable real-time optimization of manufacturing processes, ultimately reducing production costs and improving batch consistency.

Emerging Manufacturing Technologies

Emerging manufacturing technologies such as 3D printing and microfluidics offer unprecedented control over the production process, addressing many of the scale-up challenges encountered in NDDS development. As discussed previously, 3D printing can create patient-specific dosage forms and implantable devices with complex geometries that are tailored to deliver drugs in a controlled manner. These technologies also offer the flexibility to customize dosage based on individual patient parameters, paving the way for personalized

medicine.Microfluidic platforms, by contrast, enable the precise control of fluid dynamics at the microscale, ensuring consistent production of nanoparticles and other delivery vehicles with uniform size and distribution. The integration of these technologies into the production pipeline not only enhances quality control but also reduces waste and production costs. As these manufacturing innovations continue to mature, they promise to bring high-quality NDDS to market more efficiently than ever before.

Regulatory Trends and Collaborative Pathways

Recent trends in regulatory science are beginning to recognize the unique challenges and opportunities presented by NDDS. Regulatory agencies are increasingly open to adaptive pathways and accelerated approval processes for innovative formulations that meet unmet clinical needs. This evolving regulatory landscape, combined with a growing emphasis on patient-centricity, provides a more favorable environment for the development and commercialization of NDDS.Collaborative efforts between academia, industry, and regulatory bodies are helping to establish clearer guidelines and standardized protocols for evaluating NDDS. These partnerships not only foster innovation but also enhance the overall credibility and safety of the novel systems being developed. As regulatory agencies become more familiar with the nuances of NDDS, the barriers to market entry are likely to decrease, paving the way for a new generation of therapeutics.

Integration of Diagnostics and Theranostics

A promising area of opportunity in NDDS is the integration of therapeutic and diagnostic capabilities—an approach commonly referred to as theranostics. By combining drug delivery with real-time diagnostic monitoring, these integrated systems allow clinicians to track the efficacy of a treatment as it unfolds. This real-time feedback loop can provide critical information on drug distribution, target engagement, and therapeutic response, facilitating adjustments in dosage or treatment protocols as needed.Theranostic systems are particularly relevant in oncology, where early detection of treatment resistance or adverse effects can mean the difference between life and death. The opportunity to merge therapy and diagnostics into a single platform presents a powerful strategy for achieving precision medicine goals while also deepening our understanding of disease mechanisms at the molecular level.

Personalized Medicine and Patient-Centric Formulations

The ultimate goal of all drug delivery systems is to optimize therapeutic outcomes for individual patients. With the rise of personalized medicine, there is a clear opportunity to tailor formulations to the genetic, metabolic, and physiological characteristics of individual patients. Advances in genomics, proteomics, and metabolomics have provided a wealth of patient-specific data that can be integrated into the formulation design process.In practical terms, this may involve creating platforms that can be easily adjusted in terms of drug load, release kinetics, or targeting capabilities. Such flexibility is particularly important in chronic conditions where dosing regimens can change over time. Patient-centric formulations have the potential not only to improve therapeutic outcomes but also to enhance patient adherence by minimizing side effects and reducing the burden of treatment.

Future Trends: Digital Twins and Smart Systems

Looking ahead, one of the most exciting opportunities in NDDS is the development of digital twins—virtual representations of the drug delivery process that mirror physical manufacturing and biological interactions in real-time. Digital twins enable continuous monitoring and predictive modeling of formulation performance, helping to identify potential issues before they manifest in clinical settings. When coupled with smart sensors and advanced analytics, these systems offer the prospect of fully integrated, feedback-controlled drug delivery platforms that optimize therapy on the fly.In summary, while significant challenges remain in the formulation development of NDDS, the opportunities for innovation are expansive. Advances in material science, computational methods, manufacturing technologies, regulatory

processes, and personalized medicine are converging to create a future in which drug delivery is not only more effective but also tailored to the unique needs of each patient. The next section explores the future perspectives and potential trajectories that this dynamic field might take over the coming decades.

Future Perspectives and Conclusions

Emerging Trends and Convergence of Disciplines

The future of formulation development for novel drug delivery systems is poised at the intersection of multiple technological and scientific frontiers. Interdisciplinary collaboration is not only inevitable—it is essential. The convergence of nanotechnology, biotechnology, digital innovation, and data science is already reshaping the pharmaceutical landscape. As these disciplines continue to intersect, we can expect to see the emergence of highly sophisticated drug delivery systems that integrate real-time diagnostics, adaptive release mechanisms, and personalized dosing strategies.Emerging trends such as the use of artificial intelligence for predictive modeling and real-time process monitoring stand to revolutionize not only the research and development phase but also the commercial manufacturing of NDDS. In parallel, the rapid advancements in 3D printing and microfluidic technologies offer the prospect of decentralized, on-demand manufacturing processes that can produce patient-specific formulations at the point of care. These shifts have the potential to drastically reduce lead times, optimize resource utilization, and ultimately enhance patient outcomes.

The Role of Sustainability and Green Chemistry

Another critical aspect of the future of NDDS formulation development is sustainability. The pharmaceutical industry, like many others, is under increasing pressure to reduce its environmental footprint and embrace green chemistry principles. The synthesis of biodegradable, non-toxic materials and the adoption of energy-efficient manufacturing processes are becoming focal points in current research and development. Innovative strategies that prioritize sustainability—such as the use of renewable raw materials and solvent-free synthesis techniques—could transform the production of novel drug delivery systems, making them not only more effective but also environmentally responsible.

From Bench to Bedside: Translational Challenges and Opportunities

Translating promising formulations from the laboratory into clinically approved products requires overcoming a host of translational challenges. In vivo performance, long-term safety, and economic viability are all critical factors that must be addressed. Future research will likely focus on developing robust, scalable processes that can reliably reproduce the sophisticated delivery mechanisms engineered at the research stage. Close collaboration with regulatory agencies will remain vital to streamline the approval process for NDDS and bridge the gap between innovative research and widespread clinical adoption.Efforts to create standardized protocols for evaluating NDDS—coupled with the integration of digital quality control measures—will facilitate smoother scaling from pilot studies to commercial production. The integration of digital twin technology could play a seminal role in this transition, allowing for continuous monitoring and optimization of both the product and the process in real time.

Conclusion

The formulation development of novel drug delivery systems represents one of the most vibrant, challenging, and promising areas of modern pharmaceutical science. As we have explored, the evolution from traditional to advanced drug delivery platforms has been fueled by the need to overcome limitations in therapeutic efficacy, patient compliance, and systemic toxicity. With innovations ranging from nanoparticles and liposomes to microneedles, implants, and digital manufacturing techniques, NDDS are charting a course toward more precise, patient-centric therapy.Despite the many challenges—ranging from physicochemical limitations and manufacturing scalability to regulatory hurdles and economic viability—the opportunities for groundbreaking innovation are vast. Advances in materials, computational

modeling, and personalized medicine are converging to create a future where drug delivery is optimized not only for efficacy but also tailored specifically to the needs of individual patients. As interdisciplinary collaboration deepens and technological innovation accelerates, the promise of NDDS is poised to transform the treatment of complex, chronic, and life-threatening diseases.In closing, while the path from laboratory discovery to clinical application is complex and fraught with challenges, the horizon is bright with opportunities that promise to redefine how medications are formulated, delivered, and ultimately experienced by patients. The continuous dialogue between emerging technology, rigorous scientific inquiry, and thoughtful regulatory oversight will ensure that these novel drug delivery systems evolve into safe, effective, and transformational therapies for generations to come

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THE GUT-BRAIN AXIS IN AUTISM SPECTRUM DISORDER: MICROBIOME DYSBIOSIS, PROBIOTICS AND POTENTIAL MECHANISMS OF ACTION

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ABSTRACT:
The gut-brain axis has garnered significant attention in Autism Spectrum Disorder (ASD) research, particularly focusing on microbiome dysbiosis and probiotics as potential interventions. This abstract explores their interplay and mechanisms of action. ASD individuals commonly exhibit gut microbiome alterations, implicating dysbiosis in ASD pathogenesis. Probiotics, beneficial bacteria supplements, emerge as a promising therapeutic avenue due to their ability to modulate gut microbiota. Potential mechanisms underlying their efficacy include the restoration of microbial balance, regulation of immune responses, and production of neuroactive compounds. By influencing gut microbiota composition, probiotics may mitigate gastrointestinal symptoms and ameliorate behavioral manifestations in ASD. Understanding the intricate connections between the gut and brain in ASD, along with the therapeutic potential of probiotics, offers promising avenues for intervention. Further research elucidating specific mechanisms and optimizing probiotic formulations could lead to more effective treatments for individuals with ASD.
Keywords: Autism Spectrum Disorder, gut-brain axis, microbiome dysbiosis, probiotics, therapeutic mechanisms, adjunctive therapy.

INTRODUCTION: BRIDGING THE GAP- EXPLORING THE GUT-BRAIN AXIS IN AUTISM SPECTRUM DISORDER

In recent years, there has been growing recognition of the intricate interplay between the gut and the brain, often referred to as the gut-brain axis. This axis represents a complex bidirectional communication system linking the central nervous system (CNS) with the enteric nervous system (ENS) and the gut microbiota[1]. Within this framework, emerging evidence suggests that disruptions in the gut-brain axis may play a significant role in the pathophysiology of neurodevelopmental disorders, including Autism Spectrum Disorder (ASD).ASD is a heterogeneous group of neurodevelopmental conditions characterized by persistent deficits in social communication and interaction, as well as restricted, repetitive patterns of behavior, interests, or activities. While the exact etiology of ASD remains elusive, researchers have increasingly turned their attention to the potential involvement of the gut-brain axis in the development and manifestation of this complex disorder[9].At the heart of this exploration lies the understanding that the gut and brain are intimately connected through a network of neural, hormonal, and immunological pathways[2]. Communication between the gut and the brain occurs through various mechanisms, including the vagus nerve, neurotransmitters, immune mediators, and microbial metabolites. This bidirectional communication not only influences gastrointestinal function and immune responses but also impacts mood, behavior, and cognition.In the context of ASD, evidence suggests that individuals with ASD frequently

experience gastrointestinal symptoms such as abdominal pain, diarrhea, constipation, and bloating[6]. Furthermore, studies have documented alterations in the composition and diversity of the gut microbiota in individuals with ASD compared to neurotypical controls. This phenomenon, known as dysbiosis, highlights the potential role of the gut microbiome in contributing to the pathogenesis of ASD.The recognition of gut microbiome dysbiosis in ASD has sparked interest in exploring therapeutic interventions aimed at modulating the gut microbiota to improve clinical outcomes[3]. One such approach involves the use of probiotics, live microorganisms that confer health benefits when administered in adequate amounts. Probiotics have been shown to influence gut microbial composition, enhance gut barrier function, regulate immune responses, and modulate neurotransmitter activity, all of which may have implications for individuals with ASD.As we delve deeper into the intricate relationship between the gut and the brain in ASD, it becomes increasingly apparent that bridging the gap between these two systems holds immense promise for understanding the underlying mechanisms of the disorder and developing novel therapeutic strategies[5]. By exploring the gut-brain axis in the context of ASD, we aim to unravel the complexities of this multifaceted disorder and pave the way for innovative approaches to diagnosis, treatment, and ultimately, improved outcomes for individuals affected by ASD[7].

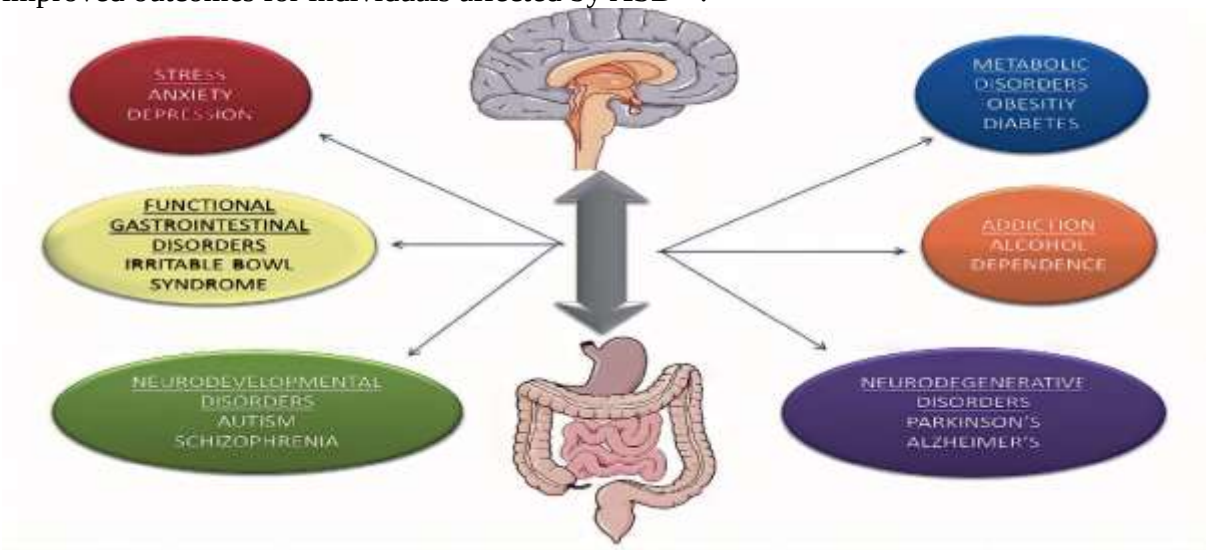

FIG:1 INTRODUCTION: BRIDGING THE GAP- EXPLORING THE GUT-BRAIN AXIS IN AUTISM SPECTRUM DISORDER

UNLOCKING THE MYSTERIES: INVESTIGATING THE CONNECTION BETWEEN GUT HEALTH AND ASD

Autism Spectrum Disorder (ASD) presents a complex array of challenges for both individuals affected and those striving to understand and support them. Despite advances in research, the underlying causes of ASD remain elusive, prompting exploration into various avenues of investigation. One particularly intriguing area of study revolves around the gut-brain axis and its potential role in ASD[11].The gut-brain axis represents a bidirectional communication network between the gastrointestinal tract and the brain. This connection involves an intricate interplay of neural, hormonal, and immunological signaling pathways, influencing not only digestive function but also cognitive, emotional, and behavioral processes[15]. Recent research has unveiled compelling evidence suggesting that disturbances within the gut-brain axis may contribute to the pathogenesis of ASD.Central to this exploration is the concept of gut health and its influence on neurological development and function. The gut harbors a diverse ecosystem of microorganisms collectively known as the gut microbiota[17]. These microbes play a vital role in maintaining intestinal homeostasis, regulating immune responses,

synthesizing essential nutrients, and influencing neurotransmitter activity.In individuals with ASD, disturbances in gut microbial composition, a phenomenon termed dysbiosis, have been frequently observed. Studies have reported alterations in the abundance, diversity, and composition of gut bacteria in individuals with ASD compared to neurotypical controls. Furthermore, research indicates a correlation between gastrointestinal symptoms and the severity of ASD symptoms, suggesting a potential link between gut health and behavioral outcomes[12].While the exact mechanisms underlying the gut-brain connection in ASD remain unclear, several hypotheses have been proposed. These include the influence of microbial metabolites on neurotransmitter synthesis and signaling, the modulation of immune responses impacting neuroinflammation, and alterations in gut permeability affecting systemic inflammation and neural function[14].The recognition of the gut-brain axis as a potential contributor to ASD pathophysiology has led to increased interest in exploring therapeutic interventions targeting gut health[19]. Probiotics, prebiotics, dietary modifications, and fecal microbiota transplantation are among the strategies being investigated for their potential to modulate the gut microbiota and improve clinical outcomes in individuals with ASD[18].As researchers strive to unravel the mysteries surrounding the gut-brain connection in ASD, it becomes increasingly evident that understanding and addressing gut health may hold promise for enhancing the well-being and quality of life of individuals with ASD[13]. By delving deeper into this intricate relationship, we aim to shed light on novel avenues for intervention and support for those affected by ASD[6].

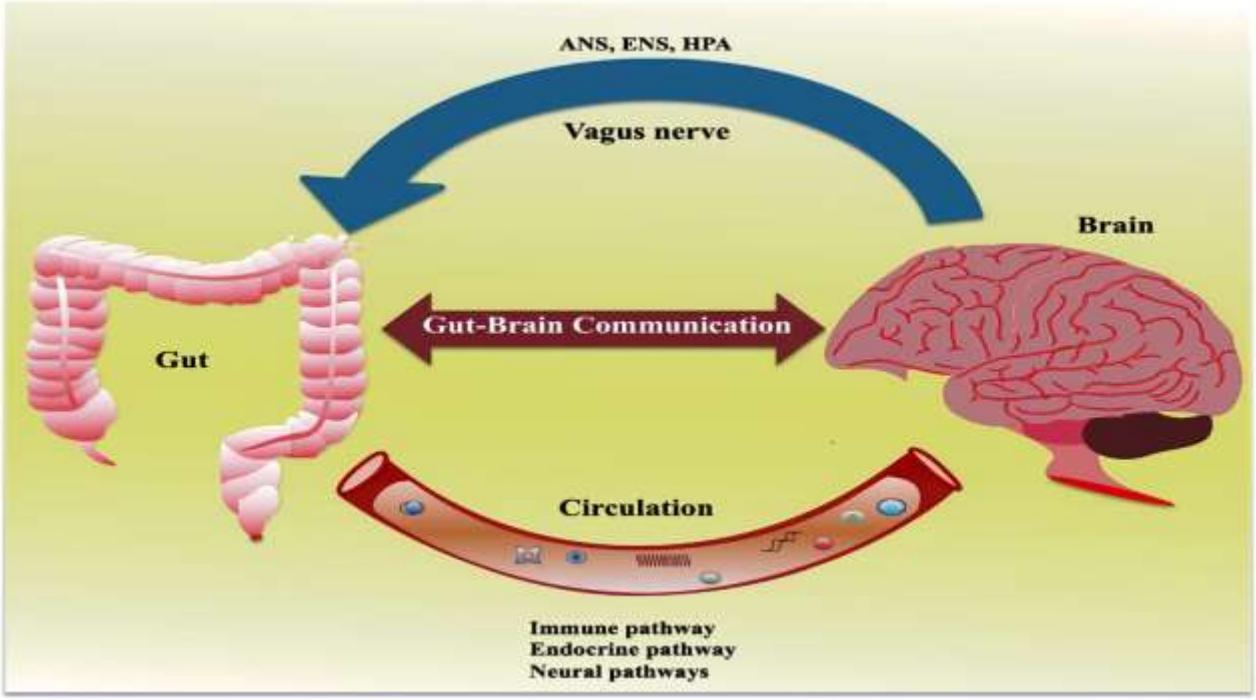

FIG:2 UNLOCKING THE MYSTERIES: INVESTIGATING THE CONNECTION BETWEEN GUT HEALTH AND ASD

OPENING DOORS TO UNDERSTANDING: THE SIGNIFICANCE OF GUT-BRAIN INTERACTION IN ASD

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterized by challenges in social communication and interaction, as well as repetitive behaviors and restricted interests. While the precise causes of ASD remain elusive, research into its etiology has increasingly focused on the interplay between the gut and the brain[20].At the heart of this exploration lies the gut-brain axis, a bidirectional communication system linking the gastrointestinal tract with the central nervous system[10]. The significance of this axis in ASD

is underscored by emerging evidence suggesting that disruptions in gut-brain interactions may contribute to the development and manifestation of the disorder[30].The gut, often referred to as the "second brain," houses a vast and diverse community of microorganisms known as the gut microbiota. These microbes play a crucial role in various physiological processes, including digestion, immune regulation, and neurotransmitter production[40]. In individuals with ASD, alterations in gut microbial composition, collectively termed dysbiosis, have been consistently reported.Moreover, studies have revealed a high prevalence of gastrointestinal symptoms, such as abdominal pain, constipation, and diarrhea, in individuals with ASD[50]. The presence of these gastrointestinal issues has been linked to the severity of ASD symptoms, suggesting a potential connection between gut health and the behavioral manifestations of the disorder[70].The mechanisms underlying the relationship between gut health and ASD are multifaceted and complex. One proposed mechanism involves the influence of gut microbial metabolites on neurotransmitter production and signaling pathways, affecting mood, behavior, and cognition[60]. Additionally, dysregulated immune responses in the gut may contribute to systemic inflammation and neuroinflammation, further exacerbating ASD symptoms.Recognizing the significance of gut-brain interactions in ASD opens new avenues for understanding and addressing the disorder[90]. Therapeutic interventions aimed at modulating the gut microbiota, such as probiotics, prebiotics, and dietary interventions, hold promise for improving gastrointestinal symptoms and potentially ameliorating ASD-related behaviors.By unraveling the intricacies of gut-brain interactions in ASD, we can gain valuable insights into the underlying mechanisms of the disorder and develop targeted interventions to improve the lives of individuals affected by ASD[100]. Through ongoing research and collaboration, we strive to open doors to understanding and support for those living with this complex condition.

BUILDING BRIDGES: EXPLORING THE POTENTIAL IMPACT OF MICROBIOME DYSBIOSIS

In recent years, there has been a surge of interest in understanding the role of the gut microbiome in various aspects of human health, including its potential impact on neurodevelopmental disorders such as Autism Spectrum Disorder (ASD)[1]. The gut microbiome, comprising trillions of microorganisms residing in the gastrointestinal tract, plays a pivotal role in maintaining host health and homeostasis[11].Microbiome dysbiosis, characterized by alterations in the composition, diversity, and function of gut microbial communities, has emerged as a prominent feature in individuals with ASD[21]. Numerous studies have reported differences in the gut microbial profiles of individuals with ASD compared to neurotypical controls, suggesting a potential link between microbiome dysbiosis and the pathophysiology of ASD[31].Understanding the potential impact of microbiome dysbiosis in ASD requires a multifaceted approach. Firstly, investigating the specific microbial taxa that are dysregulated in individuals with ASD can provide valuable insights into the potential mechanisms underlying the disorder[41]. Studies have identified alterations in various bacterial species, including reductions in beneficial commensal bacteria and increases in pathogenic species, in individuals with ASD.Secondly, exploring the functional implications of microbiome dysbiosis in ASD is essential for elucidating its effects on host physiology and behavior[51]. Dysregulated gut microbial communities may produce metabolites and signaling molecules that can influence neuroinflammation, neurotransmitter synthesis, and gut barrier integrity, all of which have been implicated in the pathogenesis of ASD.Furthermore, understanding the factors contributing to microbiome dysbiosis in ASD is critical for developing targeted interventions[61]. Environmental factors, such as diet, antibiotic exposure, and mode of delivery at birth, can profoundly impact the composition and stability of the gut microbiome during critical periods of development[71]. Identifying modifiable factors that contribute to dysbiosis may offer opportunities for early intervention and prevention

strategies.Building bridges between microbiome research and ASD holds immense promise for advancing our understanding of the disorder and developing novel therapeutic approaches[81]. Targeted interventions aimed at restoring microbial balance and promoting a healthy gut environment may offer new avenues for improving gastrointestinal symptoms and behavioral outcomes in individuals with ASD[91].By exploring the potential impact of microbiome dysbiosis in ASD, we aim to bridge the gap between gut microbiome research and clinical practice, ultimately paving the way for personalized interventions that address the unique needs of individuals with ASD[101].

CHARTING NEW PATHS: PROBIOTICS AS PROMISING TOOLS IN ASD MANAGEMENT

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterized by a range of challenges, including social communication difficulties, repetitive behaviors, and sensory sensitivities. While the exact causes of ASD remain unclear, emerging research has highlighted the potential role of the gut microbiome and its interactions with the brain in the development and progression of the disorder[2].Probiotics, live microorganisms that confer health benefits when administered in adequate amounts, have garnered increasing attention as potential therapeutic agents for ASD[26]. Probiotics work by modulating the composition and function of the gut microbiota, promoting a balanced microbial community and supporting gut health. Given the growing evidence linking microbiome dysbiosis to ASD, probiotics represent a promising avenue for intervention[22].Several lines of evidence suggest that probiotics may offer benefits for individuals with ASD. Firstly, studies have documented alterations in the gut microbiota composition of individuals with ASD, including reduced microbial diversity and imbalances in specific bacterial taxa[24]. By targeting dysbiosis, probiotics have the potential to restore microbial balance and improve gut health in individuals with ASD.Furthermore, probiotics have been shown to exert beneficial effects on gastrointestinal symptoms commonly associated with ASD, such as abdominal pain, constipation, and diarrhea[32]. By alleviating gastrointestinal discomfort, probiotics may indirectly influence behavioral symptoms and improve overall quality of life for individuals with ASD and their caregivers[36].Beyond their effects on gut health, probiotics may also exert direct effects on brain function and behavior. Preclinical studies have demonstrated that certain probiotic strains can modulate neurotransmitter activity, reduce neuroinflammation, and improve behavioral outcomes in animal models of ASD[34]. While more research is needed to elucidate the mechanisms underlying these effects in humans, the potential for probiotics to impact brain function holds promise for ASD management[42].Despite the promising findings, challenges remain in translating probiotic research into clinical practice for ASD. Variability in study designs, probiotic formulations, and participant characteristics make it difficult to draw definitive conclusions about the efficacy of probiotics in ASD[44]. Additionally, individual responses to probiotic interventions may vary, highlighting the need for personalized approaches to treatment.In conclusion, probiotics represent a promising tool in the management of ASD, offering potential benefits for gut health, gastrointestinal symptoms, and behavioral outcomes[46]. By charting new paths in probiotic research, we can further our understanding of the gut-brain axis in ASD and develop targeted interventions that address the unique needs of individuals with ASD[52]. Through continued research and collaboration, we can harness the therapeutic potential of probiotics to improve outcomes and quality of life for individuals affected by ASD[54].

DECIPHERING THE GUT-BRAIN LINK: INSIGHTS INTO ASD PATHOPHYSIOLOGY

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterized by difficulties in social communication, restricted interests, and repetitive behaviors. While the precise etiology of ASD remains elusive, growing evidence suggests that interactions between

the gut and the brain may play a significant role in its pathophysiology[56].The gut-brain axis represents a bidirectional communication network linking the gastrointestinal tract with the central nervous system[72]. This intricate connection involves a complex interplay of neural, hormonal, and immunological pathways, influencing not only digestive function but also cognitive, emotional, and behavioral processes[74][76]. Disruptions in the gut-brain axis have been implicated in various neurological and psychiatric disorders, including ASD.Deciphering the gut-brain link in ASD requires a comprehensive understanding of the factors contributing to this connection[82]. One key factor is the gut microbiome, a diverse ecosystem of microorganisms residing in the gastrointestinal tract[84][86]. The gut microbiota plays a crucial role in maintaining gut health, regulating immune responses, and producing neurotransmitters that influence brain function[92].Emerging evidence suggests that individuals with ASD may exhibit alterations in the composition and function of the gut microbiome, a phenomenon known as dysbiosis[94][96]. These alterations may contribute to gastrointestinal symptoms commonly observed in individuals with ASD, such as abdominal pain, constipation, and diarrhea[101][102]. Moreover, dysbiosis may impact neurodevelopment and behavior through the production of microbial metabolites that influence neurotransmitter activity and neuroinflammation[5].In addition to dysbiosis, disruptions in gut barrier function and immune dysregulation have been implicated in ASD pathophysiology[7]. Increased intestinal permeability, or "leaky gut," may allow harmful substances to enter the bloodstream, triggering immune responses and inflammation that could affect brain function and behavior. Furthermore, aberrant immune responses in the gut may contribute to systemic inflammation and neuroinflammation, exacerbating ASD symptoms[9].Understanding the gut-brain link in ASD offers potential insights into novel therapeutic strategies for the disorder. Targeted interventions aimed at modulating the gut microbiome, restoring gut barrier integrity, and modulating immune responses may offer promise for improving gastrointestinal symptoms and behavioral outcomes in individuals with ASD[15][17].By deciphering the gut-brain link in ASD, we can gain valuable insights into the underlying mechanisms of the disorder and develop targeted interventions that address the unique needs of individuals affected by ASD[19]. Through continued research and collaboration, we aim to unravel the complexities of ASD pathophysiology and pave the way for innovative approaches to diagnosis, treatment, and support for individuals with ASD and their families[27].

Aspect	**Description**
Gut Microbiota Dysbiosis	Individuals with ASD often exhibit alterations in gut microbiota composition, characterized by reduced microbial diversity and abundance of certain taxa. Dysbiosis may contribute to gastrointestinal symptoms and neurobehavioral abnormalities.
Gut Barrier Integrity	Impaired gut barrier function, or "leaky gut," has been observed in individuals with ASD. Increased intestinal permeability may facilitate the translocation of microbial metabolites and toxins, leading to systemic inflammation and neuroinflammation.
Neuroimmune Crosstalk	Bidirectional communication between the gut and the brain occurs via the gut-brain axis, involving neural, hormonal, and immunological pathways. Dysregulation of neuroimmune signaling may underlie ASD

	pathophysiology and contribute to behavioral symptoms.
Immune Activation	Immune dysregulation, including altered cytokine profiles and abnormal immune cell activity, has been reported in individuals with ASD. Chronic inflammation and immune activation may impact neural development, synaptic function, and behavior.
Neurotransmitter Balance	Gut microbiota can produce and modulate neurotransmitters such as serotonin, dopamine, and gamma-aminobutyric acid (GABA). Imbalances in neurotransmitter levels may influence mood, cognition, and social behavior, contributing to ASD symptomatology.

TABLE:1 DECIPHERING THE GUT-BRAIN LINK: INSIGHTS INTO ASD PATHOPHYSIOLOGY

This table provides a concise overview of the gut-brain link and its implications for ASD pathophysiology, highlighting key factors such as gut microbiota dysbiosis, gut barrier integrity, neuroimmune crosstalk, immune activation, and neurotransmitter balance.

SETTING THE STAGE: IMPORTANCE OF GUT HEALTH IN ASD DEVELOPMENT

Autism Spectrum Disorder (ASD) is a multifaceted neurodevelopmental condition characterized by challenges in social interaction, communication difficulties, and repetitive behaviors. While the etiology of ASD remains complex and multifactorial, emerging research has highlighted the crucial role of gut health in its development and manifestation[25][29].The gastrointestinal tract, often referred to as the "second brain," is home to a diverse ecosystem of microorganisms collectively known as the gut microbiota[35]. This microbiome plays a pivotal role in maintaining overall health and well-being, influencing not only digestive function but also immune regulation, neurotransmitter production, and metabolic processes[37][39].In individuals with ASD, disturbances in gut microbial composition and function, collectively termed dysbiosis, have been consistently observed. These alterations may arise from various factors, including genetics, environmental exposures, diet, and antibiotic use, among others[47]][49]. Dysbiosis in individuals with ASD has been associated with gastrointestinal symptoms, such as abdominal pain, constipation, and diarrhea, which are frequently reported in this population.Moreover, dysbiosis in individuals with ASD may have broader implications for neurodevelopment and behavior[45]. Mounting evidence suggests that gut microbiota dysregulation can influence brain function and behavior through multiple pathways, including the production of neuroactive metabolites, modulation of the immune system, and regulation of neurotransmitter signaling[57][55].The importance of gut health in ASD development is further underscored by the bidirectional communication between the gut and the brain, known as the gut-brain axis. Disruptions in this axis may contribute to the pathophysiology of ASD by altering neural circuitry, neurotransmitter balance, and immune responses[59][65].Recognizing the significance of gut health in ASD development opens new avenues for understanding and addressing the disorder[59]. Targeted interventions aimed at restoring microbial balance, promoting gut barrier integrity, and modulating immune responses may offer promise for improving gastrointestinal symptoms and behavioral outcomes in individuals with ASD[67][69].By setting the stage and highlighting the importance of gut health in ASD

development, we aim to catalyze further research into the role of the gut microbiome in neurodevelopmental disorders[75]. Through continued exploration of the gut-brain axis and its implications for ASD, we strive to advance our understanding of the disorder and develop more effective interventions to support individuals with ASD and their families[77].

A COMPLEX PUZZLE: MICROBIOME DYSBIOSIS AND ITS ROLE IN ASD

Autism Spectrum Disorder (ASD) presents a complex puzzle to researchers and clinicians alike, with its multifaceted nature challenging our understanding of its underlying mechanisms[79].Among the many pieces of this puzzle, the role of microbiome dysbiosis has emerged as a significant area of interest and investigation[85].The gut microbiome, comprising trillions of microorganisms inhabiting the gastrointestinal tract, plays a crucial role in maintaining health and homeostasis[87]. These microbes are involved in various physiological processes, including digestion, immune regulation, and neurotransmitter production. Emerging evidence suggests that disruptions in the composition and function of the gut microbiome, known as dysbiosis, may contribute to the pathophysiology of ASD[89].Studies have consistently reported alterations in the gut microbial profiles of individuals with ASD compared to neurotypical controls[99]. These alterations include changes in microbial diversity, imbalances in specific bacterial taxa, and differences in the abundance of beneficial and pathogenic microbes. Moreover, dysbiosis in individuals with ASD has been associated with gastrointestinal symptoms, such as abdominal pain, bloating, and diarrhea, which are commonly reported in this population[97][95].The implications of microbiome dysbiosis extend beyond the gut, potentially impacting neurodevelopment and behavior. The gut microbiome communicates bidirectionally with the brain through various pathways, collectively known as the gut-brain axis. Dysregulated gut microbial communities may produce metabolites that can influence neurotransmitter synthesis and signaling, neuroinflammation, and brain function, all of which have been implicated in the pathogenesis of ASD.Understanding the role of microbiome dysbiosis in ASD is further complicated by the heterogeneity of the disorder. ASD encompasses a spectrum of symptoms and underlying genetic, environmental, and physiological factors that vary from individual to individual[8][3]. As such, unraveling the specific contributions of dysbiosis to ASD pathophysiology requires a nuanced and multifaceted approach.Despite these challenges, the recognition of microbiome dysbiosis as a potential contributor to ASD offers new avenues for research and intervention. Targeted strategies aimed at modulating the gut microbiome, such as probiotics, prebiotics, and dietary interventions, hold promise for improving gastrointestinal symptoms and behavioral outcomes in individuals with ASD[18][13].As we continue to piece together the puzzle of ASD, understanding the role of microbiome dysbiosis represents a critical step toward unraveling its complexities. By elucidating the intricate interplay between the gut microbiome and ASD, we can gain valuable insights into the underlying mechanisms of the disorder and develop novel therapeutic approaches to support individuals affected by ASD and their families[28].

MICROBIOME DYSBIOSIS: EXPLORING IMBALANCES IN GUT BACTERIA COMPOSITION

The gut microbiome, a diverse community of microorganisms residing in the gastrointestinal tract, plays a crucial role in maintaining human health and well-being. Dysbiosis, characterized by alterations in the composition, diversity, and function of the gut microbiota, has emerged as a significant area of interest in various health conditions, including Autism Spectrum Disorder (ASD).In recent years, studies have revealed compelling evidence of dysbiosis in individuals with ASD, suggesting a potential link between gut microbiome imbalances and the pathophysiology of the disorder[33]. Understanding the nuances of microbiome dysbiosis is essential for unraveling its implications for ASD and exploring potential therapeutic interventions.Exploring imbalances in gut bacteria composition involves examining differences in microbial diversity, abundance, and community structure between individuals

with ASD and neurotypical controls[38][23]. Several studies have reported alterations in specific bacterial taxa, with reductions in beneficial commensal bacteria and increases in pathogenic species observed in individuals with ASD.Moreover, dysbiosis in individuals with ASD has been associated with gastrointestinal symptoms commonly reported in this population, such as abdominal pain, constipation, and diarrhea[48][43]. The presence of gastrointestinal disturbances underscores the potential impact of dysbiosis on gut health and overall well-being in individuals with ASD.Beyond gastrointestinal symptoms, dysbiosis may also influence neurological function and behavior through the gut-brain axis, a bidirectional communication pathway linking the gut with the central nervous system. Microbial metabolites, neurotransmitters, and immune mediators produced by gut bacteria can modulate neuroinflammation, neurotransmitter activity, and behavioral outcomes.By exploring microbiome dysbiosis in ASD, researchers aim to gain insights into its role in the pathogenesis of the disorder and identify potential targets for intervention. Strategies such as probiotics, prebiotics, dietary modifications, and fecal microbiota transplantation offer promising avenues for restoring microbial balance and improving gastrointestinal symptoms and behavioral outcomes in individuals with ASD[58][68].In summary, exploring imbalances in gut bacteria composition represents a critical step in understanding the role of the gut microbiome in ASD. By unraveling the complexities of microbiome dysbiosis, researchers aim to shed light on novel avenues for diagnosis, treatment, and support for individuals affected by ASD and their families[53][63].

Aspect	**Description**
Decreased Microbial Diversity	Microbiome dysbiosis in conditions like autism spectrum disorder (ASD) often involves reduced microbial diversity, characterized by fewer species and less even distribution of bacteria in the gut.
Shifts in Bacterial Abundance	Dysbiosis can lead to imbalances in the relative abundance of specific bacterial taxa. For example, there may be an overgrowth of potentially pathogenic bacteria (e.g., Clostridia) and a decrease in beneficial bacteria (e.g., Bifidobacteria).
Altered Microbial Metabolism	Dysbiotic gut bacteria may produce and metabolize compounds differently compared to a healthy microbiome. This altered metabolic activity can lead to the production of harmful metabolites or a deficiency in beneficial ones.
Disrupted Gut Barrier Function	Dysbiosis can contribute to impaired gut barrier function, leading to increased intestinal permeability or "leaky gut." This allows toxins, microbial byproducts, and undigested food particles to enter the bloodstream, triggering inflammation and immune responses.
Dysregulated Immune Responses	Imbalances in gut bacteria composition can dysregulate immune responses in the gut and systemic circulation. This may result in chronic inflammation, immune activation,

and aberrant immune cell activity, contributing to various health conditions.

TABLE:2 MICROBIOME DYSBIOSIS: EXPLORING IMBALANCES IN GUT BACTERIA COMPOSITION

This table provides an overview of the key aspects of microbiome dysbiosis, including decreased microbial diversity, shifts in bacterial abundance, altered microbial metabolism, disrupted gut barrier function, and dysregulated immune responses. These imbalances in gut bacteria composition are associated with various health conditions, including autism spectrum disorder (ASD)[78].

PROBIOTICS AS THERAPEUTIC INTERVENTIONS

A) Definition and Mechanisms of Probiotics

A probiotic is a live microorganism that, when administered in adequate amounts, confers a health benefit on the host. These microorganisms, typically bacteria or yeast, are considered beneficial for the host's health, particularly for gastrointestinal and immune function[73]. Probiotics work through various mechanisms to exert their positive effects:

- Restoration of Gut Microbiota Balance: Probiotics help maintain a healthy balance of gut bacteria by inhibiting the growth of harmful microbes and promoting the growth of beneficial ones. This balance is crucial for proper digestion, nutrient absorption, and immune function.
- Production of Neuroactive Substances: Some probiotic strains have been shown to produce neurotransmitters such as serotonin and gamma-aminobutyric acid (GABA) in the gut. These compounds can influence mood, behavior, and cognitive function, potentially impacting symptoms associated with conditions like autism spectrum disorder (ASD).
- Immunomodulation: Probiotics interact with the gut-associated lymphoid tissue and mucosal immune system, modulating immune responses. They can stimulate the production of anti-inflammatory cytokines while suppressing pro-inflammatory cytokines, contributing to immune balance and reducing inflammation.
- Enhancement of Gut Barrier Function: Probiotics strengthen the intestinal barrier, which plays a crucial role in preventing the entry of harmful substances from the gut into the bloodstream. By promoting the integrity of tight junctions between intestinal cells and enhancing mucin production, probiotics help maintain gut barrier function and reduce the risk of intestinal permeability.

THE ROLE OF PROBIOTICS: POTENTIAL THERAPEUTIC INTERVENTIONS

Probiotics, defined as live microorganisms that confer health benefits when administered in adequate amounts, have garnered considerable attention as potential therapeutic interventions for various health conditions, including Autism Spectrum Disorder (ASD). The rationale behind probiotic use in ASD stems from the growing recognition of the gut microbiome's influence on neurological function and behavior, as well as the dysbiosis commonly observed in individuals with ASD[88].Probiotics offer a promising approach to modulating the gut microbiota and promoting gut health in individuals with ASD. By introducing beneficial bacteria into the gastrointestinal tract, probiotics aim to restore microbial balance, enhance gut barrier function, regulate immune responses, and mitigate inflammation, all of which may contribute to improvements in gastrointestinal symptoms and behavioral outcomes.Several strains of probiotic bacteria have been investigated for their potential therapeutic effects in ASD. Lactobacillus and Bifidobacterium species, commonly found in probiotic supplements and fermented foods, are among the most extensively studied. These strains have been shown to exert beneficial effects on gut microbiota composition, gut barrier integrity, and immune function in preclinical and clinical studies[83].The potential benefits of probiotics in ASD extend

beyond gut health to include neurological function and behavior. Preclinical studies have demonstrated that certain probiotic strains can modulate neurotransmitter activity, reduce neuroinflammation, and improve behavioral outcomes in animal models of ASD. While more research is needed to confirm these findings in humans, the emerging evidence suggests that probiotics may offer a multifaceted approach to managing ASD symptoms.Despite the promising potential of probiotics, challenges remain in translating probiotic research into clinical practice for ASD[98]. Variability in study designs, probiotic formulations, and participant characteristics make it difficult to draw definitive conclusions about the efficacy of probiotics in ASD. Moreover, individual responses to probiotic interventions may vary, highlighting the need for personalized approaches to treatment.In conclusion, the role of probiotics as potential therapeutic interventions in ASD holds promise for improving gastrointestinal symptoms, modulating gut microbiota composition, and potentially influencing neurological function and behavior. By further investigating the effects of probiotics on gut-brain interactions in ASD, researchers aim to unlock new avenues for diagnosis, treatment, and support for individuals affected by this complex disorder. Through continued research and collaboration, we can harness the therapeutic potential of probiotics to improve outcomes and quality of life for individuals with ASD and their families[93].

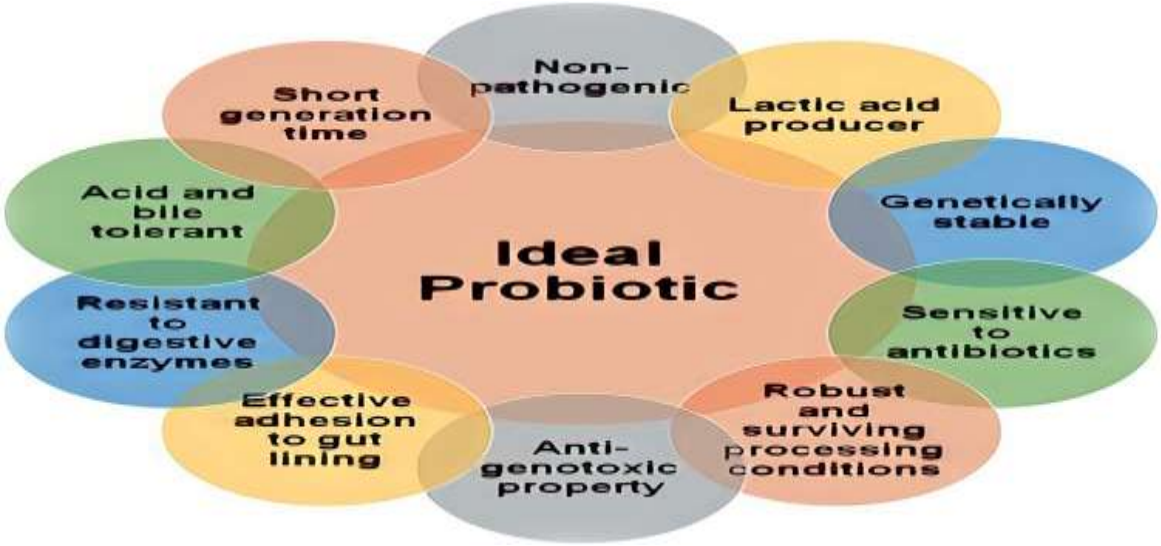

FIG:2 THE ROLE OF PROBIOTICS: POTENTIAL THERAPEUTIC INTERVENTIONS

MECHANISMS OF ACTION: HOW PROBIOTICS INFLUENCE THE GUT-BRAIN AXIS

Understanding the mechanisms by which probiotics influence the gut-brain axis is essential for elucidating their potential therapeutic effects in Autism Spectrum Disorder (ASD). The gut-brain axis represents a bidirectional communication network linking the gut microbiota with the central nervous system, impacting not only gastrointestinal function but also neurological function and behavior[15].Probiotics, live microorganisms that confer health benefits when administered in adequate amounts, have been shown to modulate the gut microbiota and promote gut health. However, their effects extend beyond the gastrointestinal tract to influence neurological function and behavior through various mechanisms.One mechanism by which probiotics influence the gut-brain axis is through the production of microbial metabolites. Probiotic bacteria can ferment dietary fibers and other substrates to produce short-chain fatty acids (SCFAs), such as acetate, propionate, and butyrate. SCFAs act as signaling molecules that can modulate neurotransmitter activity, regulate immune responses, and promote gut

barrier integrity, thereby influencing neurological function and behavior.Furthermore, probiotics may directly interact with the gut epithelium and immune cells, modulating immune responses and inflammation in the gut. By promoting a balanced immune environment and mitigating inflammation, probiotics may indirectly influence neuroinflammation and neurologic function, which have been implicated in the pathogenesis of ASD.Moreover, probiotics may exert neuroprotective effects by enhancing the production of neurotrophic factors and reducing oxidative stress in the brain. These effects can support neuronal survival and plasticity, potentially mitigating neurodevelopmental abnormalities associated with ASD.In addition to their direct effects on the gut and brain, probiotics may influence the gut-brain axis indirectly through their interactions with other components of the microbiota. By promoting the growth of beneficial bacteria and suppressing the growth of pathogenic species, probiotics can help maintain microbial balance and diversity, which is essential for gut and brain health[19].Overall, understanding the mechanisms of action by which probiotics influence the gut-brain axis is crucial for harnessing their therapeutic potential in ASD. By modulating gut microbiota composition, promoting gut barrier integrity, regulating immune responses, and exerting direct neuroprotective effects, probiotics offer a multifaceted approach to managing ASD symptoms and improving overall quality of life for individuals with ASD and their families. Through continued research and collaboration, we can further unravel the complexities of probiotic-gut-brain interactions and develop targeted interventions that address the unique needs of individuals affected by ASD[75].

Mechanism	**Description**
Modulation of Gut Microbiota	Probiotics help restore microbial balance in the gut by inhibiting the growth of pathogenic bacteria and promoting the growth of beneficial bacteria. This modulation of gut microbiota composition contributes to overall gut health and function.
Production of Neuroactive Substances	Some probiotic strains have the ability to produce neuroactive substances such as serotonin, gamma-aminobutyric acid (GABA), and dopamine in the gut. These compounds can influence brain function, mood, behavior, and cognitive processes via the gut-brain axis
Regulation of Neurotransmitter Pathways	Probiotics can influence neurotransmitter pathways in the gut and brain, including serotonin, GABA, and dopamine signaling. By modulating neurotransmitter activity, probiotics may affect mood, cognition, and behavior, potentially alleviating symptoms of neurological disorders such as ASD.
Immunomodulation	Probiotics interact with the gut-associated lymphoid tissue (GALT) and mucosal immune system, modulating immune responses and inflammation. By promoting a balanced immune profile and reducing inflammation, probiotics support gut and brain health via the immune-mediated gut-brain axis

Enhancement of Gut Barrier Function	Probiotics strengthen the intestinal barrier by promoting the expression of tight junction proteins, enhancing mucin production, and reducing intestinal permeability. By improving gut barrier function, probiotics help prevent the translocation of harmful substances and mitigate inflammation along the gut-brain axis.

TABLE:3 MECHANISMS OF ACTION: HOW PROBIOTICS INFLUENCE THE GUT-BRAIN AXIS

This table provides a concise overview of the mechanisms of action through which probiotics influence the gut-brain axis, including modulation of gut microbiota, production of neuroactive substances, regulation of neurotransmitter pathways, immunomodulation, and enhancement of gut barrier function. These mechanisms contribute to the bidirectional communication between the gut and brain, influencing neurological function, behavior, and overall health.

CLINICAL IMPLICATIONS AND FUTURE DIRECTIONS

Understanding the clinical implications of probiotics in Autism Spectrum Disorder (ASD) management and identifying future directions for research and intervention are critical for advancing the field and improving outcomes for individuals affected by ASD[100].

Clinical Implications:

- Personalized Treatment Approaches: Recognizing the heterogeneity of ASD presentations and responses to treatment, personalized approaches to probiotic therapy may be warranted. Tailoring probiotic interventions based on individual gut microbiota composition, gastrointestinal symptoms, and behavioral profiles could optimize treatment outcomes.
- Multimodal Interventions: Given the complex nature of ASD, combining probiotic therapy with other interventions, such as behavioral therapy, dietary modifications, and pharmacotherapy, may enhance treatment efficacy. Multimodal approaches that target multiple aspects of ASD pathology, including gut health, neurodevelopmental abnormalities, and behavioral symptoms, may lead to more comprehensive and lasting improvements.
- Long-Term Follow-Up: Monitoring the long-term effects of probiotic therapy in individuals with ASD is essential for assessing treatment durability and safety. Longitudinal studies tracking changes in gut microbiota composition, gastrointestinal symptoms, and behavioral outcomes over time can provide valuable insights into the sustained benefits of probiotic interventions and potential adverse effects.

Future Directions:

- Mechanistic Studies: Further research is needed to elucidate the mechanisms by which probiotics influence the gut-brain axis and modulate ASD-related symptoms. Mechanistic studies exploring the effects of probiotics on gut microbiota composition, gut barrier function, immune responses, neurotransmitter activity, and neuroinflammation can provide insights into the underlying pathophysiology of ASD and identify novel therapeutic targets.
- Clinical Trials: Well-designed, randomized controlled trials are needed to rigorously evaluate the efficacy and safety of probiotic interventions in individuals with ASD. Large-scale clinical trials that incorporate standardized protocols, validated outcome measures, and long-term follow-up assessments are essential for establishing evidence-based guidelines for probiotic therapy in ASD management.

- Biomarker Identification: Identifying reliable biomarkers associated with probiotic responsiveness and treatment outcomes in ASD can facilitate personalized treatment strategies and improve patient selection for probiotic interventions. Biomarker studies focusing on gut microbiota composition, immune function, neuroimaging findings, and behavioral assessments may provide valuable predictors of treatment response and prognosis.
- Intervention Optimization: Optimizing probiotic formulations, dosing regimens, and treatment durations to maximize therapeutic efficacy and minimize adverse effects is a key area for future research. Comparative studies evaluating different probiotic strains, combinations, and delivery methods can help identify the most effective and tolerable interventions for individuals with ASD.

In conclusion, recognizing the clinical implications of probiotics in ASD management and identifying future directions for research and intervention are essential for advancing our understanding of probiotic-gut-brain interactions and improving outcomes for individuals affected by ASD[74][58][33]. By embracing personalized approaches, multimodal interventions, and rigorous scientific inquiry, we can harness the therapeutic potential of probiotics to address the complex challenges associated with ASD and enhance the quality of life for individuals with ASD and their families.

MODE OF ACTION:

1. RESTORATION OF GUT MICROBIOTA BALANCE

Probiotics play a vital role in restoring the balance of gut microbiota, which is essential for overall health and well-being. Several factors, such as antibiotic use, dietary habits, stress, and illness, can disrupt the delicate equilibrium of microbial populations in the gut, leading to dysbiosis. Dysbiosis refers to an imbalance in the composition and function of gut microbiota, characterized by a decrease in beneficial bacteria and an overgrowth of potentially harmful microbes[25].

Probiotics help restore gut microbiota balance through various mechanisms:

- Competitive Exclusion: Probiotic strains compete with pathogenic bacteria for nutrients and binding sites in the gut. By outcompeting harmful microbes, probiotics can prevent their colonization and growth, thereby restoring balance to the microbiota.
- Production of Antimicrobial Compounds: Some probiotic strains produce antimicrobial substances, such as bacteriocins, hydrogen peroxide, and short-chain fatty acids, which inhibit the growth of pathogenic bacteria. These compounds help reduce the abundance of harmful microbes and create a more favorable environment for beneficial bacteria to thrive.
- Modulation of Microbial Metabolism: Probiotics can influence the metabolic activities of gut bacteria, leading to changes in the production of metabolites such as vitamins, short-chain fatty acids, and neurotransmitters. These metabolites play essential roles in gut health, immune function, and communication between the gut and the brain.
- Enhancement of Mucosal Immunity: Probiotics interact with the gut-associated lymphoid tissue and mucosal immune system, stimulating the production of antimicrobial peptides and immunoglobulins. By enhancing mucosal immunity, probiotics help strengthen the intestinal barrier and prevent the translocation of pathogens across the gut epithelium.

Overall, the restoration of gut microbiota balance by probiotics is crucial for maintaining gastrointestinal homeostasis, supporting immune function, and promoting overall health. By promoting a diverse and resilient microbial community in the gut, probiotics contribute to optimal digestion, nutrient absorption, and protection against gastrointestinal disorders.

PRODUCTION OF NEUROACTIVE SUBSTANCES

In addition to their role in restoring gut microbiota balance, probiotics have been shown to produce neuroactive substances within the gastrointestinal tract. These substances can influence neural signaling, mood regulation, cognitive function, and behavior. The production of neuroactive compounds by probiotics represents an emerging area of research with potential implications for conditions such as autism spectrum disorder (ASD). Some key neuroactive substances produced by probiotics include:

- Serotonin: Probiotic bacteria, particularly strains of Lactobacillus and Bifidobacterium, have been found to synthesize serotonin, a neurotransmitter primarily associated with mood regulation, appetite, and sleep. Serotonin produced in the gut can influence central nervous system function by modulating neural pathways involved in mood and behavior.
- Gamma-Aminobutyric Acid (GABA): Certain probiotic strains have the ability to produce GABA, a major inhibitory neurotransmitter in the brain. GABA plays a crucial role in regulating neuronal excitability, anxiety, stress response, and motor control. By producing GABA in the gut, probiotics may exert anxiolytic and calming effects on the central nervous system.
- Dopamine: Some probiotic bacteria can synthesize dopamine, a neurotransmitter involved in motivation, reward processing, and movement control. Dysregulation of the dopaminergic system has been implicated in neuropsychiatric disorders such as ASD and attention deficit hyperactivity disorder (ADHD). Probiotic-mediated dopamine production may modulate dopaminergic signaling pathways and affect cognitive and behavioral outcomes.
- Short-Chain Fatty Acids (SCFAs): Probiotics contribute to the production of SCFAs, such as acetate, propionate, and butyrate, through the fermentation of dietary fiber in the gut. SCFAs serve as energy sources for intestinal epithelial cells and exert various physiological effects on host metabolism, immune function, and neurotransmission. Butyrate, in particular, has been linked to improvements in cognitive function and mood regulation.

The production of neuroactive substances by probiotics underscores the bidirectional communication between the gut and the brain, known as the gut-brain axis. By modulating neural signaling pathways, probiotics may influence brain function and behavior, offering potential therapeutic benefits for neurological and neuropsychiatric conditions like ASD. Further research is needed to elucidate the specific mechanisms underlying probiotic-mediated neuroactive substance production and their effects on brain health and behavior[56].

IMMUNOMODULATION

Probiotics exert immunomodulatory effects by interacting with the gut-associated lymphoid tissue and mucosal immune system, leading to alterations in immune responses. This immunomodulation is mediated through various mechanisms and has implications for both local intestinal immunity and systemic immune function. Some key aspects of probiotic-mediated immunomodulation include:

- Regulation of Immune Cell Activity: Probiotics can modulate the activity and function of various immune cells, including T cells, B cells, dendritic cells, and macrophages. They can enhance the activity of regulatory T cells (Tregs), which play a critical role in maintaining immune tolerance and preventing excessive inflammation. Probiotics may also promote the production of anti-inflammatory cytokines, such as interleukin-10 (IL-10), while inhibiting the secretion of pro-inflammatory cytokines, such as tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6).
- Enhancement of Mucosal Immunity: Probiotics support the development and function of the gut-associated lymphoid tissue (GALT), which plays a central role in mucosal

immunity. They stimulate the production of secretory immunoglobulin A (sIgA), a key antibody involved in mucosal defense against pathogens. By enhancing mucosal immunity, probiotics help protect the intestinal epithelium from microbial invasion and maintain gut barrier integrity.

- Modulation of Systemic Immune Responses: In addition to local effects in the gut, probiotics can influence systemic immune responses. They can enhance the activity of natural killer (NK) cells, which play a crucial role in innate immunity and defense against viral infections and tumor cells. Probiotics may also promote the development of a balanced immune response, reducing the risk of allergic reactions, autoimmune disorders, and chronic inflammatory conditions.
- Anti-inflammatory Effects: Probiotics have anti-inflammatory properties, which can help mitigate inflammation in the gut and other tissues. They can suppress the activation of nuclear factor-kappa B (NF-κB), a key regulator of inflammatory gene expression, and inhibit the production of pro-inflammatory cytokines. By dampening inflammation, probiotics may alleviate symptoms associated with inflammatory bowel diseases (IBD), such as Crohn's disease and ulcerative colitis.

Overall, probiotic-mediated immunomodulation plays a crucial role in maintaining immune homeostasis, supporting host defense mechanisms, and regulating inflammatory responses[99][25]. By modulating immune cell activity, enhancing mucosal immunity, and exerting anti-inflammatory effects, probiotics contribute to overall health and may have therapeutic potential for immune-related disorders, including autism spectrum disorder (ASD).

4. ENHANCEMENT OF GUT BARRIER FUNCTION

One of the key mechanisms through which probiotics exert their beneficial effects is by enhancing the integrity and function of the gut barrier. The gut barrier, primarily composed of epithelial cells held together by tight junctions, serves as a physical and immunological barrier between the intestinal lumen and the bloodstream. A healthy gut barrier is essential for preventing the entry of harmful substances such as pathogens, toxins, and undigested food particles into the bloodstream, while allowing for the selective absorption of nutrients and water[66][77].

Probiotics support gut barrier function through several mechanisms:

- Tight Junction Regulation: Probiotics can influence the expression and assembly of tight junction proteins, such as occludin, claudins, and zonula occludens (ZO), which are crucial for maintaining the integrity of the intestinal epithelium. By promoting the formation of tight junction complexes, probiotics help strengthen the barrier function of epithelial cells and reduce intestinal permeability.
- Mucin Production: Probiotics stimulate the secretion of mucin, a gel-like substance produced by goblet cells that forms a protective layer over the intestinal epithelium. Mucin acts as a physical barrier against pathogens and helps lubricate the intestinal surface, facilitating the movement of food particles through the digestive tract. By enhancing mucin production, probiotics contribute to the maintenance of gut barrier integrity and protection against microbial invasion.
- Modulation of Immune Responses: Probiotics interact with immune cells in the gut-associated lymphoid tissue (GALT), influencing immune responses and inflammation. By promoting a balanced immune response, probiotics help prevent excessive inflammation and tissue damage, which can compromise gut barrier function. Additionally, probiotics support the development and function of regulatory T cells (Tregs), which play a key role in maintaining immune tolerance and preventing autoimmune reactions.
- Antimicrobial Activity: Some probiotic strains produce antimicrobial substances, such as bacteriocins and short-chain fatty acids (SCFAs), which inhibit the growth of

pathogenic bacteria in the gut. By reducing the abundance of harmful microbes, probiotics help prevent microbial dysbiosis and maintain a healthy microbial community, which is essential for gut barrier function.

Overall, the enhancement of gut barrier function by probiotics is critical for maintaining gastrointestinal health, preventing intestinal inflammation, and protecting against conditions such as leaky gut syndrome[25][78]. By strengthening the integrity of the gut barrier and promoting immune homeostasis, probiotics contribute to overall well-being and may have therapeutic potential for a variety of gastrointestinal disorders and systemic conditions.

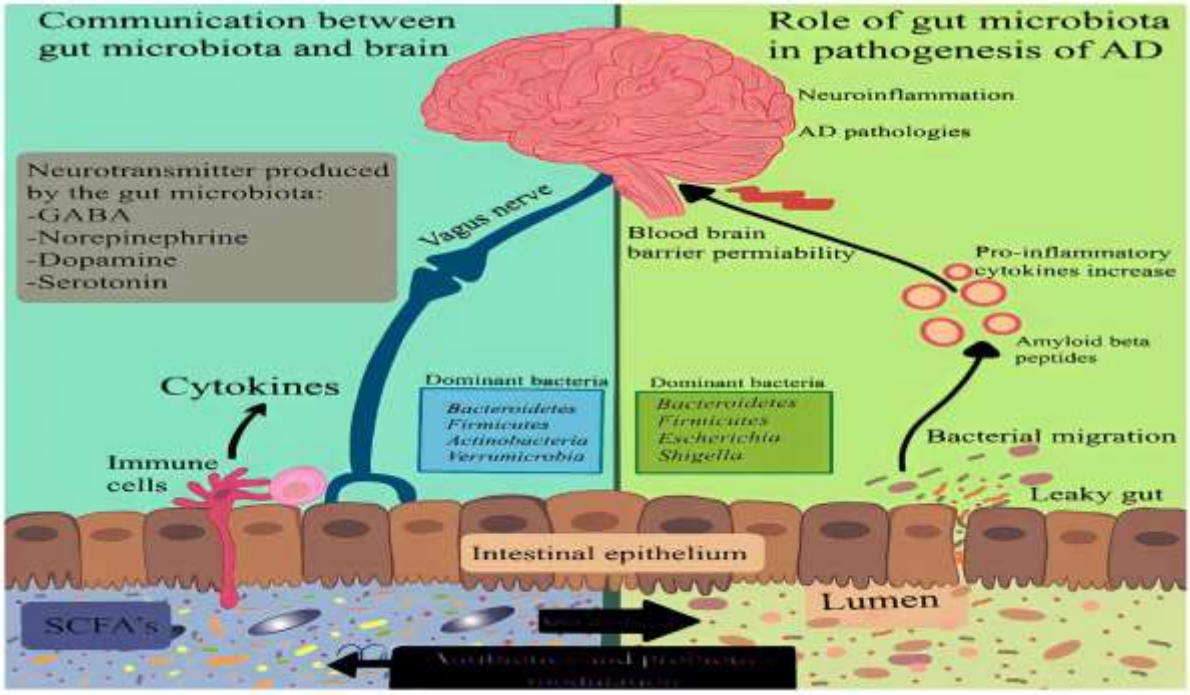

FIG:4 MODE OF ACTION GUT MICROBIOTA IN PATHOGENESIS OF AD

ENHANCEMENT OF GUT BARRIER FUNCTION
CLINICAL TRIALS AND OBSERVATIONAL STUDIES

Research into the therapeutic potential of probiotics in various health conditions, including autism spectrum disorder (ASD), involves both clinical trials and observational studies. These studies aim to investigate the efficacy, safety, and mechanisms of action of probiotics in individuals with ASD[96][91]. Here's an overview of clinical trials and observational studies related to probiotics in ASD:

A.Clinical Trials:

- Randomized Controlled Trials (RCTs): These are prospective studies in which participants with ASD are randomly assigned to receive either a probiotic intervention or a placebo/control treatment. RCTs provide high-quality evidence for evaluating the efficacy and safety of probiotics in ASD management.
- Double-Blind, Placebo-Controlled Trials: In these trials, neither the participants nor the researchers are aware of who is receiving the probiotic intervention and who is receiving the placebo/control treatment, reducing bias in the study results.
- Interventional Studies: Clinical trials may involve various types of probiotic interventions, such as single-strain or multi-strain formulations, different dosages, durations, and administration methods (e.g., capsules, powders, or fermented foods).

- Outcome Measures: Clinical trials typically assess various outcome measures related to ASD symptoms, gastrointestinal symptoms, behavior, cognition, quality of life, and biomarkers of gut health and immune function.

B.Observational Studies:

- Cohort Studies: These studies follow a group of individuals with ASD over time to assess the associations between probiotic consumption and health outcomes. Cohort studies can provide valuable insights into the long-term effects of probiotics and potential predictors of treatment response.
- Case-Control Studies: These studies compare individuals with ASD who have received probiotics with those who have not, aiming to identify associations between probiotic use and ASD-related outcomes.
- Cross-Sectional Studies: These studies analyze data from a single time point to investigate the prevalence of probiotic use among individuals with ASD and its relationship with various health outcomes.

Both clinical trials and observational studies play important roles in advancing our understanding of the effects of probiotics on ASD and informing clinical practice. They provide evidence regarding the efficacy, safety, optimal dosage, duration, and mechanisms of action of probiotics in ASD management[10][19]. However, further research, including larger-scale trials and mechanistic studies, is needed to confirm the findings and establish probiotics as a standard treatment option for ASD[101].

IMPACT ON GASTROINTESTINAL SYMPTOMS

Probiotic interventions have been investigated for their potential to alleviate gastrointestinal (GI) symptoms commonly experienced by individuals with autism spectrum disorder (ASD). GI symptoms, including abdominal pain, diarrhea, constipation, bloating, and gastroesophageal reflux, are prevalent among individuals with ASD and may contribute to behavioral challenges and decreased quality of life. Here's an overview of research findings regarding the impact of probiotics on GI symptoms in individuals with ASD:

- Reduction in Abdominal Discomfort: Clinical studies have reported that probiotic supplementation may lead to a reduction in abdominal pain, discomfort, and gastrointestinal distress in individuals with ASD. These improvements may contribute to enhanced comfort, well-being, and overall quality of life.
- Normalization of Bowel Habits: Probiotics have been associated with improvements in bowel habits, including reductions in diarrhea, constipation, and irregular bowel movements. These effects may result from the modulation of gut microbiota composition, promotion of intestinal motility, and regulation of bowel transit time.
- Alleviation of Gastrointestinal Inflammation: Probiotic interventions may help alleviate gastrointestinal inflammation and mucosal injury associated with ASD. By modulating immune responses, reducing intestinal permeability, and promoting gut barrier integrity, probiotics can mitigate inflammation and protect against gastrointestinal complications.
- Regulation of Gut Microbiota Composition: Dysbiosis, characterized by imbalances in gut microbiota composition, is commonly observed in individuals with ASD. Probiotics may help restore microbial balance by promoting the growth of beneficial bacteria and suppressing the proliferation of pathogenic microbes. This restoration of gut microbiota balance may contribute to improvements in GI symptoms and overall gastrointestinal health.
- Improvement in Digestive Function: Probiotics may enhance digestive function and nutrient absorption in individuals with ASD. By producing digestive enzymes, stimulating gastric acid secretion, and promoting the breakdown and absorption of

dietary nutrients, probiotics support optimal gastrointestinal function and nutrient utilization.

Overall, while the evidence supporting the impact of probiotics on GI symptoms in individuals with ASD is promising, further research is needed to confirm these findings and elucidate the underlying mechanisms[45]. Factors such as probiotic strain specificity, dosage, duration of treatment, and individual variability may influence treatment outcomes. Additionally, larger-scale clinical trials with rigorous study designs are necessary to establish probiotics as an effective therapeutic option for addressing GI symptoms in individuals with ASD.

MODULATION OF IMMUNE RESPONSES:

Despite the potential benefits of probiotics in managing conditions like autism spectrum disorder (ASD), there are several challenges and considerations that need to be addressed when implementing probiotic therapy. These challenges encompass various aspects of probiotic treatment, including selection of appropriate strains, dosage, treatment duration, and monitoring of treatment response. Here are some key challenges and considerations in probiotic therapy for individuals with ASD:

- Heterogeneity of Probiotic Strains: Probiotics encompass a diverse range of bacterial and yeast strains, each with unique properties and potential therapeutic effects. Selecting the most suitable probiotic strains for individuals with ASD can be challenging due to the heterogeneity of available products and the lack of consensus on which strains are most beneficial.
- Variability in Treatment Response: Individual responses to probiotic therapy can vary widely, depending on factors such as age, genetics, gut microbiota composition, diet, concurrent medications, and underlying health conditions. Some individuals with ASD may experience significant improvements in symptoms with probiotic treatment, while others may show minimal or no response.
- Optimal Dosage and Duration: Determining the optimal dosage and duration of probiotic treatment for individuals with ASD remains a challenge. Dosage recommendations may vary depending on the specific probiotic strain, formulation (e.g., capsules, powders, or fermented foods), and age of the individual. Additionally, the duration of treatment needed to achieve meaningful clinical benefits and maintain long-term effects is not well-established.
- Potential Adverse Effects: While probiotics are generally considered safe for most individuals, adverse effects such as gastrointestinal symptoms (e.g., bloating, gas, and diarrhea), allergic reactions, and systemic infections have been reported in some cases. Individuals with ASD may be particularly vulnerable to adverse effects due to underlying gastrointestinal sensitivities and immune dysregulation.
- Need for Standardization and Regulation: The probiotics market is characterized by a lack of standardization and regulation, leading to variability in product quality, potency, and efficacy. Standardized guidelines for probiotic manufacturing, labeling, and quality control are needed to ensure the safety and effectiveness of probiotic products for individuals with ASD.
- Monitoring and Follow-up: Regular monitoring of treatment response and clinical outcomes is essential to assess the effectiveness and safety of probiotic therapy in individuals with ASD. Healthcare providers should closely monitor changes in gastrointestinal symptoms, behavioral symptoms, and overall well-being and adjust treatment accordingly.

Addressing these challenges and considerations is critical for optimizing the use of probiotics in individuals with ASD and maximizing the potential benefits of probiotic therapy. Collaborative efforts among healthcare providers, researchers, regulatory agencies, and

individuals with ASD and their families are needed to overcome these challenges and advance probiotic treatment strategies for ASD management[55][33].

CONCLUSION: PROMISING INSIGHTS FOR AUTISM SPECTRUM DISORDER MANAGEMENT

Incorporating probiotics into Autism Spectrum Disorder (ASD) management offers promising avenues for improving gastrointestinal symptoms, modulating gut microbiota composition, and potentially influencing neurological function and behavior. Through personalized treatment approaches, multimodal interventions, and rigorous scientific inquiry, probiotics hold the potential to address the complex challenges associated with ASD. Future research focusing on mechanistic insights, clinical trials, biomarker identification, and intervention optimization will further advance our understanding and utilization of probiotics in ASD management, ultimately enhancing the quality of life for individuals with ASD and their families.

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AFET LOJİSTİĞİ YÖNETİMİNDE BAŞARIYI ETKİLEYEN TEMEL FAKTÖRLERİN İNCELENMESİ

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ÖZET
Günümüzde afetlerin sıklığı ve şiddetindeki artış, afet yönetimi çerçevesinde lojistik süreçlerin önemini ve etkin yönetilme gerekliliğini ortaya koymaktadır. Afet lojistiği, felaket sonrası yürütülen insani yardım operasyonlarının en kritik ve maliyetli bileşenlerinden biridir. Bu nedenle afet lojistiği operasyonlarının etkin biçimde yönetilmesi, ihtiyaçlara hızlı ve doğru yanıt verilmesi açısından hayati öneme sahiptir. Ancak afet koşullarında lojistik faaliyetleri yürütmek; sahadaki belirsizlik, kaynak kısıtlılığı, koordinasyon güçlükleri ve yoğun zaman baskısı nedeniyle oldukça karmaşıktır. Sahada ortaya çıkan lojistik sorunların sistematik olarak analiz edilmesi ve operasyonel başarıyı etkileyen faktörlerin net biçimde anlaşılması, afetlerin sosyal, ekonomik ve çevresel etkilerinin azaltılmasına ve gelecekte meydana gelebilecek felaketlere daha iyi hazırlanmaya olanak sağlayacaktır. Bu çalışma kapsamında afet lojistiği yönetiminde başarıyı etkileyen temel faktörler ayrıntılı olarak incelenmiştir. Bu bağlamda, afet lojistiğinin ticari lojistik ile benzerlikleri ve farklılıkları değerlendirilmiş, insani yardım operasyonları sırasında karşılaşılan temel sorunlar tanımlanmış ve lojistik faaliyetlerin başarısını belirleyen kritik unsurlar ortaya konmuştur. Çalışmanın bulguları, afet lojistiği operasyonlarının ticari lojistik faaliyetlerinden birçok noktada ayrıldığını göstermektedir. Afet durumunda yürütülen lojistik operasyonlar genellikle yüksek belirsizlik altında gerçekleşmekte, kaynaklar sınırlı kalmakta, koordinasyon eksiklikleri sıkça yaşanmakta ve hayat kurtarma zorunluluğu nedeniyle zaman yönetimi kritik bir önem arz etmektedir. Buna karşın afet lojistiği operasyonlarının başarısını sağlayan belirgin faktörlerin varlığı da ortaya konmuştur. Bu faktörler arasında hızlı ve zamanında müdahale kapasitesi, etkin bilgi yönetimi ve iletişim sistemleri, kaynakların (malzeme, finansal kaynaklar ve insan gücü) optimal kullanımı, afet öncesi kapsamlı planlama ve hazırlık stratejileri ile etkili dağıtım ve tedarik zinciri yönetimi yer almaktadır. Bu çalışmada afet lojistiğinde başarıya etki eden faktörlerin belirlenmesi amacıyla literatür analizi ve saha deneyimleri değerlendirilmiştir. Gerçekleştirilen analiz sonucunda tanımlanan kritik başarı faktörlerinin güçlendirilmesininn gerekliliği, böylece afet müdahale operasyonlarının etkinlik ve hızının önemli ölçüde artırılabileceği belirtilmiştir.
Anahtar Kelimeler: Afet Lojistiği, İnsani Yardım, Koordinasyon, Kaynak Yönetimi.

INVESTIGATION OF KEY FACTORS AFFECTING SUCCESS IN DISASTER LOGISTICS MANAGEMENT

ABSTRACT
The increasing frequency and severity of disasters today emphasise the importance of effective logistics management within disaster management frameworks. Disaster logistics is one of the most critical and costly components of post-disaster humanitarian operations. Therefore, the efficient management of disaster logistics operations is crucial for providing timely and accurate responses to emergent needs. However, conducting such operations in disaster zones is highly complex due to field uncertainties, limited resources, coordination challenges and intense time pressures. Systematically analysing the logistical problems encountered in the field and clearly understanding the factors influencing operational success can help to reduce the social, economic and environmental impacts of disasters, and facilitate better preparedness

for future events. In this context, this study thoroughly examines the key factors affecting success in disaster logistics management. Specifically, it evaluates the similarities and differences between disaster and commercial logistics, identifies the main issues encountered during humanitarian aid operations and outlines the critical elements that determine the success of logistics activities. The study's findings indicate that disaster logistics operations differ significantly from commercial logistics in several respects. Disaster logistics operations are usually carried out in situations of high uncertainty, with limited resources and frequent coordination difficulties, as well as critical time management challenges due to life-saving imperatives. Nevertheless, the study clearly identifies certain critical factors that enable successful disaster logistics operations despite these difficulties. These factors include the capability to respond rapidly and in a timely manner, effective information management and communication systems, the optimal utilisation of resources (including materials, finances and human resources), comprehensive pre-disaster planning and preparedness strategies, and effective distribution and supply chain management. This study evaluated literature and field experiences to identify the factors affecting success in disaster logistics. The analysis highlights the importance of strengthening these critical success factors, suggesting that doing so would significantly improve the effectiveness and speed of disaster response operations.
Keywords: Disaster Logistics, Humanitarian Aid, Coordination, Resource Management.

GİRİŞ

Afet lojistiği yönetimi, afet ve acil durumlarda ihtiyaç duyulan malzeme ve hizmetlerin etkin bir şekilde tedarik edilmesi, depolanması, taşınması ve dağıtılmasını kapsayan özel bir lojistik faaliyet alanıdır. Klasik ticari tedarik zincirlerinden farklı olarak insani yardım lojistiği, talep belirsizliği, acil zaman baskısı, altyapı hasarı ve çok sayıda paydaşın katılımı gibi benzersiz zorluklarla karakterize edilmektedir (Van Wassenhove, 2006). Afet lojistiğinin amacı, felaketzedelerin acil ihtiyaçlarını en kısa sürede karşılayarak hayat kurtarmak ve acıları hafifletmektir. Akademik literatürde insani yardım tedarik zinciri, "planlama, uygulama ve kontrol faaliyetlerini kapsayarak, afet sonrası gerekli malzemelerin ve bilgilerin kaynağından tüketim noktasına akışını yönetip insanların acılarını dindirmeyi hedefleyen süreç" olarak tanımlanmaktadır (Gheibi, Bahrami, & Farahabadi, 2021).

21. yüzyılda afetlerin sayısı ve şiddeti artma eğilimindedir. İklim değişikliği, nüfus artışı ve kentleşme gibi etmenlerin de etkisiyle her yıl yüz milyonlarca insan doğal afetlerden etkilenmekte; deprem, sel, kasırga, orman yangını gibi olaylar ciddi can kaybı ve hasara yol açmaktadır. Afetlere müdahale kapasitesini geliştirmek, günümüz toplumları için hayati bir ihtiyaç haline gelmiştir. Ancak afet yönetimi, lojistik açıdan son derece karmaşık ve çok aktörlü bir çaba gerektirmektedir. Afet lojistiği; kamu kurumları (afet yönetim ajansları, askeriye), uluslararası kuruluşlar, yerel ve uluslararası sivil toplum örgütleri , özel sektör şirketleri ve etkilenen yerel topluluklar dahil olmak üzere birçok paydaşın eş güdüm içinde çalışmasını zorunlu kılmaktadır (Yadav & Barve, 2015).

Afet lojistiği literatürü son yıllarda giderek zenginleşmiş, konuyla ilgili vaka analizleri, optimizasyon modelleri, saha araştırmaları ve derlemeler yayınlanmıştır. Yapılan araştırmalar, insani yardım operasyonlarının geleneksel ticari lojistikten farklı dinamikleri olduğunu ve başarılı bir afet lojistiği yönetimi için özgün strateji ve faktörlerin belirlenmesi gerektiğini ortaya koymaktadır (Tasnim, Hamid, Dwivedi, & Shareef, 2022). Örneğin, Van Wassenhove, (2006), afetlere hazırlığın beş ana unsurunu (insan kaynakları, bilgi yönetimi, süreç yönetimi, finansal kaynaklar ve toplumsal/topluluk düzeyi işbirliği) vurgulayarak hazırlıklılık düzeyinin müdahale etkinliğine doğrudan etki ettiğini göstermiştir. Benzer şekilde Kovács & Spens, (2007), afet lojistiğinin operasyon fazlarına (hazırlık, müdahale ve iyileşme) ve aktörler arası ilişkilere dikkat çekerek her bir aşamada farklı başarı kriterleri olduğunu belirtmiştir.

Literatürde öne çıkan diğer konular arasında tedarik zinciri esnekliği ve dayanıklılığı, insani lojistikte yenilikçi teknolojilerin kullanımı, bağış yönetimi, gönüllü ve insan kaynağı yönetimi, bilgi paylaşımı ve koordinasyon mekanizmaları gibi temalar bulunmaktadır.

Bu çalışmanın amacı, afet lojistiği yönetiminde başarıya etki eden temel faktörleri genel bir perspektifte ortaya koymak ve aralarındaki etkileşimleri tartışmaktır. Bu amaçla en güncel ve etkili akademik yayınlar (özellikle Science Citation Index kapsamındaki çalışmalar) analiz edilmiş; literatürde tanımlanan faktörler, güncel zorluklar ve uygulamadan örnekler çerçevesinde incelenmiştir. Çalışma, belirli bir ülkeye veya afet türüne odaklanmamakta; bunun yerine genel geçer ilkeler ve başarı faktörleri üzerinde durmaktadır. Böylelikle, farklı afet senaryolarında ve farklı coğrafyalarda geçerli olabilecek bir başarı faktörleri çerçevesi oluşturulması hedeflenmiştir.

ARAŞTIRMA ve BULGULAR

Afet lojistiği yönetiminin başarısı önündeki engelleri ve zorlukları anlamak, başarı faktörlerini doğru konumlandırmak için ön koşuldur. Mevcut literatür, insani yardım lojistiğinde karşılaşılan başlıca güçlükleri çeşitli araştırmalarla ortaya koymuştur. Bunların başında altyapı hasarı ve yetersizlikleri gelmektedir. Deprem, sel gibi büyük afetlerden sonra yollar, köprüler, havaalanları ve iletişim altyapısı ciddi şekilde zarar görebilmekte; bu durum yardım malzemelerinin bölgeye ulaştırılmasını güçleştirmektedir. Nitekim yetersiz ulaşım altyapısı, insani lojistik operasyonlarında kritik bir sorun olarak tanımlanmıştır (Imbriale, 2025). Özellikle afet bölgesine erişim yollarının kapanması veya lojistik merkezlerin (liman, depo vb.) hasar alması durumunda, en iyi planlar dahi sekteye uğrayabilmektedir.

Diğer önemli bir zorluk, talep belirsizliği ve öngörülemeyen ihtiyaç dalgalanmalarıdır. Afetlerin doğası gereği, tam olarak neye, ne kadar ve nerede ihtiyaç duyulacağını önceden kesin olarak bilmek mümkün değildir (Van Wassenhove, 2006). Örneğin, büyük bir deprem sonrasında bölgedeki yaralı sayısı, gerekli sağlık malzemesi miktarı veya barınma ihtiyacı ilk etapta belirsiz olabilmektedir.

Afet lojistiğinde karşılaşılan bir başka temel güçlük, koordinasyon eksikliği ve çok aktörlü ortamın karmaşıklığıdır. Uluslararası yardımların söz konusu olduğu büyük felaketlerde, onlarca farklı kuruluş ve grubun sahada faaliyet gösterdiği bilinmektedir. Örneğin, bir mega deprem sonrasında Birleşmiş Milletler ajansları, Kızılhaç/Kızılay, yerel ve yabancı STK'lar, ordu birimleri ve özel sektörden gönüllüler aynı anda bölgede operasyon yapabilmektedir. Eğer bu aktörler arasında etkin bir koordinasyon mekanizması yoksa, bazı bölgelere mükerrer yardım giderken bazıları ihmal edilebilir; lojistik altyapı (havaalanı, depo gibi) tıkanıklıkları yaşanabilmekte; hatta aktörler arasında rekabet ya da iletişimsizlik sonucu kaos oluşabilmektedir (Yadav & Barve, 2015). Bu sorunu aşmak için Birleşmiş Milletler tarafından 2005'te geliştirilen "küme yaklaşımı" (cluster approach) gibi girişimler, belirli sektörler (lojistik, barınma, gıda, sağlık vb.) özelinde lider kuruluşlar atayarak koordinasyonu sağlamaya çalışmıştır. Ancak pratikte koordinasyon, her afetin dinamiklerine bağlı olarak halen en büyük meydan okumalardan biridir. Güven eksikliği, bilgi paylaşımındaki isteksizlik veya kurumların farklı öncelikleri, etkin işbirliğini zorlaştıran insani lojistik gerçekleridir (Tasnim et al., 2022).

Başarı Faktörleri ve Temel Bileşenler

Afet lojistiğinde başarıyı getiren temel faktörler, literatürde kritik başarı faktörleri (Critical Success Factors, CSF) olarak anılmaktadır. Pek çok çalışma farklı boyutlara odaklanarak insani lojistik performansını artıran unsurları belirlemiştir (Yadav & Barve, 2015). Bu çalışmada, özellikle öne çıkan faktörler altı ana başlık altında incelenmiştir: Koordinasyon ve işbirliği, zaman yönetimi ve hızlı müdahale, kaynak tahsisi ve lojistik planlama, teknoloji ve dijital araçların kullanımı, insan kaynakları ve eğitim, paydaş işbirliği ve yerel katılım. Bu faktörlerin her biri aşağıda açıklanmakta ve ilgili literatür bulgularıyla desteklenmektedir.

Koordinasyon ve İşbirliği

Koordinasyon, birden fazla aktörün uyum içinde çalışmasını ve ortak bir hedefe yönelik hareket etmesini sağlayan süreçler bütünüdür. Afet lojistiğinde koordinasyon, hem operasyonel düzeyde (sahada malzeme akışının düzenlenmesi, görev paylaşımı, bilgi paylaşımı) hem de stratejik düzeyde (planlama ve politika uyumu) ele alınmalıdır. Yatay koordinasyon, benzer seviyedeki kuruluşlar arasında (örneğin iki STK ya da komşu ülkelerin ekipleri arasında) işbirliği ve bilgi alışverişini ifade ederken; dikey koordinasyon, hiyerarşik seviyeler arasında (merkezi yönetim – yerel yönetim – saha ekibi gibi) uyumu kapsamaktadır (Yadav & Barve, 2015).

Zaman Yönetimi ve Hızlı Müdahale

Afetlerin ardından zamana karşı yarış, lojistik operasyonların en ayırt edici özelliklerinden biridir. "Acil yardım" kavramının özünde, ihtiyaç duyulan yardımın mümkün olan en kısa sürede kriz bölgesine ulaştırılması yatmaktadır. Bu nedenle, afet lojistiğinde zaman yönetimi (timeliness) kritik bir başarı ölçütü olarak kabul edilmektedir. Başarılı bir afet lojistiği operasyonu, doğru malzemeyi doğru yere sadece etkin biçimde değil, aynı zamanda hızlı bir şekilde ulaştırabilmelidir. Zaman yönetiminin önemi, literatürde çeşitli çalışmalar ve vaka analizleriyle vurgulanmıştır (Van Wassenhove, 2006).

Kaynak Tahsisi ve Lojistik Planlama

Afet lojistiği yönetiminde kaynakların etkin tahsisi ve lojistik planlamanın optimizasyonu, operasyonların başarısı için kritik öneme sahiptir. Burada "kaynak" kavramı geniş bir anlam taşır: malzemeler (yardım ürünleri), insan gücü (personel, gönüllüler), araçlar ve ekipman, depolar ve altyapı, ve tabi ki mali kaynaklar bu kapsamda değerlendirilebilir. Afet sonrası ortamda bu kaynaklar genellikle sınırlıdır veya talebi karşılamakta yetersiz kalabilmekte; bu nedenle mevcut kaynakların doğru zamanda, doğru iş için, doğru miktarda tahsis edilmesi gerekmektedir. Malzeme ve envanter yönetimi, kaynak tahsisinin önemli bir boyutudur. Hangi malzemeden ne kadar ihtiyaç olduğu, elde ne kadar bulunduğu ve bunların nerede depolandığı soruları hızlı ve doğru biçimde cevaplanmalıdır (Tasnim et al., 2022).

Teknoloji ve Dijital Araçların Kullanımı

Teknolojinin ilerlemesiyle birlikte, afet lojistiği yönetiminde dijital araçlar ve yenilikçi teknolojilerin kullanımı, başarı faktörleri arasında giderek daha fazla önem kazanmaktadır. Modern insani yardım operasyonları, bilgiye hızlı erişim ve işlemenin yanı sıra fiziksel lojistik süreçlerde teknolojik desteğe büyük ölçüde dayanır hale gelmiştir. Bilgi ve iletişim teknolojileri (ICT), afet lojistiğinin planlanması, koordinasyonu ve icrasında merkezi bir rol oynamaktadır (Yadav & Barve, 2015). Örneğin, SUMA ve LSS (Logistics Support System) gibi yazılımlar, afet durumunda gelen yardım malzemelerinin envanterini tutmak, depolara giriş-çıkışlarını kaydetmek ve dağıtımını planlamak için özel olarak geliştirilmiştir. Bu sistemler, büyük hacimli verileri düzenleyerek insan hatasını azaltır ve kaynakların hesap verebilir şekilde yönetilmesine yardımcı olmaktadır. Şeffaflık da böylece artar; hangi bağışın nereye harcandığı veya hangi malzemenin nerede kullanıldığı takip edilebilir hale gelmektedir (Tasnim et al., 2022).

İnsan Kaynakları ve Eğitim

Afet lojistiğinin sahadaki başarısını belirleyen en önemli unsurlardan biri de insan kaynaklarıdır. Lojistik süreçleri ne kadar otomasyona bağlanırsa bağlansın, karar veren, uygulayan ve uyum sağlayan insanlar olmadan başarıya ulaşamamaktadır. Bu nedenle, eğitimli, yetkin ve deneyimli personel afet lojistiğinde kritik bir başarı faktörüdür. Van Wassenhove, (2006)'nun hazırlık çerçevesinde saydığı beş unsurdan ilki insan kaynaklarıdır; yazar, planlama, koordinasyon ve müdahaleyi yapabilecek nitelikte insanların seçilip eğitilmesinin afetlere hazırlığın temel taşı olduğunu vurgulamıştır.

Paydaş İşbirliği ve Yerel Katılım

Devlet mekanizmaları, afet yönetiminin hem sorumlusu hem de kolaylaştırıcısı konumundadır. Yadav & Barve, (2015) çalışmaların da altını çizdiği üzere, hükümet politikaları ve organizasyon yapısı, insani tedarik zincirinin en güçlü belirleyicilerinden biridir ve hükümet desteği adeta diğer tüm başarı faktörlerinin temelinde yatmaktadır.

Yerel yönetimler ve toplumun katılımı, paydaş işbirliğinin diğer bir boyutudur. Yerel aktörler, afet alanını en iyi bilen ve orada uzun vadede yaşamaya devam edecek kesimdir. Bu yüzden, onların sürece dahil edilmesi hem operasyonun başarısını hem de kalıcılığını etkilemektedir.

SONUÇ

Bu araştırmanın bulguları, akademik ve pratik açılardan çeşitli çıkarımlar sunmaktadır. Akademik olarak, afet lojistiği alanında kritik başarı faktörlerinin bütüncül bir çerçevede incelenmesi, gelecekteki çalışmalar için bir temel oluşturabilmektedir. Pratik açıdan ise, insani yardım operasyonlarını planlayan ve yürütenler için somut öneriler çıkmaktadır. Özellikle afet öncesi hazırlık çalışmalarına yatırım yapmak kritik görünmektedir.

Sonuç olarak, afet lojistiği yönetiminde başarı; doğru zamanda doğru kararları alabilen, elindeki kaynakları en akıllı biçimde kullanabilen ve tüm paydaşları ortak hedef doğrultusunda seferber edebilen bir yönetim yaklaşımını gerektirmektedir.

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AŞI REDDİ VE ANA-ÇOCUK SAĞLIĞINA ETKİLERİ

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ÖZET
Giriş: Aşı reddinin Ana-çocuk sağlığına etkilerini içerdiği veriler kullanılarak ülkelerin gelişmişliği ve o ülkelerin genel sağlık durumu hakkında fikir sahibi olunabilmektedir. Bu hizmetlerin başarılı bir şekilde yürütülmesi için devlet destekli, multidisipliner çalışma olanaklarının sağlanması gerekir.
Amaç: Bu derlemenin amacı, Aşı reddinin ana ve çocuk sağlığına olan etkilerinin incelenmesidir.
Yöntem: Literatür taraması 01-15 Haziran 2025 tarihleri arasında yapılmıştır. Çalışma sırasında 'Aşı" VE "Aşı reddi" VE "Aşı tutumu ve tereddütü" VE "Ana-çocuk sağlığı" VEYA "Sağlık" VE "Aşı takvimi" VE "Aşının önemi" VE "Aşı reddinin ana, çocuk sağlığına etkisi" kelimeleri ve bu kelimelerin İngilizce tercümeleri kullanılarak Google Akademi, Medline, Pubmed ve Sciencedirect arama motorlarında taramalar yapılmıştır.
Literatür Bulguları: Sağlıkta aşı reddi kavramı toplumsal boyutta her kesimi ilgilendiren bir durumdur. Genel anlamda sağlıkta aşı reddi kavramı; siyasal, kültürel, dinsel, mesleksel, sınıfsal, sosyal ve ekonomik nedenlerden ötürü ortaya çıktığını ifade eder. Özellikle hassas grup olarak nitelendirdiğimiz ana-çocuk sağlığına etkisi için yöneticilerin ulusal değerlere ve evrensel standartlara uygun yol haritaları olmalı ayrıca gerçekçi hedef ve stratejileri bulunmalıdır.
Sonuç: Aşı reddinin Ana-çocuk sağlığını etkilediğini ve bu etkinin toplumsal anlamda sonuçları olduğunu aşı reddi için yapılan çalışmaların geliştirilmesi için atılacak olan her adım aslında toplumun da sağlık alanında gelişmesinin önünü açacak ve sağlıklı, doğru, yararlı halk sağlığı tepkilerinin oluşmasını sağlayacaktır. Geri kalmış, gelişmekte olan veya gelişmiş ülkelerde her zaman en önemli sağlık politika hedeflerinden olan aşı reddinin ana-çocuk sağlığına yönelik tutumun iyi yönetildiğinde sağlıklı nesillerin dolayısıyla sağlıklı toplumun temelini oluşturacaktır.
Anahtar Kelimeler: Aşı, Ana-çocuk sağlığı, Aşı reddi, Aşının önemi, Aşı takvimi.

VACCINE REJECTION AND ITS EFFECTS ON MATERNAL AND CHILD HEALTH

ABSTRACT
Introduction: Using the data containing the effects of vaccine refusal on maternal and child health, it is possible to have an idea about the development of countries and the general health status of those countries. In order for these services to be carried out successfully, state-supported, multidisciplinary working opportunities should be provided.
Aim: The aim of this review is to examine the effects of vaccine refusal on maternal and child health.
Method: Literature review was conducted between 01-15 June 2025. During the study, the words 'Vaccine' AND 'Vaccine refusal' AND 'Vaccine attitude and hesitancy' AND 'Maternal and child health' OR 'Health' AND 'Vaccine calendar' AND 'Importance of

vaccination' AND 'Impact of vaccination refusal on maternal and child health' and their English translations were used to search Google Academy, Medline, Pubmed and Sciencedirect search engines.
Literature Findings: The concept of vaccine refusal in health is a situation that concerns every segment of society. In general, the concept of vaccine refusal in health means that it occurs due to political, cultural, religious, professional, class, social and economic reasons. Especially for its effect on maternal and child health, which we call a sensitive group, managers should have roadmaps that are in line with national values and universal standards, and they should also have realistic goals and strategies.
Conclusion: Every step to be taken to develop studies on vaccine refusal that affect maternal and child health and that this effect has social consequences will actually pave the way for the development of the society in the field of health. and will ensure the formation of healthy, correct and beneficial public health responses. When the attitude towards maternal and child health, which has always been one of the most important health policy targets in underdeveloped, developing or developed countries, is managed well, it will form the basis of healthy generations and therefore a healthy society.
Keywords: Vaccine, Maternal and child health, Vaccine refusal, Importance of vaccination, Vaccination calendar.

GİRİŞ

Dünya Sağlık Örgütü (DSÖ), aşıları belirli hastalıklara karşı bağışıklık sağlayan biyolojik ürünler olarak tanımlamaktadır. Bağışıklama yoluyla yapılan aşı uygulamaları, bulaşıcı hastalıklara karşı koruma sağlayarak her yıl 2 ila 3 milyon ölümün önüne geçmektedir (DSÖ, 2023). Günümüzde aşıların etkinliği, sağladığı yararlar ve güvenilirliği geniş ölçüde kabul görmüş olsada, nadir görülen yan etkilerine dikkat çekilerek zaman zaman tartışmalara konu olmaktadırlar (Hasar ve ark. 2021).

Hastalığa yol açan virüs, bakteri gibi mikroorganizmaların zararlı özelliklerinden arındırılarak geliştirilen ve vücuda verildiğinde bağışıklık kazandıran biyolojik maddelere aşı denir. Aşılama ise, morbidite ve mortaliteye sebep olan hastalıkların bireyler ve toplum üzerindeki olumsuz etkilerini azaltmak veya tamamen ortadan kaldırmak amacıyla, zayıflatılmış ya da etkisiz hale getirilmiş mikroorganizmaların uygun yöntemlerle vücuda verilmesidir. Bu sayede sadece bireylerde değil, aynı zamanda toplum genelinde de bağışıklık, yani sürü bağışıklığı (Herd Immunity) oluşur. Aşılama programları, bulaşıcı hastalıkların yayılımını engellemek, hastalıkların yol açtığı sağlık sorunlarını azaltmak ve toplumsal sağlığın gelişimini desteklerken maliyetlerin etkin bir şekilde yönetilmesini amaçlamaktadır (Oktem ve ark. 2023).

AMAÇ:

Bu derlemenin amacı, Aşı reddinin ana ve çocuk sağlığına olan etkilerinin incelenmesidir.

YÖNTEM:

Literatür taraması 01-15 Haziran 2025 tarihleri arasında yapılmıştır. Çalışma sırasında 'Aşı" VE "Aşı reddi" VE "Aşı tutumu ve terdeütü" VE "Ana-çocuk sağlığı" VEYA "Sağlık" VE "Aşı takvimi" VE "Aşının önemi" VE "Aşı reddinin ana, çocuk sağlığına etkisi" kelimeleri ve bu kelimelerin İngilizce tercümeleri kullanılarak Google Akademi, Medline, Pubmed ve Sciencedirect arama motorlarında taramalar yapılmıştır.

LİTERATÜR BULGULARI

Aşı

Aşılar, bağışıklık sisteminin belirli enfeksiyonlara karşı korunmasını sağlamak amacıyla geliştirilen ve hastalık etkenlerine ait zayıflatılmış ya da etkisizleştirilmiş mikroorganizma parçalarını içeren biyolojik ürünlerdir. Bu preparatlar, vücuda uygulandığında bağışıklık sistemi bu etkenleri tanımayı öğrenir ve olası bir enfeksiyon durumunda hızlı ve etkili bir

savunma yanıtı geliştirir. Aşılar yalnızca bireysel koruma sağlamaz; aynı zamanda halk sağlığı açısından da kritik bir rol oynar. Geniş çaplı aşılama uygulamaları sayesinde toplumda sürü bağışıklığı oluşur. Bu durum, aşı olamayan bireyleri örneğin bağışıklık sistemi zayıf olanlar, alerjik yapıya sahip kişiler ya da bebekler dolaylı yoldan koruyarak hastalıkların yayılmasını önlemeye yardımcı olur. (Mac donald ve ark. 2020).

Aşının Önemi

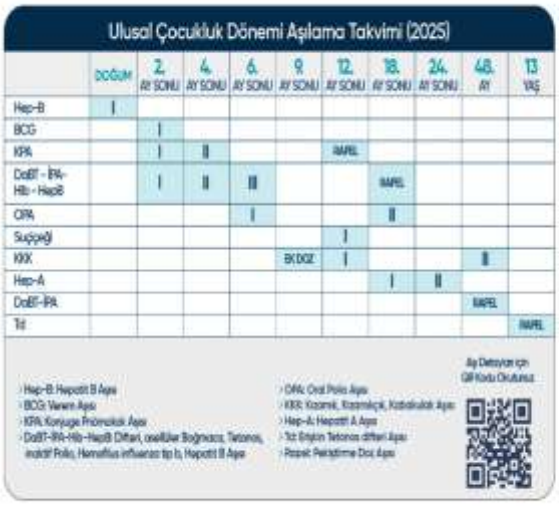
Aşılar, insan sağlığını koruma açısından en etkili ve güvenilir önlemlerden biridir. Bağışıklık sistemi, aşılar sayesinde hastalık etkenlerini tanımayı öğrenerek bu mikroorganizmalara karşı önceden hazırlıklı hale gelir. Bu durum, bireyin hastalığa yakalanması durumunda ya hiç belirti göstermemesi ya da enfeksiyonu hafif atlatmasını sağlar. Aşıların en önemli faydalarından biri, bulaşıcı ve hayatı tehdit edebilecek hastalıkların önlenmesidir. Örneğin; kızamık, çocuk felci, tetanoz, verem ve difteri gibi ciddi hastalıklar, yaygın aşılama çalışmaları sayesinde büyük ölçüde kontrol altına alınmış ve toplum sağlığı açısından önemli kazanımlar elde edilmiştir. Geçmişte çok sayıda ölüme yol açan bu hastalıklar, bugün düzenli aşılama programları sayesinde oldukça nadir görülmektedir (Taşcı 2021).

Aşılar yalnızca bireyin değil, toplumun genel sağlığının korunmasında da hayati öneme sahiptir. Nüfusun büyük bir kısmı aşılandığında, bulaşıcı hastalıkların yayılması sınırlanır ve sürü bağışıklığı adı verilen toplumsal bir koruma mekanizması devreye girer. Bu bağışıklık duvarı, bağışıklık sistemi zayıf olanlar, henüz aşılanmamış bebekler ya da kronik rahatsızlıkları nedeniyle aşı olamayan bireyler için koruyucu bir çevre oluşturur. COVID-19 pandemisinde de açıkça görüldüğü üzere, aşılar küresel sağlık krizlerinin yönetilmesinde temel araçlardan biridir. Salgınların yayılım hızını azaltarak sağlık sistemlerinin üzerindeki yükü hafifletir ve birçok insanın hayatını kurtarır (Li ve ark. 2020).

Aşı Takvimi

Türkiye'de yürürlükte olan çocukluk çağı aşı takvimine göre, toplamda 13 farklı enfeksiyon hastalığına karşı koruyucu aşılama hizmeti sunulmaktadır. Bu hastalıklar arasında difteri, boğmaca, tetanos, çocuk felci (polio), hepatit B, hepatit A, Haemophilus influenzae tip b (Hib), tüberküloz, kızamık, kabakulak, kızamıkçık, suçiçeği ve pnömokok enfeksiyonları yer almaktadır. Bu aşılama programı, çocukların erken yaşlardan itibaren ciddi enfeksiyonlara karşı bağışıklık geliştirmesini hedefleyerek toplum sağlığının korunmasına önemli katkı sağlamaktadır (Sağlık bakanlığı 2025).

2025 yılında güncellenen Ulusal Aşı Takvimi aşağıdaki gibidir (Sağlık bakanlığı 2025).





Aşı Reddi

Aşı reddi, bireylerin ya da ebeveynlerin, tıp otoriteleri ve sağlık kuruluşları tarafından önerilen, güvenliği ve etkinliği bilimsel araştırmalarla kanıtlanmış aşılama uygulamalarını, kişisel, dini, kültürel, felsefi veya psikolojik nedenlerle bilinçli olarak yaptırmama kararı alması durumudur. Bu durum, yalnızca bireyin kendi sağlığını değil, aynı zamanda toplum sağlığını da olumsuz yönde etkileyen ciddi bir halk sağlığı problemidir. Aşılar, bireyleri bulaşıcı hastalıklardan korumak amacıyla geliştirilen, bağışıklık sistemini belirli hastalıklara karşı hazırlayan biyolojik ürünlerdir. Aşılama yoluyla toplumda bağışıklık oranı arttıkça, hastalıkların yayılma hızı düşer ve bazı hastalıkların tamamen ortadan kalkması bile mümkün hale gelir. Bu duruma toplumsal bağışıklık (sürü bağışıklığı) denir. Ancak, yeterli sayıda insan aşılanmadığında bu bağışıklık duvarı yıkılır ve önlenebilir hastalıkların yeniden yayılması riski artar. Aşı reddi, işte bu kritik bağışıklık düzeyini tehdit eden başlıca unsurlardan biridir (Aygün ve ark. 2020).

Dünya'da Aşı Reddi

Aşılama oranları dünya genelinde ülkelerin gelişmişlik düzeyine göre farklılık göstermektedir. Gelişmiş ülkelerde aşılama kapsamı genellikle %90'ın üzerinde seyrederken, düşük ve orta gelirli ülkelerde bu oran %70–80 düzeylerinde kalabilmektedir. 1990'lı yıllardan itibaren "aşı reddi" kavramı küresel ölçekte daha fazla dikkat çekmeye başlamış ve çeşitli sosyoekonomik, politik ve kültürel etkenlerin bu durumu tetiklediği görülmüştür. Sağlık hizmetlerinin yetersizliği, ekonomik istikrarsızlıklar, silahlı çatışmalar, aşıya erişimde yaşanan güçlükler ve aşı karşıtı söylemlerin yaygınlaşması, aşı reddinin artmasına neden olan başlıca faktörler arasında yer almaktadır. Avrupa'da difteri, tetanoz ve boğmacaya karşı bağışıklama oranı %92'ye, Amerika kıtasında ise %91'e kadar gerilemiştir (Çıtak ve ark. 2021; DSÖ, 2017).

2018 yılı verilerine göre, dünya genelinde yaklaşık 19 milyon bebek, rutin bağışıklama kapsamında en az bir doz kızamık aşısı alamamıştır. Bu durum özellikle sağlık altyapısının yetersiz olduğu ülkelerde daha belirgin hale gelmiştir. Aşılamanın yetersiz kaldığı ülkeler arasında Hindistan, Nijerya ve Pakistan gibi az gelişmiş ülkeler öne çıkmaktadır. Aynı yıl küresel düzeyde bildirilen kızamık vakası sayısı 324.277 olarak kaydedilmiş; 2019'un başlarında ise bu sayı 74.338 olarak rapor edilmiştir. Bu veriler, kızamık gibi önlenebilir hastalıklarda bile bağışıklama oranlarının düşmesinin ciddi halk sağlığı tehditlerine yol açabileceğini göstermektedir (DSÖ, 2022).

2000 ile 2018 yılları arasında kızamık aşısı sayesinde küresel vaka sayılarında yaklaşık %73 oranında azalma sağlanmıştır. Ancak bu önemli düşüşe rağmen, kızamık halen dünya genelinde yaygın bir sağlık sorunu olmaya devam etmektedir. 2018 yılında kızamığa bağlı ölümlerin sayısı 140.000'in üzerinde gerçekleşmiştir. Bu durum, aşılamadaki ilerlemelere rağmen, hastalığın tamamen kontrol altına alınamadığını ve bağışıklama programlarının sürdürülmesinin hayati önem taşıdığını göstermektedir (DSÖ, 2022).

DSÖ (2020), kızamık ve çocuk felci gibi yeniden ortaya çıkan bulaşıcı hastalıkların kontrol altına alınabilmesi için acil müdahale gerekliliğine dikkat çekmiştir. Özellikle Pakistan, Afganistan ve bazı Afrika ülkelerinde çocuk felci virüsünün yayılımında artış beklendiği ve aşılama faaliyetlerinin aksaması durumunda önümüzdeki on yıl içinde yaklaşık 200.000 yeni vakanın ortaya çıkabileceği öngörülmektedir. Ayrıca, Avrupa kıtasında ve Amerika Birleşik Devletleri'nin bazı eyaletlerinde bağışıklama oranlarının son on yılda %2 ile %4 arasında azaldığı belirtilmektedir. DSÖ, 2030 yılına kadar dünya genelindeki tüm çocukların aşılanmasını hedeflemektedir. Bu hedef, küresel sağlık eşitsizliklerini azaltmayı ve salgın hastalıkların yayılmasını önlemeyi amaçlamaktadır (Hazır 2018).

Türkiye'de Aşı Reddi

Türkiye'de "aşı reddi" kavramı 2010 yılından itibaren kullanılmaya başlanmıştır. Medyada yer alan bazı haberler ve kamuoyuna yansıyan olaylar, aşı reddi tutumunun toplumda yaygınlaşmasında etkili olmuştur. 2015 yılında Ordu ilinde bir ailenin ikiz çocuklarına aşı yaptırmayı reddetmesi, kamuoyunda geniş yankı uyandırmıştır. Bu olay sonrasında yetkili

makamlar tarafından aile hakkında sağlık tedbiri alınması amacıyla dava açılmıştır. Ancak aile, bireysel hakların ihlali ve aydınlatılmış onam alınmaması gerekçeleriyle karşı dava açmış ve hukuki sürecin sonunda davayı kazanmıştır. Bu gelişme, aşıya yönelik bireysel tutumların hukuki boyutta da tartışılmasına neden olmuştur (Bozkurt 2018).

Söz konusu davanın aile lehine sonuçlanmasının ardından, bazı gazetelerde "İkiz bebeklerine aşı yaptırmayan savcının hukuk zaferi" gibi başlıklarla haberler yayımlanmıştır. Bu olayın medyada geniş yer bulması, kamuoyunda aşı karşıtlığına dair farkındalığı artırmış ve toplumda benzer tutumların yaygınlaşmasına zemin hazırlamıştır. Özellikle sosyal medyada paylaşılan bu haber, bireylerin aşıya yönelik tereddütlerini pekiştirmiş ve benzer durumların art arda yaşanmasına, adeta bir domino etkisi oluşmasına neden olmuştur (Yıldız ve ark. 2021).

Türkiye'de aşıyı reddeden aile sayısına bakıldığında, yıllar içinde ciddi bir artış gözlemlenmektedir. 2011'de bu sayı 183 iken, 2013'te 980'e, 2015'te 5.400'e, 2016'da 12.000'e, 2018'de 23.000'e ve 2019'da 40.000'e yükselmiştir. Aşı reddinde 50.000'e ulaşıldıktan sonra ise bir azalma görülmüş, ancak bunun sonucu olarak çocukluk çağı bulaşıcı hastalıklarında salgın riski doğabileceği düşünülmektedir. Eğer aşı reddi artışı bu şekilde devam ederse, önümüzdeki beş yıl içinde bağışıklama oranlarının %80 seviyelerine gerilemesi beklenmektedir. Bu durum, aşıyla önlenebilir hastalıkların görülme sıklığında artışlara yol açacaktır (Şimşek 2020).

Aşı Reddi Nedenleri

Aşı reddi nedenleri, aileler ve bireyler arasında ülkeden ülkeye, bölgeden bölgeye ve kültürden kültüre değişiklik göstermektedir. Bazı gruplar dini inançları nedeniyle aşıyı kabul etmezken, diğerleri aşının etkisiz veya gereksiz olduğunu düşündükleri için aşı olmaktan kaçınmaktadır (Barutcu ve ark. 2021).

Aşının içeriğine yönelik güvensizlik, ilerleyen dönemlerde kısırlık veya otizm gibi hastalıklara yol açacağına dair endişeler de aşı reddinin temel sebepleri arasında bulunmaktadır. Bunun yanı sıra, medya organlarında yayılan aşı karşıtı haberler ve toplumda tanınan kişilerin aşı karşıtı görüşleri de bu durumu etkileyen faktörlerdir. Dünya Sağlık Örgütü'ne göre, aşı reddi sebepleri üç ana kategori altında sınıflandırılmaktadır. Bu kategoriler ise şunlardır: Bağlamsal nedenler, Birey ve grup etkileri ile Aşı ve aşılanmaya ait faktörlerdir (Yorulmaz ve ark. 2022).

1. Bağlamsal etkiler

a. İletişim ve medya araçları
b. Toplum üzerinde etkili kişiler ve aşı karşıtı/ destekleyicisi lobiler
c. Tarihi etkiler
d. Sosyo-demografik özellikler
e. Politikalar/yasalar
f. Coğrafi engeller
g. İlaç endüstrisi

2. Birey ve grup etkileri

a. Geçmiş aşı uygulamaları tecrübeleri
b. Sağlık ve önleyici uygulamalara ilişkin inanç ve yaklaşımlar
c. Bilgi/farkındalık
d. Sağlık sistemi ve sağlayıcılara güven, kişisel deneyimler
e. Risk/yarar
f. Sosyal normlar

3. Aşı ve Aşılamaya Ait Etkiler

a. Riskler/yararlar (bilimsel kanıtlara dayalı)
b. Yeni aşı veya yeni formülasyonların tanıtımı
c. Uygulama şekli
d. Aşı programlarının düzenlenmesi/ulaştırma şekli
e. Aşı kaynaklarına ulaşım

f. Aşılama takvimi
g. Maliyet
h. Sağlık çalışanlarının rolü (Yorulmaz ve ark. 2022).

Aşılar ve Sosyal Medya

Günümüzde televizyon, sosyal medya ve dijital platformlar, geniş kitlelere hızlı ve etkili bir şekilde ulaşmanın önemli araçlarıdır. İnsanlar bilgi edinmek için sıklıkla bu online mecraları kullanmakta; bu platformlar, bilgilerin yayılımını kontrol etme ve toplumun inançları ile davranışlarını şekillendirme konusunda güçlü bir rol oynamaktadır (Schellenberg ve ark. 2020).

Çevrimiçi platformlarda aşılama hakkında yanlış bilgilerin yaygınlığı, bilimsel gerçeklerin anlaşılmasını zorlaştırmakta ve toplumun aşılama programlarına olan bakış açısını olumsuz yönde etkileyerek halk sağlığı açısından ciddi bir tehdit oluşturmaktadır. Günümüzde, aşıların faydalarından çok, bilimsel temeli olmayan iddialar medya aracılığıyla sıkça gündeme getirilmektedir (Díaz Crescitelli ve ark. 2020).

Aşı Reddinin Önlenmesinde Halk Sağlığı Hemşirelerinin Rolü

Aşı reddinin önüne geçilmesinde halk sağlığı hemşireleri önemli bir role sahiptir. Bu hemşireler, bağışıklama süreçleri hakkında bireyleri, grupları ve toplumu bilgilendirmek ve rehberlik etmekle yükümlüdür. Aşı reddini azaltmak için konunun ciddiyetine dikkat çekerek bilinçlendirme faaliyetleri yürütmeleri gerekir. Halk sağlığı hemşireleri, aileler ve bireyler ile aşı uygulaması arasında köprü görevi görür. Öncelikli olarak kendi alanlarındaki bilgilerini güncel tutmalı ve aşıyla ilgili doğru, güvenilir bilgileri sunmaya hazır olmalıdırlar (Gül ve ark. 2021).

Halk sağlığı hemşiresi, hizmet verdiği birey veya ailenin aşıyla ilgili kuşku, endişe ve kararsızlıklarını açıkça dile getirmelerine olanak tanımalıdır. Bu endişelere bilimsel dayanaklı bilgilerle yanıt vererek doğru ve güvenilir bilgi sağlamalıdır. Etkili iletişim becerilerini ustalıkla kullanması gerekmektedir. Doğru iletişim yöntemleriyle aşının güvenliği ve önemi vurgulandığında, birey ve ailelerin aşı reddi davranışları üzerinde daha olumlu etkiler yaratılabilir. Ayrıca, halk sağlığı hemşiresi, birey ve ailelere doğruluğu kanıtlanmamış medya içeriklerine itibar etmemeleri gerektiğini ve güvenilir bilgi kaynaklarını tercih etmelerinin önemini anlatmalıdır (Gür 2021).

Aşı Reddinin Ana-Çocuk Sağlığı Üzerine Etkileri

Aşı reddi, bireylerin veya toplulukların önerilen aşıları kabul etmeyi reddetmesi ya da uygulamada gecikme göstermesi durumudur ve bu durum, anne ve çocuk sağlığı üzerinde ciddi olumsuz sonuçlar doğurabilmektedir. Aşılar, bulaşıcı hastalıkların önlenmesinde en etkili halk sağlığı stratejilerinden biri olarak kabul edilmektedir. Ancak, aşı reddi çocuklar ve annelerin hastalıklara karşı savunmasız kalmasına neden olur. Özellikle çocukluk çağında uygulanan aşıların reddi veya gecikmesi, kızamık, boğmaca ve çocuk felci gibi hastalıkların tekrar ortaya çıkmasına zemin hazırlayabilir. Bu tür durumlar, çocuklarda ağır sağlık sorunları, hastaneye yatış gereksinimi ve hatta ölümle sonuçlanabilen komplikasyonlara yol açabilmektedir. Ayrıca, aşılama oranlarındaki azalma toplum bağışıklığını zayıflatarak salgınların daha kolay yayılmasına imkan tanımaktadır (Yiğit ve ark. 2020).

Anne sağlığı açısından bakıldığında, aşı reddinin oluşturduğu riskler oldukça büyüktür. Özellikle gebelik sürecinde bazı aşıların yapılmaması, anne ve bebeğin grip, tetanoz gibi enfeksiyonlara karşı savunmasız kalmasına yol açabilir. Bu tür enfeksiyonlar, erken doğum, düşük doğum ağırlığı ve farklı komplikasyonların ortaya çıkma ihtimalini artırmaktadır. Bu nedenle, gebelikte annenin gerekli aşıları yaptırması, hem kendisinin hem de bebeğinin sağlığının korunması için hayati bir öneme sahiptir (Turunç 2021).

Aşı reddi, toplum sağlığında güvensizlik ve yanlış bilgilerin hızla yayılmasıyla yakından ilişkilidir. Sosyal medya ve çeşitli iletişim araçlarında yayılan aşı karşıtı kampanyalar, anne babaların aşılarla ilgili şüphelerini artırmakta ve bu durum çocukların aşılanma oranlarını

olumsuz yönde etkilemektedir. Bunun sonucunda, aşı reddinin ana ve çocuk sağlığı üzerindeki etkileri hem bireysel hem de toplumsal boyutta önemli sorunlar yaratmaktadır. Bu sebeple, doğru ve güvenilir bilginin yayılması, halk arasında aşı bilincinin güçlendirilmesi ve güven ortamının oluşturulması hayati bir gerekliliktir (Yılmaz ve ark. 2023).

Aşı Reddinin Ana-çocuk Sağlığı Üzerine Etkileri Üzerine Yapılan Çalışma Örnekleri

1. Mujica (2023) tarafından Latin Amerika ve Karayipler'de anne ve çocuk sağlığı göstergeleri üzerine yapılan araştırma, 1990'lardan 2010'a kadar önemli ilerlemeler kaydedildiğini belirtmektedir. Ancak son yıllarda, özellikle sosyoekonomik eşitsizliklerin artması, bazı topluluklarda aşılama oranlarının düşmesine ve dolayısıyla çocuk sağlığına olumsuz etkilerinin artmasına işaret etmektedir.
2. Lignou ve Wolfe (2024), COVID-19 sonrası ulusal sağlık sistemlerinde çocuk sağlığı perspektifinin dahil edilmesi gerektiğini vurgulamaktadır. Bu çalışma, aşı reddi ve sağlık hizmetlerine erişimdeki eşitsizliklerin, özellikle kriz dönemlerinde ana-çocuk sağlığını ciddi şekilde etkilediğini ve sağlık adaleti sağlanmadan bu sorunların çözülemeyeceğini belirtmektedir.
3. Bambra (2022), pandemilerin sosyoekonomik eşitsizliklerle ilişkisini inceleyerek, bulaşıcı hastalıkların yayılmasında ve aşıların kabulünde görülen farklılıkların çocuk sağlığı üzerindeki etkilerini detaylandırmaktadır. Aşı reddinin özellikle dezavantajlı gruplarda salgın riskini artırdığı ve çocuk sağlığını olumsuz etkilediği vurgulanmaktadır.
4. Yüksel ve Topuzoğlu (2019), Türkiye'de aşı reddi ve aşı karşıtlığının artışına odaklanan çalışmalarında, bu durumun çocuklarda kızamık, boğmaca gibi hastalıkların yeniden görülmesine ve bunun da çocuk sağlığında ciddi komplikasyonlara yol açtığını ortaya koymaktadır.
5. Hasar, Özer ve Bozdemir (2021) ise aşı reddi nedenlerini inceleyerek, ebeveynlerin yanlış bilgi ve güvensizlik nedeniyle aşıları reddetmelerinin, çocukların enfeksiyonlara karşı korunmasız kalmasına neden olduğunu belirtmiştir. Bu durumun hem bireysel hem de toplumsal sağlık üzerinde olumsuz etkileri olduğu belirtilmektedir.

SONUÇ

Aşı reddi, ana ve çocuk sağlığı üzerinde doğrudan ve dolaylı olarak ciddi olumsuz etkiler yaratmaktadır. Araştırmalar göstermektedir ki, aşıların reddedilmesi sadece bireysel çocukların enfeksiyon hastalıklarına karşı savunmasız kalmasına yol açmakla kalmamakta, aynı zamanda toplumda bağışıklık seviyesinin düşmesine neden olarak bulaşıcı hastalıkların yayılımını kolaylaştırmaktadır. Bu durum özellikle, gelişmekte olan ülkelerde ve sosyoekonomik açıdan dezavantajlı gruplarda daha belirgin olarak gözlemlenmektedir. Aşı reddinin yaygınlaşması, çocuklukta önlenebilir hastalıkların yeniden ortaya çıkmasına ve salgınların tetiklenmesine zemin hazırlamaktadır. Bu hastalıkların sonuçları ise, yalnızca sağlık sistemi üzerinde aşırı yük oluşturmakla kalmaz, aynı zamanda çocukların yaşam kalitesini, gelişim süreçlerini ve uzun vadeli sağlık durumlarını da olumsuz etkiler.

Ana sağlığı açısından bakıldığında, aşı reddi, gebelik döneminde ve doğum sonrası anne sağlığını da riske atmaktadır. Çünkü bağışıklık sisteminin zayıflığı ve hastalıkların yaygınlaşması, anne ve bebek arasında ciddi sağlık sorunlarına neden olabilir. Özellikle anne sütü ile geçen antikorlar ve koruyucu aşılar, çocukların ilk yaşam aylarında enfeksiyonlara karşı önemli bir savunma mekanizmasıdır. Ancak aşı reddi bu mekanizmanın zayıflamasına ve dolayısıyla hem annenin hem de çocuğun hastalıklara karşı korunmasız kalmasına sebep olmaktadır.

Ayrıca, aşı reddinin psikososyal boyutları da göz ardı edilmemelidir. Ebeveynlerde aşıya karşı oluşan güvensizlik ve yanlış bilgi, sağlık sistemine olan bağlılığı zayıflatmakta, bu da sağlık hizmetlerine erişimde ve sağlık eğitimi süreçlerinde aksamalara neden olmaktadır. Bu durum,

ana-çocuk sağlığında eşitsizliklerin derinleşmesine ve sağlık kaynaklarının etkin kullanımının önüne geçilmesine sebep olmaktadır.

Sonuç olarak, aşı reddinin önlenmesi için toplumun tüm kesimlerine yönelik çok yönlü, kültürel hassasiyeti olan ve bilimsel temelli bilgilendirme çalışmaları yapılması zorunludur. Sağlık çalışanlarının rolü, doğru bilgi aktarımı ve güven ortamı yaratmada kritik öneme sahiptir. Ayrıca, politika yapıcıların aşıya erişim, eğitim ve sağlık hizmetlerinde eşitliği sağlayacak düzenlemeler geliştirmesi gerekmektedir. Aşı reddinin etkili bir şekilde önlenmesi, sadece bireysel değil, toplumsal sağlık düzeyinin iyileştirilmesi ve sürdürülebilir sağlık sistemlerinin inşası açısından hayati bir gerekliliktir.

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AURORA-B İNHİBİTÖRÜ İLE KOMBİNE EDİLEN BAZI *SALVIA* TÜRLERİNİN MEME KANSERİ HÜCRE HATTINDA SİTOTOKSİK ETKİSİNİN ARAŞTIRILMASI

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ÖZET
Kanser vakalarının artması ve sebep olduğu ölüm oranlarının azaltılamaması sebebiyle insan yaşamını tehdit eden önemli bir sorun olarak karşımızda durmaktadır. Kanserin sağaltımında kullanılan mevcut yöntemler hem yetersiz kalmakta hem de yan etkileri sebebiyle hastalarda önemli sorunlara yol açmaktadır. Bunun yanında, tedaviye karşı mevcut veya sonradan ortaya çıkan direnç, aşılması gereken önemli bir sorunu oluşturmaktadır. Bu noktada, bitkiler ve bitkisel ürünler bir umut olarak görülebilmektedir. Gerek yan etkilerinin az olması gerekse ulaşılabilir olması bu umudu desteklemektedir. Bazı *Salvia* türleri, günümüzde sağlık ve kozmetik alanında birçok amaçla kullanılmaktadır. Aurora B inhibitörleri kanser tedavisinde kullanılan ajanlardan birisidir. Kanserleşme sürecinde hücre döngüsünün rolü düşünüldüğünde bu inhibitörlerin önemi artmaktadır. Bu çalışmada, antikanser yönüyle yeterince araştırılmamış olan *Salvia euphratica, Salvia staminea, Salvia trichoclada* ile Aurora B inhibitörü kombinasyonunun MCF7 meme kanseri hücre hattındaki etkisi çeşitli antikanser yönüyle araştırıldı. IC_{50} ve IC_{25} değerlerinin belirlenmesi için kristal viyole canlılık deneyi yapıldı. Daha sonra bitki ve kemoterapik ajan monoterapi ve kombine tedavi olarak uygulandı. Koloni formasyon ve yara iyileşme analizleriyle hücrelerin çoğalma ve göç yetenekleri değerlendirildi. *Salvia* türleri ve Aurora B inhibitörü monoterapi olarak kullanılmasıyla ortaya çıkan sitotoksik ve antikanser etkinin kombinasyon tedavisi ile değişmediği görülmüştür.
Anahtar Kelimeler: Kanser, fitoterapi, *Salvia,* Aurora B

INVESTIGATION OF CYTOTOXIC EFFECT OF SOME *SALVIA* SPECIES COMBINED WITH AURORA-B INHIBITOR ON BREAST CANCER CELL LINE

ABSTRACT
Due to the increase in cancer cases and the failure to reduce the mortality rates it causes, it stands before us as an important problem that threatens human life. Current methods used in cancer treatment are both inadequate and cause significant problems in patients due to their side effects. In addition, current or subsequent resistance to treatment constitutes an important problem that needs to be overcome. At this point, plants and herbal products can be seen as a hope. Both their low side effects and their accessibility support this hope. *Salvia* species are used for many purposes in the field of health and cosmetics today. Aurora B inhibitors are one of the agents used in cancer treatment. Considering the role of the cell cycle in the cancerization

process, the importance of these inhibitors increases. In this study, the effect of the combination of *Salvia euphratica, Salvia staminea, Salvia trichoclada* and Aurora B inhibitor, which has not been sufficiently investigated in terms of anticancer, on the MCF7 breast cancer cell line was investigated in terms of various anticancer aspects. Crystal violet viability assay was performed to determine IC_{50} and IC_{25} values. Later, the plant and chemotherapeutic agent were applied as monotherapy and combined treatment. The proliferation and migration abilities of the cells were evaluated with colony formation and wound healing assays. It was observed that the cytotoxic and anticancer effects of using *Salvia* species and Aurora B inhibitor as monotherapy did not change with the combination treatment.
Keywords: Cancer, phytotherapy, *Salvia,* Aurora B

GİRİŞ

Sağlıklı hücrelerde belirli bir düzen ve kontrol altında gerçekleşen hücre bölünmesinin kontrolsüz hale gelmesi kanser olarak tanımlanmaktadır. 100'den fazla türü bulunan bu hastalıkta, DNA hasarı ve apoptotik süreçte hasar vardır (Alberts et al., 2017; Pecorino, 2012). 2020 yılı kanser verileri incelendiğinde, 50 milyona yakın yeni vak ve 10 milyona yakın kanser kaynaklı ölüm göze çarpmaktadır (Bray et al., 2024). Kadınlarda en fazla ölüme neden olan kanser türünün meme kanseri olduğu bildirilmektedir (Sung et al., 2021). Sadece 2020 yılında 2,3 milyon yeni kanser vakası rapor edilmiştir (Zhu & Yu, 2022). Kemoterapi ile gerçekleştirilen tedavilerin yetersizliği sebebiyle yeni yaklaşımlara ihtiyaç duyulmaktadır. Yapılan çalışmalar, bitkilerin barındırdığı önemli bileşenlerin kanser hücrelerinin yaşadığı transformasyonu önlemede etkili olabileceğini ortaya koymaktadır (Sever et al., 2023; Zoberi et al., 2002). Amerika başta olmak üzere gelişmiş ve gelişmekte olan birçok ülkede bitkisel ürünlerin kullanımı yaygın bir yaklaşımdır. Kanser tedavisinde de bu ürünlerin kullanıldığı bilinmektedir. Bazen bitkisel ürünlerin bizzat kendisi kullanılırken, bazen de kemoterapik ajanlara destek olması amacıyla tercih edilebilmektedir. Kemoterapide kullanılan birçok ajanın bitkilerden ilham alınarak oluşturulduğu kabul edilmektedir (Amin et al., 2009).

Aurora kinaz ailesi, hücre döngüsünün düzenlenmesinde görev alan kinazlardır. Özellikle mitoz safhasında kromozomların uygun ve hatasız ayrılması, sentrozomların büyümesi ve bölünmesi, kromozomların yoğunlaşması gibi birçok önemli reaksiyonda aktif rol almaktadır (Bolanos-Garcia, 2005; Carmena ve Earnshaw, 2003; Kimura ve Okano, 2005). A, B, C olmak üzere 3 formu bulunan bu kinaz ailesinin bazı kanser çeşitlerinde yüksek düzeyde bulunması sebebiyle kanser tedavisinde hedeflenebilir noktalar olabileceği düşünülmektedir. Bu amaçla birçok Auorora inhibitörleri(ABİ) geliştirilmiştir (Borah ve Reddy, 2021; Liang vd., 2012; Libertini vd., 2010).

Salvia ailesinin Dünya'da 900'den fazla türü bulunmaktadır. Ülkemizde özellikle Akdeniz bölgesinde yaygın olarak görülen bu bitkilerin çeşitli hastalıkların tedavisi ve korunma sürecinde tercih edildiği bilinmektedir. Tedavi edici etkilerini antioksidan, anti-inflamatuvar özellikleri aracılığıyla gösterdiği tahmin edilmektedir (Yaman, 2021). Türkiye'de 90'dan fazla türün bulunduğu *Salvia* ailesi, antiseptik, antibakteriyel, diüretik, spazmolitik, homeostatik ve yara iyileştirici olarak tercih edilebilmektedir (Eminagaoglu et al., 2022; Hedge, 1982; Topcu et al., 2003). *Çeşitli Salvia türlerinin,* antioksidan, antibakteriyel ve antikolinesteraz özellik gösterdiği tespit edilmiştir (Demirezer et al., 2015; Doğan et al., 2022; Emre & Kursat, 2022; Kerem, 2015). Ayrıca bazı *Salvia* türlerinin, akciğer ve meme kanseri hücre hatlarında antikanser etki gösterdiği belirlenmiştir (Guerrero et al., 2006; Moridi Farimani & Miran, 2014). Çalışmamızda araştırılan *Salvia* türleri hakkında yapılmış antikanser etki çalışmalarının sayıca az olması, bu çalışmanın özgünlüğünü artırmaktadır. Ayrıca *Salvia* türleri ile ABİ kombinasyonunun literatürde yer almaması çalışmayı değerli kılmaktadır.

MATERYAL VE METOT

Bitkilerin Toplanması, Teşhisi

Bingöl iline ait çeşitli bölgelerden çiçekli dönemde toplanan 3 farklı *Salvia* türünün teşhisi Bingöl Üniversitesi Biyoloji Anabilim dalı öğretim üyesi Prof. Dr. Lütfi BEHÇET tarafından yapıldı ve Bingöl Üniversitesi Herbaryumu(BIN)'na kondu. Güneş görmeyen kuru bir ortamda bekletilen bitkilerin kuruması sağlandı. Daha sonra toprak üstü kısımları öğütülerek etanol ekstraksiyonu gerçekleştirildi. Ekstrakt haline getirilen bitki özütü hücre kültürü çalışmalarında kullanılmak üzere DMSO içerisinde çözüldü. Ana stok -20'de saklandı (Erdogan et al., 2023)

Hücre Kültürü Çalışmaları

İnsan meme MCF-7 kanseri hücre hatları, %10 FBS, %1 L-glutamin ve %1 penisilin-streptomisin içeren yüksek glikozlu DMEM besiyeri kullanılarak 37°C'de, %95 nem ve %5 CO_2'li ortamda kültüre edilerek çoğaltıldı. Hücrelerin günlük takibi sağlandı. %80 yoğunluğa ulaşan hücreler pasajlandı (Erdoğan, 2016; Guo et al., 2013). Hücre kültürü çalışmalarında, hücrelere *Salvia* ve ABİ kombinasyonları 72 saat boyunca mono ve kombine olarak uygulandı. Kontrol grubuna sadece besiyeri+DMSO karışımı uygulandı.

Hücre Canlılığının Belirlenmesi

Salvia ve ABİ uygulamalarının meme kanseri hücre hattında etkisini belirlemek amacıyla kristal viyole canlılık deneyi yapıldı (Parker et al., 2022). Öncelikle meme kanseri hücre ekimi 24 kuyucuklu plakaların her birine 50 bin hücre olacak şekilde yapıldı. Hücrelerin tutunduğundan emin olunduktan sonra hücreler *Salvia* türü ve bunların ABİ kombinasyonu ile tedavileri 72 saat olarak uygulandı. Tedavi süresinin sonunda tedavi ajanı içeren besiyerler çekilip kuyucuk yüzeyleri PBS ile yıkandı. Ardından metanol-asestik asit (3:1) solüsyonundan her kuyucuğa yaklaşık 1 ml eklenip oda sıcaklığında hücreler 5 dakika fikse edildi. Fiksasyon solüsyonu ortamdan uzaklaştırılıp 1 ml 0.5% kristal viyole (Crystal Violet) boyasıyla boyandı. 15 dakika oda sıcaklığında inkübasyonun ardından boyanan kuyucuklar musluk suyu altında dikkatlice yıkanıp %10 asetik asit (1 ml %100 Asetik asit + 9 ml ddH_2O) eklenerek çalkalayıcıda 5 dakika çalkalandı. Daha sonra kuyucuklardaki asetik asit mikropipet aracılığıyla çekilip spektrofotometrede ölçüm küvetleriyle 595 nm dalga boyunda hücre canlılığı yönüyle analiz edilip veriler istatistiksel olarak değerlendirildi.

Koloni Oluşum Deneyi

Salvia türleri ve ABİ tedavisinin meme kanseri hücre hattının koloni yapma kabiliyetine olan etkisini incelemek amacıyla koloni oluşum deneyi yapıldı. Bu deney için, 6 kuyucuklu plakalara kuyucuk başına 1 x 10^3 hücre olacak şekilde hücreler ekildi. Hücrelerin tutunduğundan emin olunduktan sonra 72 saatlik tedaviler gerçekleştirildi. Tedavi süresi sonunda tedavi ajanı içeren DMEM aspire edildi. Yerine taze besiyeri ekildi. Hücreler 15 gün boyunca inkübe edildi. Süre sonunda besiyeri uzaklaştırıldı ve hücreler PBS ile yıkanıp metanol: asetik asit (3: 1) ile fikse edildi ve 15 dakika boyunca kristal viyole ile boyandı (Gomez et al., 2015). 50 hücreden fazlası koloni olarak kabul edildi. Koloniler sayılarak istatiksel analiz yapıldı.

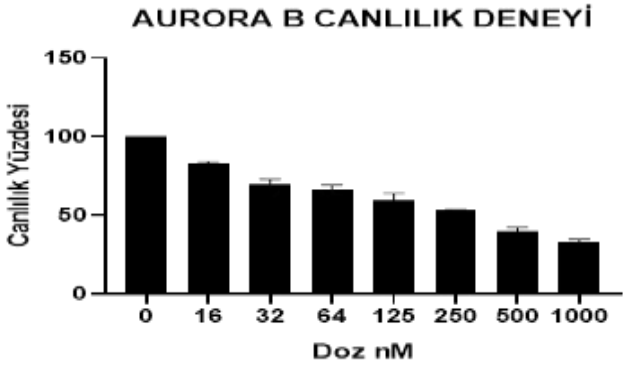
Migrasyon Yeteneğinin Belirlenmesi

Tedaviye maruz bırakılan kanser hücrelerinin göç etme kabiliyetini ölçmek amacıyla migrasyon deneyi gerçekleştirildi (Zomer et al., 2019). Öncelikle 6 kuyucuklu plakalara ertesi gün yeterli yoğunluk oluşturacak kadar MCF-7 kanser hücreleri ekildi ve ertesi gün 1ml'lik steril pipet ucuyla plate tabanında lineer bir hat oluşturuldu. Ölen hücrelerin uzaklaştırılması için kuyucuk tabanı iki kez PBS ile yıkandı. Daha sonra yara alanlarının fotoğrafları çekildi. Tedavi grubu ilgili *Salvia* türleri ve kemoterapik ajanlar ile mono ve kombine olarak uygulandı. 0-12-24 saatin sonunda yara alanları mikroskobik olarak fotoğraflandı. Yara kapanma yüzdesi her grup için 0.-12. ve 24. saatlik görüntüler için normalize edilerek belirlendi.

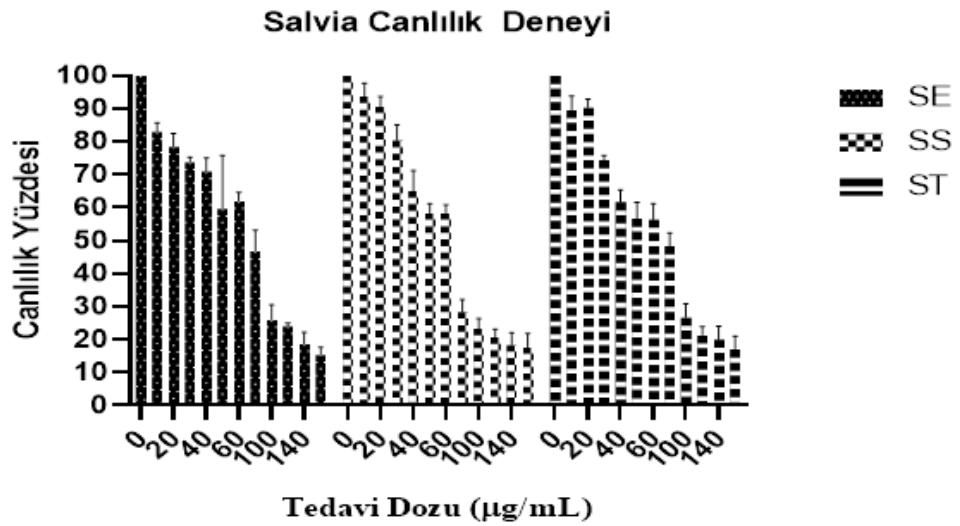
SONUÇLAR VE TARTIŞMA

Canlılık deneyi

Salvia türlerinin ve ABİ'nin meme kanseri hücre hattında sitotoksik özelliğini ve IC_{50}-IC_{25} değerini hesaplamak amacıyla kristal viyole canlılık deneyi yapılmıştır. Bu amaçla hücreler 72 saat süre artan dozlarda ABİ (0-1-2…1000 nM) ve *Salvia* türleri (0-10-20… 140 µg/mL) ile tedavi edildi (Şekil 1). Tedavi sonunda *Salvia* türleri ve ABİ için elde edilen IC_{50} ve IC_{25} dozları Tablo 1.de grafikler Şekil 2 ve Şekil 3'te verilmiştir. Elde edilen IC_{50} ve IC_{25} değerleri kullanılarak yapılan kombinasyon tedavisine ait tedavi taslağı Şekil 4'te, elde edilen grafik Şekil5'te verilmiştir.

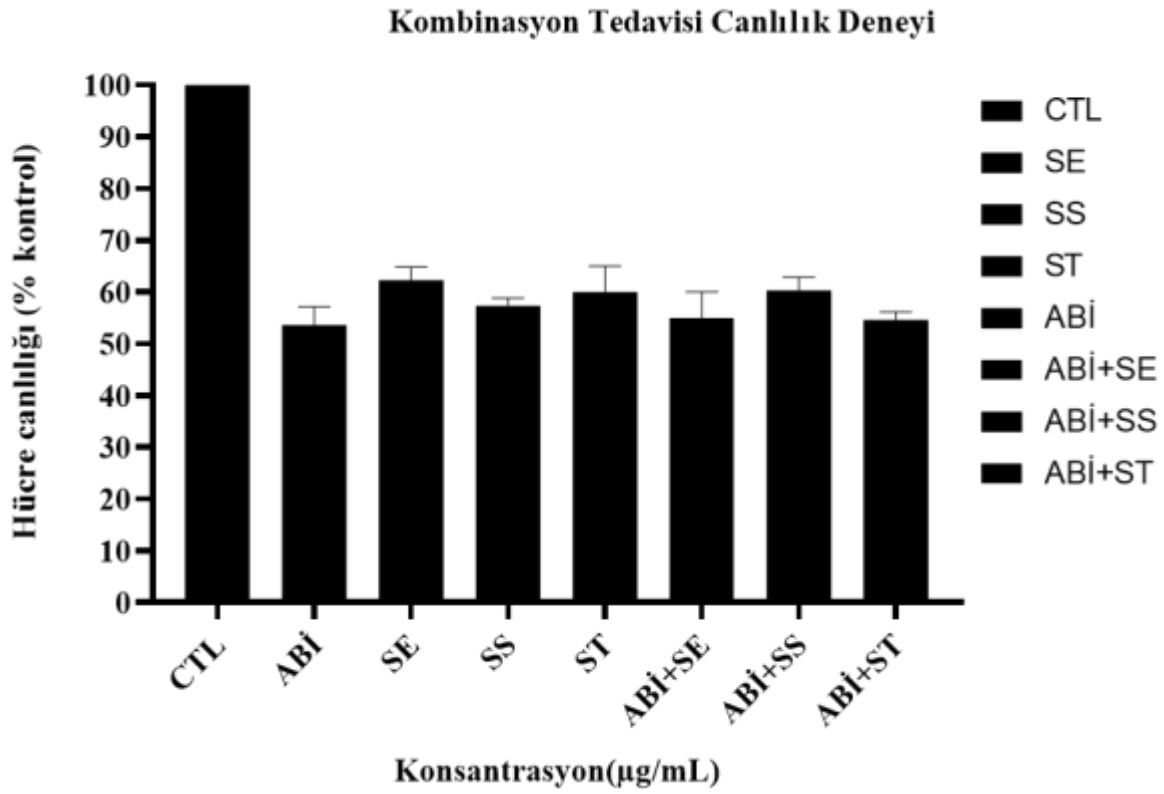




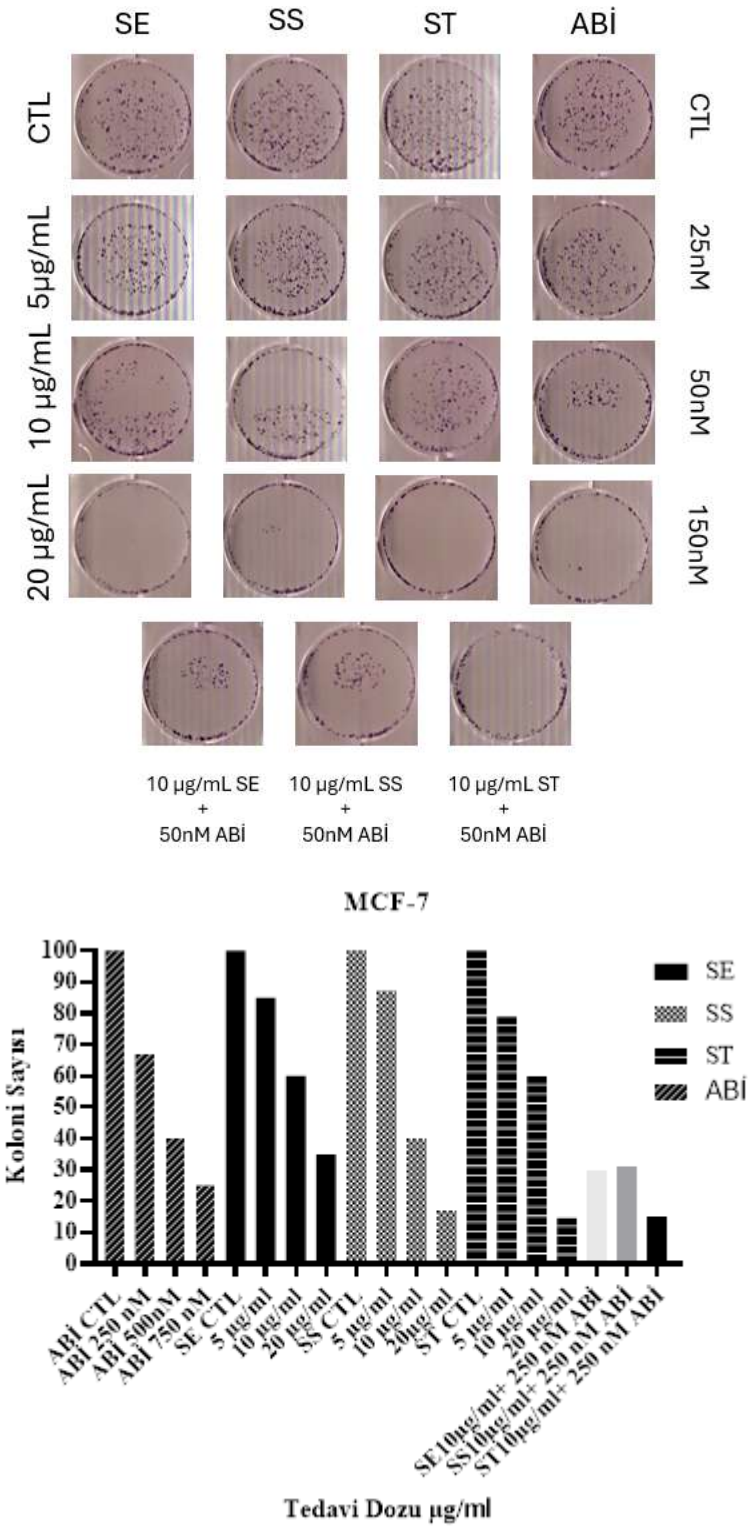


Şekil 1. MCF-7 Hücre hattında *Salvia* türleri ve ABİ'nin sitotoksik etkininin incelenmesi amacıyla 72saatlik tedavinin ardından kristal viyole canlılık deneyleri gerçekleştirildi (ABİ: Aurora B inhibitörü, SE: *Salvia euphratica*, SS: *Salvia staminea*, ST: *Salvia trichoclada*)

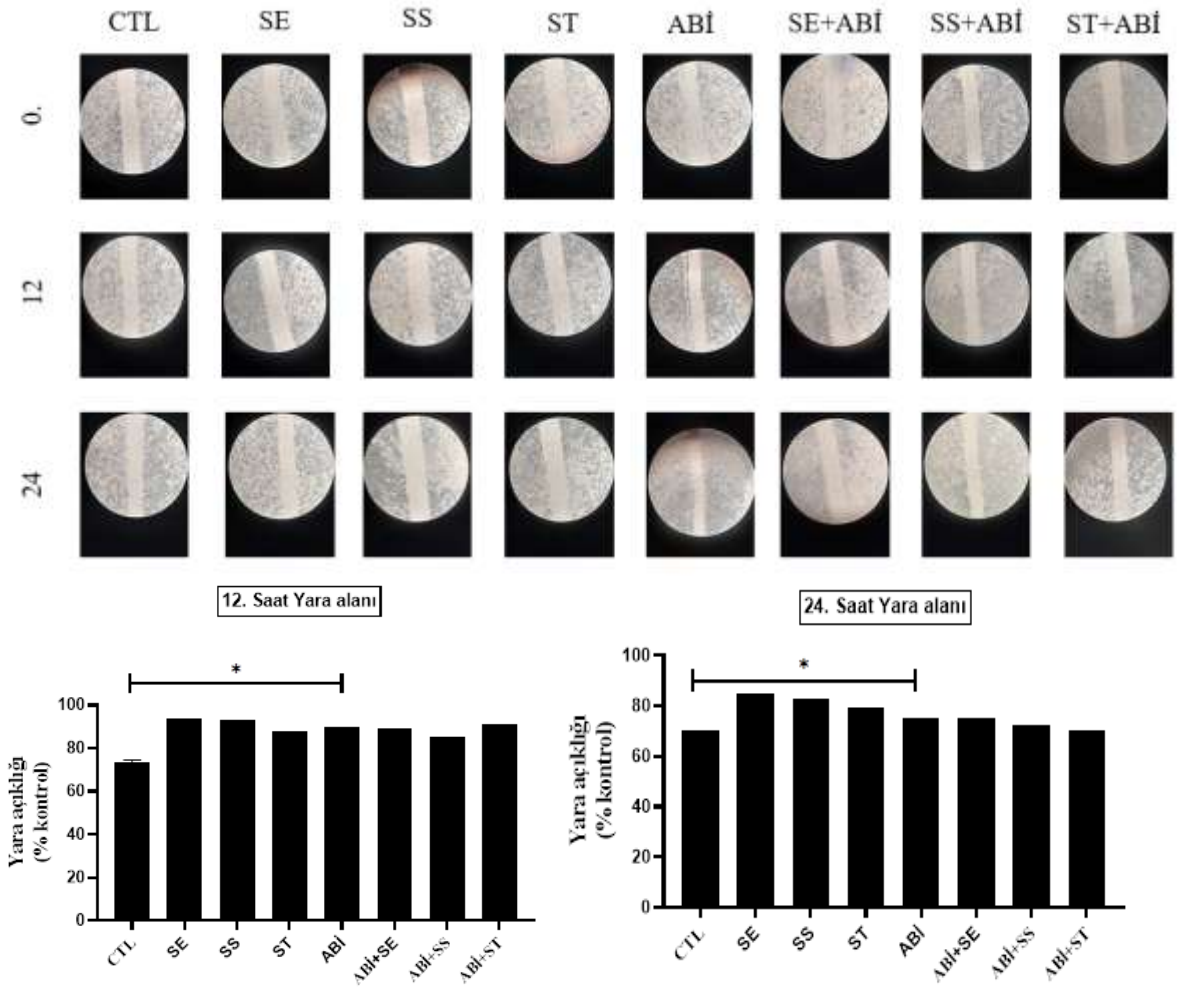
	SE	**SS**	**ST**	**ABİ**
IC50	68,08 µg/ml	61,38 µg/ml	64,24 µg/ml	229 nM
IC25	31,144 µg/ml	34,33 µg/ml	30,39 µg/ml	42 nM



Şekil 2. Kombinasyon tedavisi canlılık deneyi. Monoterapi için tespit edilen IC_{50}, kombinasyon tedavisi için IC_{25} dozları kullanılarak yapıldı. (ABİ: Aurora B, SE: *Salvia euphratica*, SS: *Salvia staminea*, ST: *Salvia trichoclada*).



Şekil 3. MCF-7 Hücre hattında *Salvia* türleri ve ABİ'nin sitotoksik etkininin incelenmesi amacıyla 72saatlik tedavinin ardından kristal viyole canlılık deneyleri gerçekleştirildi (ABİ: Aurora B inhibitörü, SE: *Salvia euphratica*, SS: *Salvia staminea*, ST: *Salvia trichoclada*)



Şekil 4. *Salvia* türleri ve ABİ ile tedavi edilen MCF-7 hücre hattında koloni oluşum deneyi (ABİ: Aurora B, SE: *Salvia euphratica*, SS: *Salvia staminea*, ST: *Salvia trichoclada*)

SONUÇ

2018 yılı araştırmalarına göre kadınlarda en fazla görülen ve 600 binden fazla ölüme sebep olan meme kanseri ile ilgili araştırmalara hala ihtiyaç duyulmaktadır (Ferlay et al., 2021). Birçok tedavi yönteminin varlığına rağmen yeni tedavi yaklaşımlarına ihtiyaç duyulmaktadır. Bitkiler, bu ihtiyacı karşılama konusunda önemli bir seçenek olarak görülmektedir (Ranjan et al., 2019). Bitkilerin böylesine önemli bir seçenek olmasında; kanser tedavisinin tüm birçok evresinde tedaviye desteklemesi, sağlıklı hücreler için toksik olmaması, etkisini birden fazla mekanizma üzerinden göstermesi ve çoğu zaman kemoterapik ajanlar ile sinerjik etki oluşturması sebebiyle doğal ürünler büyük önem görmektedir (Wani et al., 2016). Bitkilerin kullanıldığı veya ilham alındığı birçok ilaç bulunmaktadır. Yapılan tahminlere göre antikanser potansiyel taşıyan bitki sayısının 3 binin üzerinde olduğu ifade edilmektedir (Yiğit, 2021). ABİ kanser tedavisinde günümüzde ilgi uyandıran ajanlardan birisidir (Bejar et al., 2021). Adaçayı olarak bilinen *Salvia* türlerin dünyanın birçok bölgesinde çeşitli hastalıkları tedavisinde ve bu hastalıklardan korunmak amacıyla kullanılmaktadır. Sahip olduğu yüksek antioksidan özelliğin bu kullanımda etkili olduğu ifade edilmektedir. (Allegri et al., 2021; Hu et al., 2015). Çalışmamızda kullanılan *Salvia* türlerinin meme kanseri hücre hattında sitotoksik etki gösterdiği, hücrelerin migrasyon yeteneğini ve koloni oluşturma kabiliyetini azalttığı görüldü. Doğal ürünler ile kemoterapik ajanların kombine edilmesinde beklenen genellikle sinerjizmdir. Ancak nadir de olsa antagonizm veya nötr etki görülebilmektedir (Hackman et al., 2020). Bu

çalışmada; ABİ ve *Salvia* ekstraktları arasında meme kanseri hücre hattında canlılık yönünden belirgin bir sinerjik veya antagonistik etkileşim tespit edilememiştir. Migrasyon yeteneği ve koloni yapma kabiliyeti yönüyle kombinasyon tedavisi sonrası anlamlı bir fark bulunmamıştır. Bu veriler, ilgili *Salvia* türleri ile ABİ'nin birlikte kullanımında birbirlerinin etkilerini nötralize etmediğini ve yan etki riskini artırmadan ayrı ayrı uygulanabileceklerine işaret etmektedir. Daha ileri deneyler ve farklı dozlar ile yapılacak çalışmalar birlikte kullanım potansiyellerine daha fazla ışık tutacaktır

Teşekkür
Bu çalışma, TÜBİTAK 2209 projesi ile desteklenmiştir.

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BAZI *SALVIA* TÜRLERİNİN RESVERATROL İLE KOMBİNE EDİLMESİNİN MEME KANSERİNDE ANTİKANSER ETKİSİ

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ÖZET
Kanser hem yıkıcı etkileri hem de artan görülme sıklığı nedeniyle küresel sağlık açısından önemli bir tehdit oluşturmaktadır. Konvansiyonel tedavi yöntemleri, özellikle kemoterapi, ciddi yan etkileri ve kanserli hücreleri spesifik olarak hedefleyememesi gibi sınırlılıklar nedeniyle yetersiz kalabilmektedir. Ayrıca, kullanılan ilaçlara karşı gelişen direnç de tedavi sürecini olumsuz etkilemekte ve yeni tedavi yaklaşımlarına olan ihtiyacı artırmaktadır. Bu bağlamda, bitkisel bazlı doğal bileşikler, düşük yan etki profilleri ve çok yönlü etki mekanizmaları nedeniyle dikkat çekmektedir. Bazı *Salvia* türleri, sahip oldukları potansiyel sebebiyle farklı sağlık alanlarında kullanılmaktadır. Polifenolik bir bileşik olan resveratrol ise birçok kanser hücresine karşı antiproliferatif etkiler göstermekte, ancak biyoyararlanımı düşük olan önemli bir bileşendir. Bu çalışmada, literatürde antikanser etkisi yeterince araştırılmamış olan *Salvia euphratica, Salvia staminea, Salvia trichoclada* ile resveratrol kombinasyonunun MCF7 meme kanseri hücre hattı üzerindeki etkisi sitotoksisite yönüyle incelenmiştir. Kristal viyole canlılık testiyle IC_{50} ve IC_{25} değerleri belirlenmiş, ardından tekli ve kombine tedaviler uygulanmıştır. Koloni formasyon ve yara iyileşme analizleriyle hücrelerin çoğalma ve göç yetenekleri değerlendirilmiştir. *Salvia* türleri ve resveratrolün monoterapi olarak kullanılmasıyla ortaya çıkan sitotoksik ve antikanser etkinin kombinasyon tedavisi ile değişmediği görülmüştür.
Anahtar Kelimeler: Kanser, fitoterapi, *Salvia*

ANTI-CANCER EFFECT OF SOME *SALVIA* SPECIES COMBINED WITH RESVERATROL ON BREAST CANCER

ABSTRACT
Cancer poses a significant threat to global health due to its devastating effects and increasing incidence. Conventional treatment methods, especially chemotherapy, can be inadequate due to serious side effects and limitations such as the inability to specifically target cancerous cells. In addition, resistance to the drugs used also negatively affects the treatment process and increases the need for new treatment approaches. In this context, plant-based natural compounds attract attention due to their low side effect profile and versatile mechanisms of action. Salvia species are used in different health fields due to their potential. Resveratrol, a polyphenolic compound, shows antiproliferative effects against many cancer cells, but has low bioavailability. In this study, the effect of the combination of *Salvia euphratica, Salvia*

staminea, Salvia trichoclada and resveratrol on MCF7 breast cancer cell line was investigated in terms of cytotoxicity. IC_{50} and IC_{25} values were determined by crystal violet viability assay, followed by single and combined treatments. Proliferation and migration abilities of cells were evaluated by colony formation and wound healing assays. It was observed that the cytotoxic and anticancer effect of *Salvia* species and resveratrol as monotherapy did not change with combination therapy.
Keywords: Cancer, phytotherapy, *Salvia*

GİRİŞ

Kanser, genellikle somatik hücrelerde ortaya çıkan DNA hasarı ile karakterize genetik bir hastalık grubunu ifade etmektedir. Kontrolsüz olarak hücre çoğalması ile karakterize bu hastalık grubunda, hücre bölünmesinin kontrolü ve apoptotik süreçte bozukluk söz konusudur. Tanımlanmış 100'den fazla kanser türü bulunmaktadır (Alberts et al., 2017; Pecorino, 2012). 2020 yılında 50 milyondan fazla kanser vakasının tespit edildiği bilinmektedir. Aynı yıl içinde kanser sebebiyle yaşamını yitirenlerinin sayısının ise 10 milyonun üzerinde olduğu belirtilmiştir (Bray et al., 2024). Meme kanseri kadınlarda en fazla görülen ve ölüme sebep olan kanser türüdür (Sung et al., 2021). 2020 yılında görülen 2,3 milyon vaka sayısı ile meme kanseri önemli bir tehdit oluşturmaktadır (Zhu & Yu, 2022). Günümüz kanser tedavisinde tümör dokunun cerrahi, kemoterapi ve radyoterapi gibi yöntemlerle tedavi edilebileceğini ortaya koyulmuştur. Bu tedavi yöntemleri tek başına ya da kombinasyon halinde kullanılmasıyla özellikle solid tümörlerde kanserin ilerlemesi yavaşlatılmakta veya durdurabilmektedir. Ancak, bu tedavi seçeneklerinin başarı yüzdesi metastaz durumu ile aşağılara düşmektedir (Shewach & Kuchta, 2009). Yapılan çalışmalar, bitkilerin barındırdığı önemli bileşenlerin kanser hücrelerinin yaşadığı transformasyonu önlemede etkili olabileceğini ortaya koymaktadır (Sever et al., 2023; Zoberi et al., 2002). Bir polifenolik bileşik olan resveratrol, üzüm ve yerfıstığı başta olmak üzere birçok bitki türünde doğal olarak bulunmaktadır (Shankar et al., 2007). Resveratrolün çeşitli kanser türlerinin tüm evrelerinde etkin anti-tümör aktivitesinin olduğu gözlemlenmiştir ve bu etkileri birçok farklı kanser hücre hattında gözlemlenmiştir (Roy et al., 2009). Örneğin, resveratrol kullanımının yumurtalık (Opipari et al., 2004), meme (Kim et al., 2004; Pozo-Guisado et al., 2002), akciğer (Stervbo et al., 2006) ve prostat (Benitez et al., 2009) kanseri hücreleri dâhil olmak üzere farklı insan kanser hücrelerinin proliferasyonunu inhibe ettiğini göstermiştir. Resveratrolün bu önemli etkileri, hücre döngüsü progresyonunu durdurma (Bai et al., 2010), hücre farklılaşmasını destekleme (Wolter & Stein, 2002) ve programlanmış hücre ölümünü indükleme (Brito et al., 2008) kabiliyeti ile ilişkilendirilmiştir.

Bitki ve bitkisel kökenli ürünlerin tamamlayıcı tedavi olarak kullanımı, özellikle ABD gibi gelişmiş ülkelerde yaygın bir uygulamadır. Bu ülkede kanser hastalarının yarısından fazlası sadece bitkisel ürünlerden, bu bitkilerden türetilmiş ajanlardan faydalanarak veya diğer tedavi yöntemleriyle kombinasyon şeklinde tedavi olduğu bilinmektedir. Ayrıca birçok alanda olduğu gibi kanser tedavisinde kullanılan birçok ilaç, bitkisel kaynaklardan elde edilmektedir (Amin et al., 2009).

Dünyada 900'den fazla tür içeren *Salvia,* L. Lamiaceae (Labiatae) familyası üyesidir. *Salvia* latince bir kelime olup iyileşme anlamı taşımaktadır. Akdeniz bölgesinde yaygın olarak bulunan bu cins üyeleri; birçok sistemik hastalığın tedavisinde kullanılmaktadır. Tedavi edici etkilerini antioksidan, anti-inflamatuvar mekanizmaları ile gerçekleştirmektedir (Yaman, 2021). Türkiye'de 90 civarında *Salvia* türünün yetiştiği ve bunların antiseptik, antibakteriyel, diüretik, spazmolitik, homeostatik ve yara iyileştirici olarak geleneksel tıpta kullanıldığı bilinmektedir (Eminagaoglu et al., 2022; Hedge, 1982; Topcu et al., 2003). *Salvia* türlerinden olan *Salvia euphratica* birçok çalışmada antioksidan, biyokimyasal, antibakteriyel ve antikolinesteraz yönleriyle incelenmiştir (Demirezer et al., 2015; Doğan et al., 2022; Emre &

Kursat, 2022; Kerem, 2015). *Salvia pachyphylla* ve *Salvia clevelandii* türlerinin, akciğer ve meme kanseri hücre hatlarında sitotoksik etkiye sahip olduğu gösterilmiştir (Guerrero et al., 2006). *Salvia leriifolia* türünün prostat ve HeLa hücre hatlarında antiproliferatif etkiye sahip olduğu tespit edilmiştir (Choudhary et al., 2012). *Salvia urmiensis* bitkisinin MCF-7 hücre hattında sitotoksik etkiye sahip olduğu bilinmektedir (Moridi Farimani & Miran, 2014). Çalışmamızda araştırılan *Salvia* türleri hakkında yapılmış antikanser etkileri ile ilgili yeterli çalışmanın olmayışı özgünlüğü artırmaktadır

MATERYAL VE METOT

Bitkilerin Toplanması, Teşhisi

Kullanılan *Salvia* türleri Haziran-Temmuz ayları arasında çiçekli döneminde Bingöl ilinde toplanmıştır. Toplanan Salvia türlerine ait birer duplet herbaryum materyali haline getirilerek Bingöl Üniversitesi Herbaryumu(BIN)'na kondu. Bitkilerin teşhisi Prof. Dr. Lütfi BEHÇET tarafından yapıldı. Çalışma için kullanılacak olan materyal güneş görmeyen nemsiz ortamda kurutuldu. Daha sonra çalışmada kullanılacak kısımlar öğütülüp ekstraksiyon için hazır hale getirildi.

Hücre Kültürü Çalışmaları

İnsan meme MCF-7 kanseri hücre hatları, %10 FBS, %1 L-glutamin ve %1 penisilin-streptomisin içeren yüksek glikozlu DMEM besiyeri kullanılarak 37°C'de, %95 nem ve %5 CO_2'li ortamda kültüre edilerek çoğaltıldı. Hücreler günlük olarak kontrol edildi ve ihtiyaç duyuldukça besiyerleri yenilendi. %80 oranında yoğunluğa ulaştıkları zaman hücreler tripsin ile muamele edilerek pasajlandı. (Erdoğan, 2016; Guo et al., 2013) . Hücre kültürü çalışmalarında, hücrelere *Salvia* ve Resveratrol ile kombinasyonları 72 saat boyunca mono ve kombine olarak uygulandı. Kontrol grubu olan hücrelere ise sadece besiyeri+DMSO karışımı uygulandı.

Hücre Canlılığının Belirlenmesi

Hücre canlılığı testi için Parker ve ark.'nın açıkladığı protokol optimize edilerek uygulandı (Parker et al., 2022). Öncelikle meme kanseri hücre ekimi 6 cm^2 lik hücre çoğaltma kabında yapıldı. Daha sonra ilgili hücre hatları *Salvia* türü ve bunların resveratrol kombinasyonu ile tedavileri gerçekleştirildi. Tedavi süresinin sonunda besiyerler aspire edilip yüzey PBS ile yıkandı. Ardından metanol-asestik asit (3:1) solüsyonu ile her kuyucuğa yaklaşık 1 ml eklenip oda sıcaklığında hücrelere 5 dakika fikse edildi. Fiksasyon solüsyonu ortamdan uzaklaştırılıp 1 ml 0.5% kristal viyole (Crystal Violet) boyası ile muamele edildi. 15 dakika oda sıcaklığında inkübasyonun ardından boyanan kuyucuklar musluk suyu altında dikkatlice yıkanıp %10 asetik asit (1 ml %100 Asetik asit + 9 ml ddH_2O) eklenerek 5 dakika çalkalayıcıda çalkalandı. Daha sonra kuyucuklardaki asetik asit mikropipet aracılığıyla çekilip spektrofotometrede ölçüm küvetleriyle 595 nm dalga boyunda hücre canlılığı yönüyle analiz edilip veriler istatistiksel olarak değerlendirildi.

Koloni Oluşum Deneyi

Koloni oluşumu deneyi, farklı tedavilerin hücrelerin koloni oluşumunu azaltma etkisini belirlemek için yapıldı. Bu deney için, 6 kuyucuklu plakalara kuyucuk başına 5 x 10^2 hücre olacak şekilde hücreler ekildi. Ertesi gün, hücreler 72 saat boyunca uygun tedavilerle muamele edildi ve tedaviden sonra, besiyeri uzaklaştırılıp taze besiyerinde hücreler 15 gün boyunca inkübe edildi. Bu süreden sonra besiyeri uzaklaştırıldı ve hücreler PBS ile yıkanıp metanol: asetik asit (3: 1) ile fikse edildi ve 15 dakika boyunca kristal viyole ile boyandı (Gomez et al., 2015). 50 hücreden fazlası koloni olarak kabul edildi. Koloniler sayılarak istatiksel analiz yapıldı.

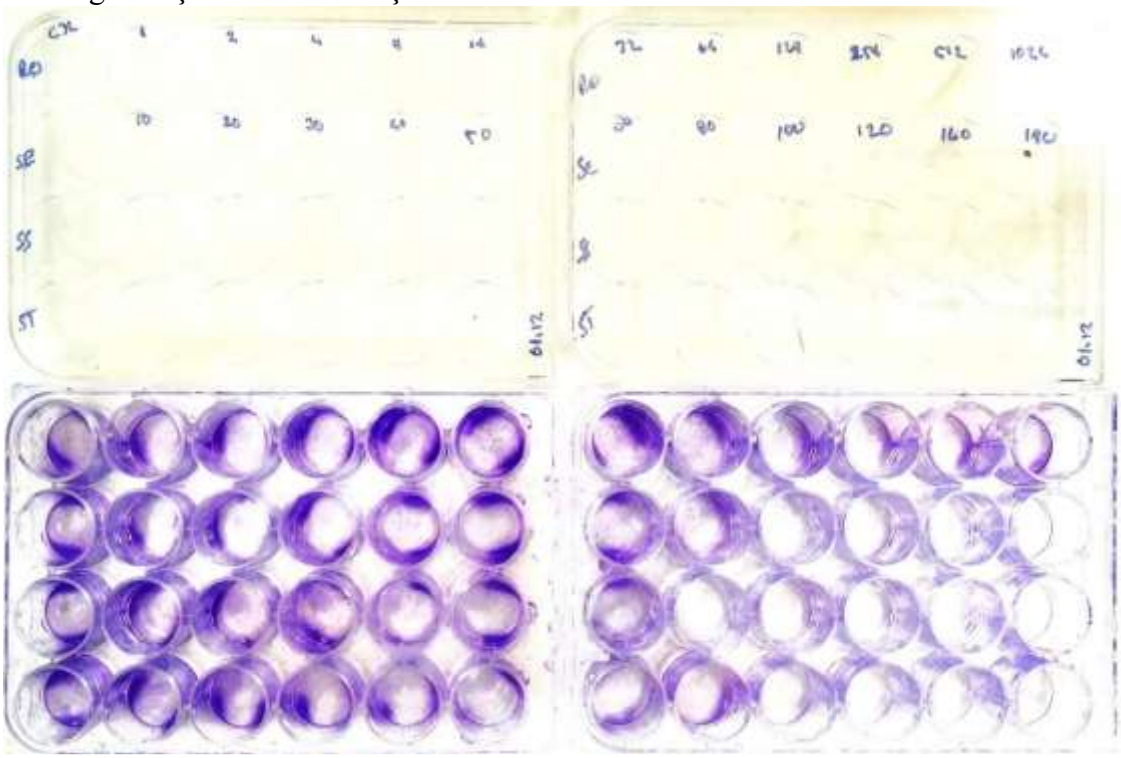
Migrasyon Yeteneğinin Belirlenmesi

İn vitro yara iyileşmesi yeteneğinin belirlenmesi için Zomer ve Ark. (Zomer et al., 2019) yöntemi kullanıldı. 6 kuyucuklu plakalara MCF-7 kanser hücreleri ekildi ve ertesi gün 1ml'lik steril pipet ucuyla plate tabanında bir çizik oluşturuldu. Kazınan hücrelerin uzaklaştırılması için iki kez PBS ile yıkandı. Daha sonra yaraların fotoğrafları çekildi. Tedavi grubu ilgili bitki ve kemoterapik ajanlarla muamele edildi. 0-6-12-24 saatin sonunda yara alanları mikroskobik olarak fotoğraflandı ve Image J yazılımı kullanılarak ölçüldü. Yara kapanma yüzdesi her grup için 0.-6.-12. ve 24. saatlik görüntüler için normalize edilerek belirlendi.

SONUÇLAR VE TARTIŞMA

Canlılık deneyi

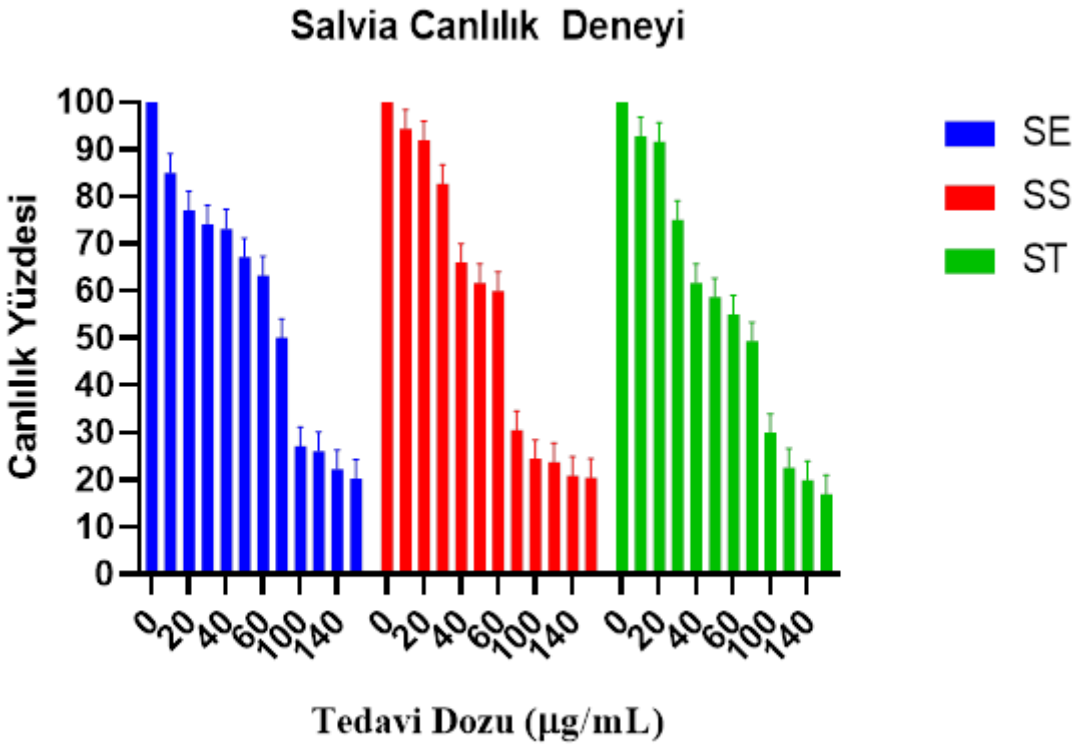
Kullanılan *Salvia* türlerinin ve resveratrolün kolon kanseri hücre hattında sitotoksik özelliğini ve IC_{50} değerini hesaplamak amacıyla kristal viyole canlılık deneyi yapılmıştır. Bu amaçla hücreler 72 saat süre artan dozlarda Res (0-1-2…1024 µg/mL) ve *Salvia* türleri (0-10-20… 180 µg/mL) ile tedavi edildi (Şekil 1). Tedavi sonunda *salvia* türleri ve Resveratrol için elde edilen IC_{50} ve IC_{25} dozları Tablo 1.de grafikler Şekil 2 ve Şekil 3'te verilmiştir. Elde edilen IC_{50} ve IC_{25} değerleri kullanılarak yapılan kombinasyon tedavisine ait tedavi taslağı Şekil 4'te, elde edilen grafik Şekil5'te verilmiştir.



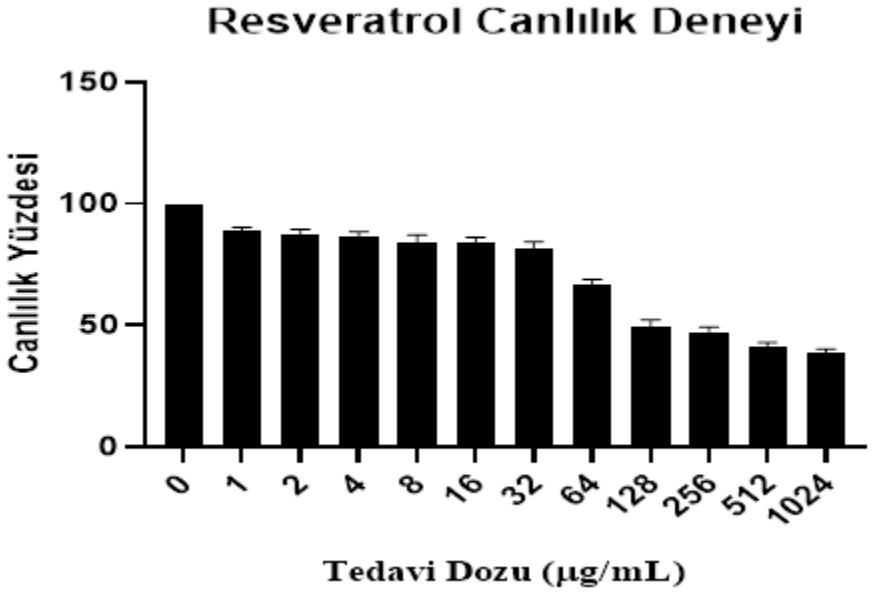
Şekil 2. MCF-7 Hücre hattında *Salvia* türleri ve Resveratrolün sitotoksik etkininin incelenmesi amacıyla 72saatlik tedavinin ardından kristal viyole canlılık deneyleri gerçekleştirildi (RES: Resveratrol, SE: *Salvia euphratica, SS: Salvia staminea, ST: Salvia trichoclada*)

Tablo 1 IC50 veIC25 değerleri

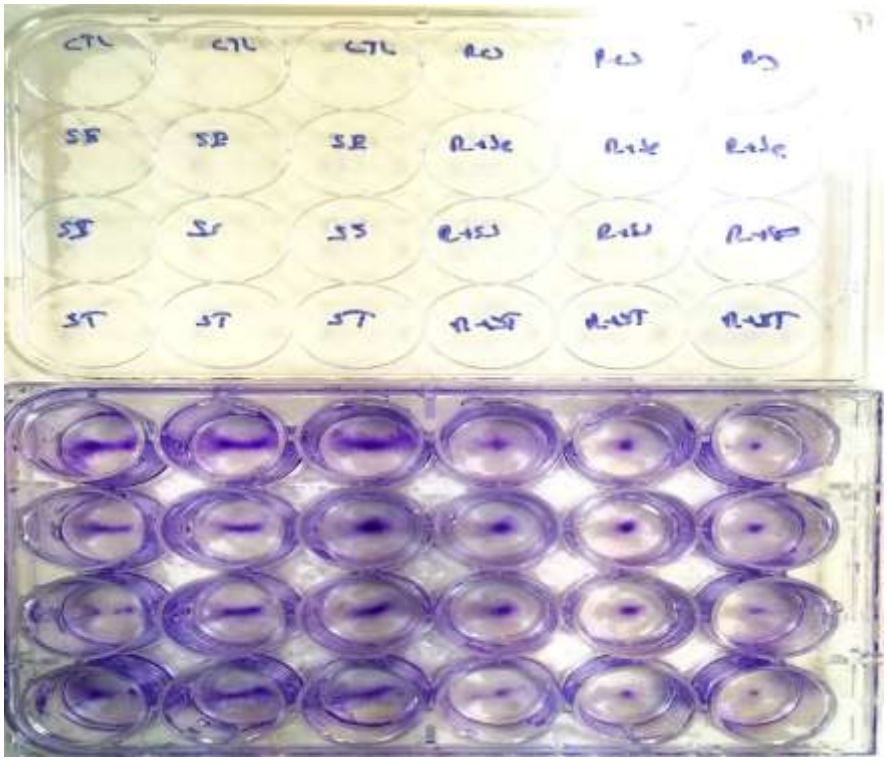
	SE	**SS**	**ST**	**RES**
IC50	71,98 µg/ml	63,81 µg/ml	65,95 µg/ml	224,59 µg/ml
IC25	35,08 µg/ml	36,69 µg/ml	31,13 µg/ml	29,40 µg/ml



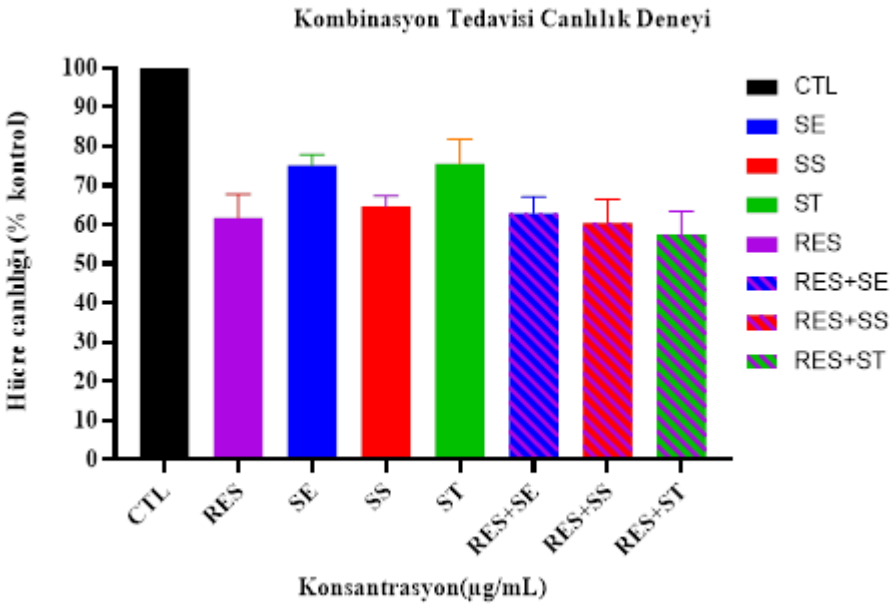
Şekil 3. Kristal viyole canlılık deneyi grafiği. *Salvia* türleri ile yapılan tedavinin ardından kontrol grubu canlılığına normalize edilmiştir. (RES: Resveratrol, *SE: Salvia euphratica, SS: Salvia staminea, ST: Salvia trichoclada*)



Şekil 4. Kristal viyole canlılık deneyi grafiği. Resveratrol ile yapılan tedavinin ardından kontrol grubu canlılığına normalize edilmiştir.



Şekil 5. Kombinasyon tedavisi canlılık deneyi. Monoterapi için tespit edilen IC50, kombinasyon tedavisi için IC25 dozları kullanılarak yapıldı. (RES: Resveratrol, *SE: Salvia euphratica, SS: Salvia staminea, ST: Salvia trichoclada*).

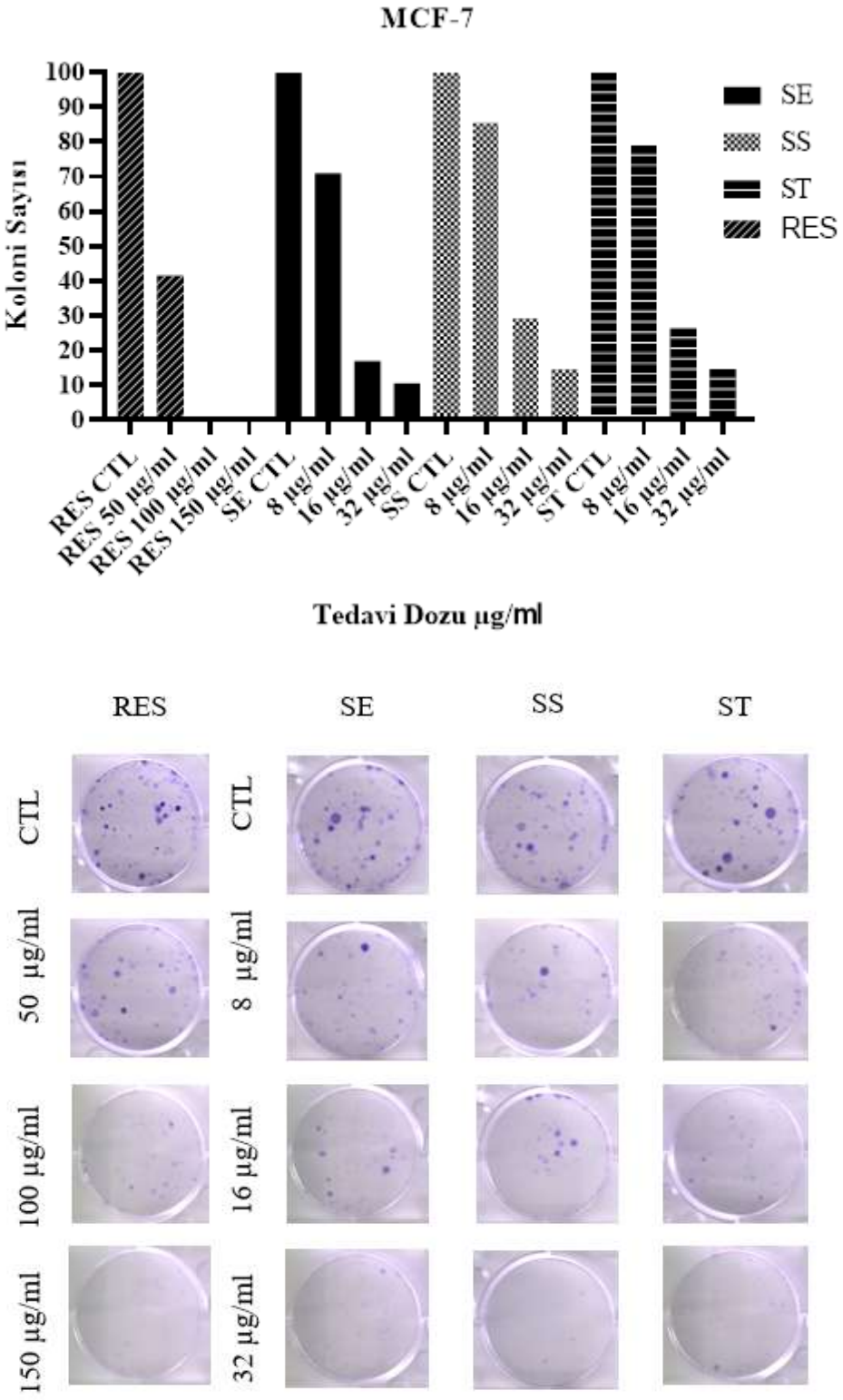


Şekil 6. Kombinasyon tedavisi canlılık grafiği. Kontrol grubuna normalize edilmiş canlılık grafiği. (RES: Resveratrol, *SE: Salvia euphratica, SS: Salvia staminea, ST: Salvia trichoclada*).

Koloni formasyon deneyi

Kullanılan *Salvia* türlerinin ve resveratrolün kolon kanseri hücre hattında sitotoksik özelliğini ve IC_{50} değerini hesaplamak amacıyla kristal viyole canlılık deneyi yapılmıştır. Bu amaçla hücreler 72 saat süre artan dozlarda Res (0-1-2…1024 µg/mL) ve *Salvia* türleri (0-10-20… 180 µg/mL) ile tedavi edildi (Şekil 1). Tedavi sonunda *Salvia* türleri ve Resveratrol için elde edilen IC_{50} ve IC_{25} dozları Tablo 1.de grafikler Şekil 2 ve Şekil 3'te verilmiştir. Elde edilen IC_{50} ve

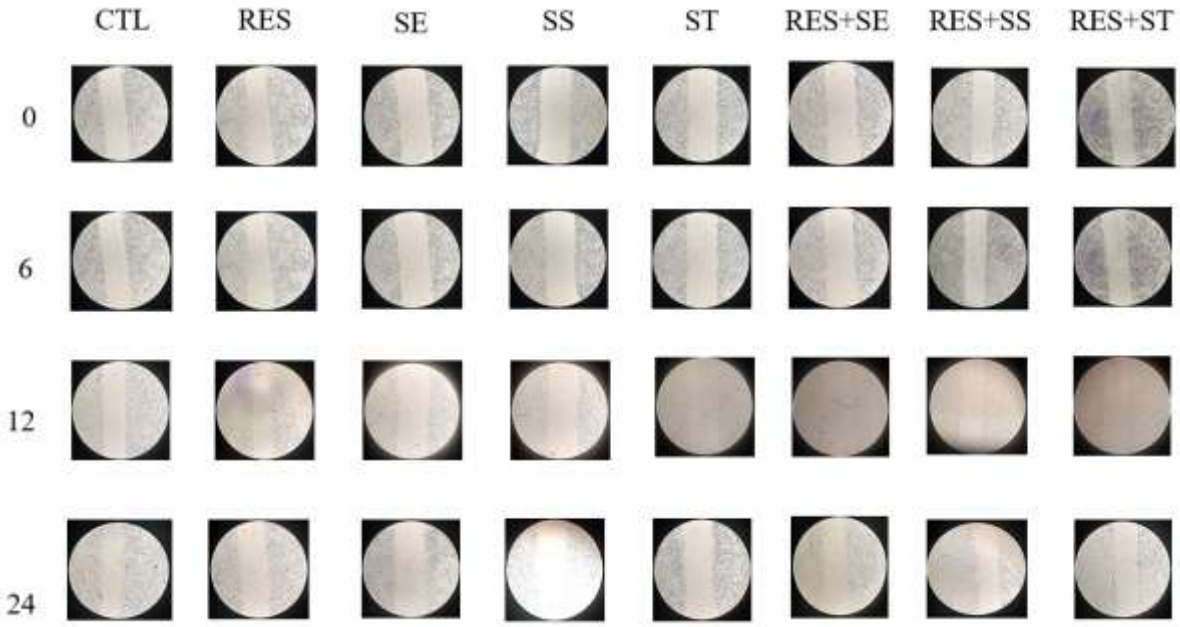
IC_{25} değerleri kullanılarak yapılan kombinasyon tedavisine ait tedavi taslağı Şekil 4'te, elde edilen grafik Şekil5'te verilmiştir.

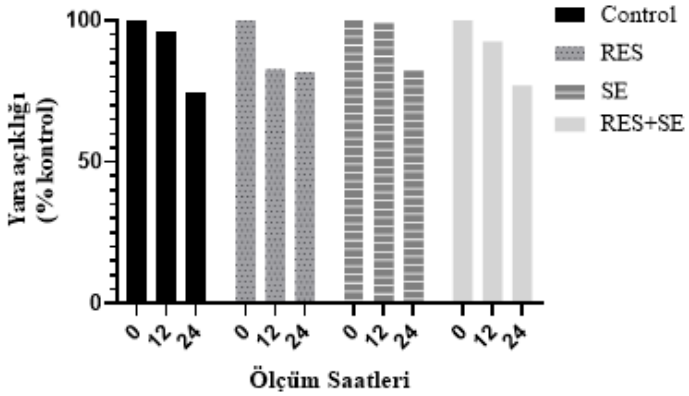


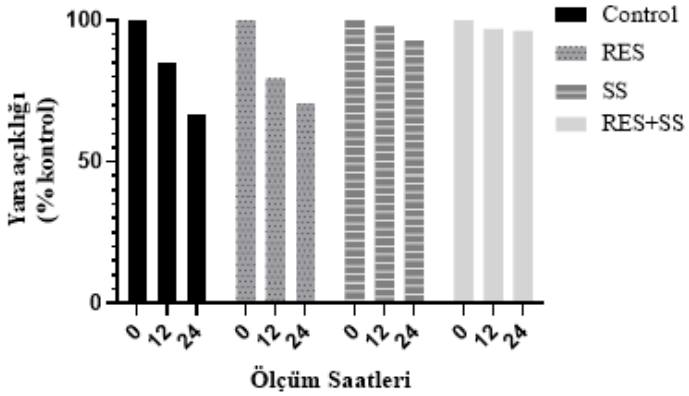
Şekil 7. *Salvia* türleri ve resveratrol ile tedavi edilen MCF-7 hücre hattında koloni oluşum deneyi (RES: Resveratrol, *SE: Salvia euphratica, SS: Salvia staminea, ST: Salvia trichoclada*)

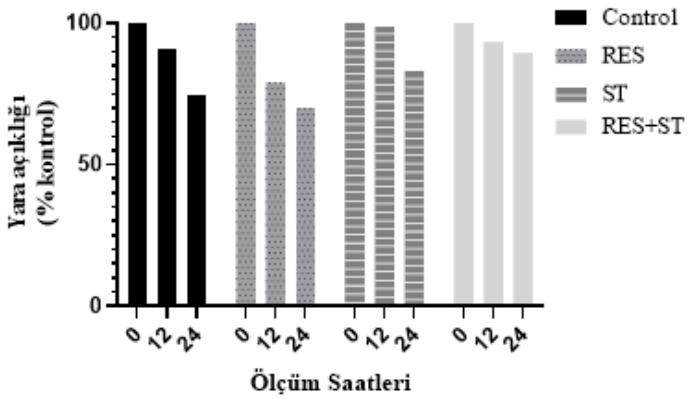
Migrasyon deneyi

Kullanılan *Salvia* türlerinin ve resveratrolün kolon kanseri hücre hattında sitotoksik özelliğini ve IC_{50} değerini hesaplamak amacıyla kristal viyole canlılık deneyi yapılmıştır. Bu amaçla hücreler 72 saat süre artan dozlarda Res (0-1-2…1024 µg/mL) ve *Salvia* türleri (0-10-20… 180 µg/mL) ile tedavi edildi (Şekil 1). Tedavi sonunda *salvia* türleri ve Resveratrol için elde edilen IC_{50} ve IC_{25} dozları Tablo 1.de grafikler Şekil 2 ve Şekil 3'te verilmiştir. Elde edilen IC_{50} ve IC_{25} değerleri kullanılarak yapılan kombinasyon tedavisine ait tedavi taslağı Şekil 4'te, elde edilen grafik Şekil5'te verilmiştir.









SONUÇ

Meme kanserinin kadınlarda en sık görülen kanser türü olduğu bilinmektedir. 2018 verilerine göre dünya genelinde 2 milyondan fazla meme kanseri vakası ve 600 binden fazla meme kanserine bağlı ölüm bildirilmiştir (Bray et al., 2018). Kadınlarda en fazla görülen kanser türü olan meme kanseri tedavisi noktasında birçok gelişmeye rağmen bu kanser türü bir sağlık sorunu olarak karşımızda durmaktadır. Bu sebeple kanser tedavisinde yeni yaklaşımlara ihtiyaç duyulmaktadır (Shewach & Kuchta, 2009). Kanser tedavisinin tüm aşamalarında tedaviye destek olması, toksik olmaması, birden fazla yolakta etkili olması ve genellikle ilaçlarla sinerjik etki göstermesi sebebiyle doğal terapötikler büyük önem taşımaktadır (Wani et al., 2016). Bitki kaynaklı antikanser özellik gösteren 3000'nin üzerinde bitki olduğu belirtilmektedir. Amerika'da hastaların önemli bir kısmını sadece bitkiler ile veya kemoterapi-radyoterapiye ek olarak bitkisel kaynaklı ürünler ile tedavi edildiği bilinmektedir (Yiğit, 2021). Resveratrol birçok kanser türünde kullanılan başarılı bir bitkisel üründür (Leon-Galicia et al., 2013). *Salvia*

cinsi üyeleri dünyanın birçok bölgesinde tedavi edici etkileri sebebiyle uzun süredir kullanılmaktadır. Antioksidan, antitümör, apoptozu indükleyici özellikleri sebebiyle bu bitkinin çeşitli türleri tedavinin asıl unsuru veya diğer tedavi seçeneklerini destekleyici olarak kullanılmaktadır. Literatürde RES'in meme kanseri dahil birçok kanser türünde sitotoksik özellik gösterdiği bilgisi bulunmaktadır (Ren et al., 2021). Bizim çalışmamızda literatür ile uyumlu olarak RES'in MCF-7 hücre hattında sitotoksik etki gösterdiği, migrasyon yeteneğini ve koloni yapma kabiliyetini azalttığı görüldü. *Salvia* türlerinin dünyanın birçok bölgesinde kanser tedavisinde kullanıldığı bilinmektedir. İçerdiği fenolik bileşiklerin anti-kanser etkinin ortaya çıkmasını sağladığı bildirilmektedir (Hu et al., 2015; Lee et al., 2010; Tayarani-Najaran et al., 2013). Çalışmamızda kullanılan *Salvia* türlerinin meme kanseri hücre hattında sitotoksik etki gösterdiği, hücrelerin migrasyon yeteneğini ve koloni oluşturma kabiliyetini azalttığı görüldü (Kerem, 2015). Doğal ürünlerin uzun yıllardır çeşitli hastalıklardan korunma sürecinde ve hastalıkların tedavisinde kullanılmasına rağmen bazı durumlarda ilacın etkinliğini azaltıcı veya nötr etki gösterdiği bilinmektedir. İlacın moleküler etkinin azalması veya tersine çevrilmesi ihtimali klinik öncesi ve klinik araştırmalarda çoğu kez ihmal edilmektedir. Birçok bitkisel ürünün tıbbi tedavileri olumsuz etkilediği tespit edilmiştir (Hackman et al., 2020). Çalışmamızda RES ve *Salvia* ekstraktları arasında hücre canlılığı açısından belirgin bir sinerjik veya antagonistik etkileşim gözlenmemiştir. Yara iyileşmesi ve koloni oluşumu testleri de kombinasyonun hücresel proliferasyon ve göç üzerinde anlamlı bir etkisi olmadığını desteklemiştir. Bu sonuçlar, iki maddenin birlikte kullanımında birbirlerinin etkilerini nötralize etmediğini ve yan etki riskini artırmadan ayrı ayrı uygulanabileceklerini göstermektedir. İlerleyen çalışmalarda farklı dozlar ve moleküler mekanizmalarla ilgili araştırmalar, klinik kullanım potansiyellerine daha fazla ışık tutacaktır

Teşekkür

Bu çalışma, TÜBİTAK 2209 projesi ile desteklenmiştir.

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ÜLKELERDE KULLANILAN GÜNCEL AŞI TAKVİMLERİ VE HEMŞİRELİK: ÇOCUKLUK ÇAĞI AŞILARINDA NE DURUMDAYIZ?

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ÖZET
Aşılar, bulaşıcı hastalıkları önlemenin ve halk sağlığını korumanın en etkili yöntemlerinden biri olarak yaygın bir şekilde kabul edilmektedir. Kızamık, kızamıkçık, rotavirüs, çocuk felci ve kabakulak gibi birçok hastalığın önlenmesi amacıyla sağlık profesyonelleri aşıya başvurmaktadır. Aşılama tek bir hastalığı önlemek için belirli zaman periyodlarında tercih edilen bir yöntem olabileceği gibi ulusal aşı takvimleri gibi rutin her çocuğa uygulanması istenen bir yöntem olarak da tercih edilebilmektedir. Dünya çapında neredeyse tüm ülkelerde aşılama programları uygulanmasına rağmen, ulusal olarak kabul edilen ve rutin olarak uygulanan aşılar ülkeden ülkeye farklılık göstermektedir. Örneğin, bazı gelişmiş ülkelerde aşılama programları kapsamlıdır ve HPV, rotavirüs ve meningokok gibi aşılar rutin olarak uygulanmaktadır. Buna karşın, bazı gelişmekte olan ülkelerde temel aşılar mevcut olmasına rağmen, yeni nesil aşılara erişim sınırlıdır. Az gelişmiş ülkelerde, lojistik zorluklar ve fon yetersizliği aşılara erişimi zorlaştırmaktadır. Bazı ülkelerde, temel aşılar bile düzenli olarak uygulanamamaktadır. Son yıllarda, aşı olmayı reddeden kişilerin sayısı artmıştır. Bu fenomen, yanlış bilgilerin yayılması ve aşı geliştirme sürecine genel olarak güvenilmemesine bağlanabilir. Bu durum, bazı salgın hastalıkların yeniden ortaya çıkmasına neden olabilir. Toplum eğitimi girişimleri, kayıt sistemlerinin dijitalleştirilmesi ve mobil aşılama ekiplerinin görevlendirilmesi, özellikle kırsal bölgelerde aşı kapsamını artırma potansiyeline sahiptir. Sonuç olarak, küresel aşı eşitliğinin sağlanması, yeni teknolojilerin geliştirilmesi ve halkın bilinçlendirilmesinin bulaşıcı hastalıklarla mücadelede belirleyici olacağı açıktır. Bu derleme, küresel aşılama uygulamalarını ve bunların halk sağlığı üzerindeki etkisini incelemek için farklı gelişmişlik düzeylerindeki ülkelerin aşılama programlarını incelemektedir.
Anahtar sözcukler: Aşı; Aşı takvimi, Aşı reddi, Küresel sağlık, Hemşirelik

CURRENT VACCINATION CALENDARS USED IN COUNTRIES AND NURSING: HOW ARE WE DOING WITH CHILDHOOD VACCINES?

ABSTRACT
Vaccines are widely recognised as one of the most effective methods of preventing infectious diseases and protecting public health. Health professionals use vaccination to prevent many diseases such as measles, rubella, rotavirus, polio and mumps. Vaccination can be a method preferred at certain time periods to prevent a single disease, or it can be preferred as a method that is routinely required to be administered to every child, such as

national vaccination calendars. Although vaccination programmes are implemented in almost all countries worldwide, nationally accepted and routinely administered vaccines vary from country to country. For example, in some developed countries, vaccination programmes are comprehensive and vaccines such as HPV, rotavirus and meningococcal are routinely administered. In contrast, in some developing countries, although basic vaccines are available, access to next-generation vaccines is limited. In less developed countries, logistical challenges and lack of funding make access to vaccines difficult. In some countries, even basic vaccines cannot be administered regularly. In recent years, the number of people refusing to be vaccinated has increased. This phenomenon can be attributed to the spread of misinformation and a general lack of trust in the vaccine development process. This may lead to the re-emergence of some epidemics. Community education initiatives, digitisation of registration systems and deployment of mobile vaccination teams have the potential to increase vaccination coverage, particularly in rural areas. In conclusion, it is clear that ensuring global vaccine equity, developing new technologies and raising public awareness will be decisive in the fight against infectious diseases. This review examines the vaccination programmes of countries at different levels of development to examine global vaccination practices and their impact on public health.
Keywords: Vaccination; Vaccine schedule, Vaccine refusal, Global health, Nursing

Giriş

Dünya tarihi boyunca birçok salgın ve bulaşıcı hastalık salgını yaşanmıştır. Bunlar ölüm ve hastalık oranlarını artırmanın yanı sıra ülkelerin ekonomilerine de yük getirmiştir. Aşılama, salgın ve bulaşıcı hastalıklarla mücadelede en sık kullanılan yöntemdir. Aşılar, bu mücadelede son derece önemli bir araçtır ve etkinlik, maliyet ve uygulanabilirlik açısından avantajlar sunar (Akgül & Ergün, 2023). Dünya Sağlık Örgütü (DSÖ) aşılama ile birçok hastalığın önlenebilir hastalıklar içerisinde değerlendirilebileceğine dair veriler sunmaktadır (Reuben ve ark., 2020). Gelişmiş ülkelerde aşılama programları bilimsel komiteler tarafından belirlenir ve düzenli olarak güncellenir. Örneğin Amerika Birleşik Devletleri'nde bu görev Aşılama Uygulamaları Danışma Komitesi (ACIP) tarafından yürütülürken, Avrupa ülkelerinde Avrupa Hastalık Önleme ve Kontrol Merkezi (ECDC) ve ulusal bulaşıcı hastalık enstitüleri (örneğin Almanya'daki STIKO) sorumludur. Kanada'da ise bu sorumluluk Ulusal Aşılama Danışma Komitesi'ne (NACI) aittir. Çoğu gelişmiş ülkede aşılar ücretsizdir ve hükümet tarafından karşılanır. Bu, yüksek aşılama oranlarının korunmasında önemli bir rol oynar (Orenstein & Ahmed, 2017). Aşılama programlarındaki farklılıkların birçok nedeni vardır. Örneğin, suçiçeği gibi hastalıklar, çocukluk çağında ciddi komplikasyonlara neden olmadıkları için Birleşik Krallık ve İsveç gibi bazı Avrupa ülkelerinde aşılama programına dahil edilmemiştir. Buna karşılık, Amerika Birleşik Devletleri ve Japonya, komplikasyon riskini azaltmak için bu aşıyı iki doz halinde uygulamaktadır. Bazı ülkeler, ekonomik değerlendirmelere (örneğin maliyet etkinliği) dayanarak belirli aşıları (örneğin rotavirüs) zorunlu programa dahil etmiştir. Japonya, aşılama programına daha temkinli bir yaklaşım sergileyerek bazı aşıları zorunlu değil, "önerilen" olarak sınıflandırmaktadır (Dünya Sağlık Örgütü, 2021). DTaP ve polio aşılarının dozu ülkeden ülkeye değişmektedir. Örneğin: Amerika Birleşik Devletleri: Beş doz DTaP aşısı 2, 4, 6, 15-18 ay ve 4-6 yaşlarında uygulanırken, Birleşik Krallık'ta dört doz 8, 12 hafta ve 3 yaşında uygulanmaktadır. Pnömokok (PCV13) aşısı: Amerika Birleşik Devletleri ve bazı ülkeler: 3+1 programı; Fransa ve Almanya: 2+1 programı. Bu farklılıklar, bağışıklık tepkisi süresi, yerel hastalık yaygınlığı ve sağlık sistemi uygulanabilirliği gibi faktörlere dayanmaktadır. (Dünya Sağlık Örgütü, 2020). Tüm gelişmiş ülkeler, farmakovijilans sistemleri aracılığıyla aşılamanın yan etkilerini düzenli olarak izlemektedir. Amerika Birleşik Devletleri'ndeki VAERS, Birleşik Krallık'taki Yellow Card Scheme ve Fransa'daki ANSM gibi bu sistemler, halk ve sağlık profesyonellerinden gelen geri bildirimleri analiz etmektedir (Shimabukuro ve ark., 2015).

Gelişmiş ülkelerin belirli bölgelerinde aşı tereddütleri artmıştır. Ancak Fransa ve İtalya, aşılamayı zorunlu hale getirerek aşılama kapsamını artırmıştır. Bu arada Kanada ve İsveç gibi ülkeler ikna temelli kampanyalarla ilerlemektedir (Dubé ve ark., 2015). Hindistan ve Endonezya gibi ülkelerde, bu hastalıkların endemik olması nedeniyle hepatit A, tifo ve Japon ensefaliti aşıları da kullanılmaya başlanmıştır. Türkiye ve Brezilya gibi ülkelerde ise suçiçeği ve hepatit B aşıları önceliklidir. Bazı ülkelerde PCV13 (pnömokok) veya rotavirüs aşıları aşılama programının ilerleyen aşamalarında uygulanmakta veya bölgesel olarak uygulanmaktadır (örneğin Endonezya). Uzak bölgelerde soğuk zincirin sürdürülememesi bazı aşıların dağıtımını sınırlamaktadır. Ülkeler arasındaki aşılama programlarındaki farklılıklar genellikle hastalık yaygınlığı, maliyet ve lojistik koşullar nedeniyle ortaya çıkmaktadır (Ozawa ve ark., 2016). Türkiye: HBV, DTaP, Hib, IPV, PCV13, MMR ve suçiçeği gibi aşılar doğumdan iki yaşına kadar üç ila dört doz halinde uygulanmaktadır. Brezilya ve Meksika: Birçok aşı üç doz artı bir takviye dozu gerektirir. Bu, WHO'nun önerilerine yakındır. Hindistan: İlk üç doz genellikle 6, 10 ve 14. haftalarda verilir. Dozlar arasındaki aralık bazen daha kısadır. Endonezya: Aşılar genellikle iki dozla sınırlıdır ve bu, bölgeye göre değişebilir. Güney Afrika: 6, 10 ve 14. haftalarda doz programı yaygındır. Hepatit B doğumda uygulanır. Gelişmekte olan ülkelerde aşılar genellikle yasal olarak zorunlu değildir, ancak sağlık hizmetlerine erişimin olduğu bölgelerde ücretsiz olarak sağlanır. Zorunlu aşılama, yasal gerekliliklerden çok pratik erişimle sınırlıdır. Erişim genellikle düşüktür ve kırsal ve çatışma bölgelerinde sağlık merkezlerine erişim çok zordur. Bu nedenle, mobil klinikler ve UNICEF ve WHO destekli kampanyalar kritik bir rol oynamaktadır. Bunlar, WHO'nun Genişletilmiş Aşılama Programı (EPI) kapsamında yürütülmektedir. Aşılar çoğunlukla uluslararası bağışlar (Gavi, the Vaccine Alliance, 2023) yoluyla sağlanmaktadır. (2023). Sarı humma ve sıtma gibi endemik hastalıklar, bazı ülkelerin programlarına ek aşıların dahil edilmesine neden olmaktadır (örneğin, Nijer ve Güney Sudan'da sarı humma aşısı). Bazı ülkelerde, rotavirüs ve pnömokok aşıları, maliyetleri ve bağışlara bağımlı olmaları nedeniyle henüz yaygın olarak bulunmamaktadır. Aşı saklama koşulları, soğuk zincirin sürdürülememesi ve nakliye zorlukları gibi sorunlar nedeniyle program tam olarak uygulanamamaktadır (Dünya Sağlık Örgütü, 2023). Aşılama programı genellikle üç dozluk bir rejimden oluşur: DTP, polio, Hib ve Hep B gibi aşılar genellikle 6, 10 ve 14. haftalarda üç doz halinde uygulanır. Kızamık ve sarı humma aşıları: Bunlar genellikle dokuzuncu ayda tek doz olarak uygulanır. BCG ve hepatit B (doğum dozu): Bunlar doğumda veya sağlık merkezine ilk ziyaret sırasında uygulanır. (Dünya Sağlık Örgütü, 2024). Pilot izleme sistemleri, UNICEF ve WHO (Dünya Sağlık Örgütü) ile işbirliği içinde bazı bölgelerde incelenmektedir (Dünya Sağlık Örgütü, 2023).

Gelişmiş ülkelerde hemşireler, aşılama politikalarının uygulanması ve iyileştirilmesinde rol almaktadır. Aşılama programlarının etkinliğini artırmak için geri bildirim sağlarlar ve sağlık sisteminin iyileştirilmesine katkıda bulunurlar (Edmonds & Laskey, 2021). Gelişmekte olan ülkelerde ise hemşireler, toplumun kültürel norm ve geleneklerini göz önünde bulundurarak aşı tereddütleriyle mücadele eder ve aşıların kabulünü artırmak için stratejiler geliştirir. Bu, hemşirelerin sadece klinik becerilere sahip olmalarını değil, aynı zamanda kültürel duyarlılık ve sosyal anlayışa da sahip olmalarını gerektirir (Green & Tones, 2018). Az gelişmiş ülkelerde, hemşireler genellikle uluslararası sağlık kuruluşları ve hükümetler tarafından düzenlenen aşılama kampanyalarında aktif rol oynarlar. Bu kampanyalar, yerel halkı aşı olmaya teşvik etmek için değerli bir fırsat sunar (Rani & Kumar, 2019).

Sonuç ve Öneriler

Gelişmiş ülkelerde aşılama programları dijital izleme sistemlerinin desteğiyle genellikle kapsamlı ve sistematik olsa da, düşük gelirli ülkelerde temel aşıların temini ve sürdürülebilirliği bazen aksayabilmektedir. Bu bağlamda, küresel eşitsizlikleri azaltmak için uluslararası işbirliği ve finansal destek mekanizmalarının etkinliğini artırmak çok

önemlidir. Tarih boyunca, aşı tereddütleri bilimsel verilerden çok kültürel, politik ve psikolojik faktörlerden etkilenmiştir. Özellikle sosyal medya çağında, yanlış bilginin yayılma hızı halkın aşı güvenliğine olan güvenini sarsmaktadır. Bu nedenle, sağlık okuryazarlığını artırmak, bilgiye dayalı farkındalık kampanyaları yürütmek ve güvene dayalı iletişim stratejileri benimsemek önerilmektedir. Gelecekteki aşı teknolojileri, özellikle mRNA tabanlı platformlar, viral vektör sistemleri ve nanoteknolojik çözümler, daha az yan etkiyle hızlı bir şekilde üretilebilen kişiselleştirilmiş aşılar sunma potansiyeline sahiptir. Bu gelişmeler, pandemiler ve kanser, otoimmün hastalıklar ve bağımlılık gibi kronik sağlık sorunları için çözümler sunabilir. Pandemilerle uyumlu olarak Ar-Ge yatırımlarının artırılması, uluslararası klinik işbirliklerinin genişletilmesi ve etik onay süreçlerinin hızlandırılması öncelikli olarak ele alınmalıdır. Hemşirelik mesleği de aşılama programlarında çok önemli bir rol oynamaktadır. Hemşireler uygulayıcı, eğitimci, rehber ve denetçidir. Bu nedenle, ülkelerin aşılama planları sadece teknik bilgiyi değil, iletişim becerileri, sosyal farkındalık, kültürel yeterlilik ve kriz yönetimi gibi alanları da içermelidir. Sağlık sistemlerinin sürdürülebilirliğini sağlamak için hemşireler aşılama politikalarının merkezine yerleştirilmeli ve sürekli mesleki gelişimleri desteklenmelidir. Sonuç olarak, bilimsel gelişmeler, sosyo-kültürel farkındalık, disiplinler arası işbirliği ve insan hakları dikkate alınarak etkili ve kapsayıcı bir aşılama stratejisi oluşturulabilir. Ancak bu bütüncül bakış açısı ile gelecekteki küresel sağlık krizlerini önleyebilir ve halk sağlığını korunabilir.

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ÇOCUKLARDA EK GIDAYLA BESLENME VE HEMŞİRELİK: EK GIDAYA GEÇİŞTE GÜNCEL YAKLAŞIMLAR NELERDİR?

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ÖZET
Ek gıda uygulaması, ebeveynlerin anne sütü dışında çocuklarına besin sağlanması olarak da tanımlanabilir ve genellikle bebeğin gelişimsel hazırlığına bağlı olarak 6 aylıkken başlar. İlk altı ay anne sütüyle beslenen bir bebeğin beslenme döngüsüne ek gıda kaynaklarının eklenme süreci, ek gıdalara geçiş olarak adlandırılır. İlk altı ay boyunca sadece anne sütü ile beslenmeyi, ardından bir yaşına kadar anne sütü ile birlikte tamamlayıcı gıdaların kademeli olarak verilmesini savunmaktadır. Amaç, çocuğun gıdaya alışmasını kolaylaştırmak, çiğneme ve yutma becerilerinin gelişimini desteklemek ve yeterli beslenmeyi sağlamaktır. Sütten kesilmenin ilk aşamasında önerilen gıdalar arasında demir açısından zengin tahıllar ile sebze ve meyve püreleri bulunmaktadır. Şeker, tuz ve alerjenlerden kaçınılması tavsiye edilir. Beslenme sıklığı genellikle altı ila sekiz aylıkken günde iki kez, dokuz ila 12 aylıkken günde üç kez olmaktadır. Ayrıca, tamamlayıcı gıdalara geçiş sırasında çocukların kaçınması gereken belirli gıdalar vardır. Yasak gıdalar olarak da tanımlanabilen bu gıdalar arasında bal, fındık ve konserve ürünler bulunur. Bu süreçte, bakım verenler birçok zorlukla karşılaşır. Bu zorluklar, yiyecekleri reddetme, yutma güçlüğü ve ebeveynlerin endişesi gibi çeşitli sorunları kapsar. Ayrıca, gıda alerjileri, deri döküntüleri ve kusma gibi semptomlar da ortaya çıkabilir. Alerjenlerin dikkate alınması zorunludur. Bebek öncülüğünde beslenme ve karma yöntemler dahil olmak üzere mevcut yaklaşımların, gıda çeşitliliğini ve motor becerileri desteklediği gösterilmiştir. Ayrıca, teknoloji tabanlı uygulamalar (beslenme, tele-sağlık vb. için mobil ve web uygulamaları) ve probiyotiklerin süreci kolaylaştırdığı gösterilmiştir. Hemşireler, ebeveyn eğitimi, alerji izleme ve boğulma önleme gibi alanlarda rehberlik görevi görürler. Probiyotikler ve kültürel etkilerin incelenmesi konusunda gelecekte araştırma yapılması önerilmektedir.
Anahtar Kelimeler: Çocuk; Beslenme; Ek gıda; Hemşirelik

SUPPLEMENTARY NUTRITION IN CHILDREN AND NURSING: WHAT ARE THE CURRENT APPROACHES TO TRANSITION TO SUPPLEMENTARY FOOD?

ABSTRACT
Supplementary feeding can also be defined as the provision of food other than breast milk by parents to their children and usually starts at the age of 6 months, depending on the developmental readiness of the baby. The process of adding additional food sources to the nutritional cycle of an infant who is breastfed for the first six months is called transition to additional foods. It advocates exclusive breastfeeding for the first six months, followed by the gradual introduction of complementary foods along with breast milk until the age of one year. The aim is to facilitate the child's habituation to food, to support the development of chewing

and swallowing skills and to ensure adequate nutrition. Foods recommended in the first phase of weaning include iron-rich cereals and vegetable and fruit purees. Avoidance of sugar, salt and allergens is recommended. Feeding frequency is usually twice a day from six to eight months of age and three times a day from nine to 12 months of age. There are also certain foods that children should avoid during the transition to complementary foods. These foods, which can also be defined as forbidden foods, include honey, nuts and canned foods. During this process, carers face many challenges. These challenges include food refusal, swallowing difficulties and parental anxiety. Symptoms such as food allergies, skin rashes and vomiting may also occur. It is imperative that allergens are taken into account. Current approaches, including infant-led feeding and mixed methods, have been shown to support food variety and motor skills. In addition, technology-based applications (mobile and web applications for nutrition, telehealth, etc.) and probiotics have been shown to facilitate the process. Nurses act as guides in areas such as parent education, allergy monitoring and choking prevention. Future research on probiotics and cultural influences is recommended.
Keywords: Child; Nutrition; Supplementary food; Nursing

GİRİŞ

Tamamlayıcı gıdalara geçiş, bebeklerin anne sütü veya mama ile beslenmesinden katı gıdalara geçiş sürecini ifade eder. Bu, sağlıklı büyüme ve gelişme için kritik bir dönemdir. Bebekler hızla büyürler ve bu nedenle her gün daha fazla gıdaya ihtiyaç duyarlar; bu dönemde beslenme alışkanlıkları da değişir. Her bebeğin gelişiminin farklı olabileceğini kabul etmek önemlidir, çünkü bu süreç kişisel özellikler ve büyüdükleri sosyal ve duygusal ortam gibi çeşitli faktörlere bağlıdır. Dünya Sağlık Örgütü (WHO), ilk altı ay boyunca sadece anne sütü ile beslenmeyi, ardından tamamlayıcı gıdaların verilmesini önermektedir (WHO, 2024). Bu geçiş, beslenme açısından olduğu kadar motor becerilerin gelişimi, bağırsak sağlığı ve alerji risklerinin yönetimi açısından da önemlidir. Bu dönemde bebeklere anne sütü veya mama dışında katı ve yarı katı gıdalar verilir, bu nedenle beslenme açısından kritik bir dönemdir. Bu dönemin zamanlaması, sunulan gıda türleri ve gıdaların veriliş yöntemleri, sağlıklı beslenme alışkanlıklarının gelişmesinde temel bir rol oynar. Bu dönemde bebekleri çeşitli gıdalarla tanıştırmak hem kısa hem de uzun vadede olumlu beslenme davranışlarının gelişmesine yardımcı olur. (Gümüştakım ve ark., 2017; Sivri ve Özpulat, 2014)

Katı gıdalara geçiş sadece beslenme ihtiyaçlarını karşılamakla ilgili değildir; aynı zamanda bebeklerin tat tercihlerini şekillendiren ve yeni tatlara ve dokulara alışmalarına yardımcı olan deneyimsel bir süreçtir. Bu dönemde amaç, bebekleri çok sayıda gıdayı hızlı bir şekilde tüketmeye zorlamak yerine, çeşitli tat ve dokularla tanıştırarak duyusal gelişimlerini desteklemektir. Bebeklerin büyük çoğunluğu fizyolojik olarak altı aylıktan önce katı gıdalara ihtiyaç duymasa da, bu erken deneyimler motor beceri gelişimi ve gıdaların duyusal farkındalığı için önemlidir. Hemşireler, ebeveynlere bu süreçte rehberlik ederek bebeklerin sağlıklı beslenme alışkanlıkları geliştirmelerine destek olurlar. Türkiye Sağlık Bakanlığı da benzer kılavuzlar sunarak, tamamlayıcı gıdalara geçişin altı aydan itibaren kademeli olarak başlatılmasını önermektedir (T.C. Sağlık Bakanlığı, 2023). Ancak, ebeveynlerin bu süreçte karşılaştıkları zorluklar, kültürel farklılıklar ve alerji riskleri, hemşirelik müdahalelerini daha da önemli hale getirmektedir. Bu derleme, tamamlayıcı gıdalara geçiş sürecini hemşirelik perspektifinden incelemek, mevcut yaklaşımları ve bu süreçte hemşirelerin rolünü araştırmak amacıyla hazırlanmıştır. Çalışma, bu geçişin temellerini, karşılaşılan zorlukları, alerji yönetimini, mevcut yaklaşımları ve hemşirelik stratejilerini kapsamlı bir şekilde değerlendirecektir.

Tamamlayıcı gıdalara geçiş genellikle altı aylıkken başlar, ancak bu, bebeğin gelişimsel hazırlığına bağlı olarak değişebilir. Dünya Sağlık Örgütü (WHO) ve Amerikan Pediatri Akademisi (AAP), katı gıdalara geçiş yaparken bebeğin başını dik tutma, oturma ve yutma gibi fizyolojik göstergeleri dikkate almayı önermektedir (AAP, 2024). Türkiye'de Sağlık Bakanlığı,

bu geçişin kademeli olarak ve 6 ila 12 ay arasında, emzirmeye devam edilerek yapılması gerektiğini vurgulamaktadır (T.C. Sağlık Bakanlığı, 2023). Yeterli ve dengeli beslenme, sağlıklı büyüme ve gelişme için çok önemlidir. Doğumdan sonraki ilk iki yıl, beslenme açısından kritik bir dönemdir. Bu dönemde hızlı büyüme ve gelişme, yetersiz beslenme ve sık enfeksiyonlar gibi olumsuz sağlık sonuçlarına yol açabilir. Anne sütü, yeni doğan bebekler için en uygun besin kaynağıdır. Bu nedenle, bebeklerin ilk altı ay boyunca sadece anne sütü ile beslenmesi önerilir. Bağışıklık bileşenleri sayesinde anne sütü, bebekleri çeşitli hastalıklardan korur ve gelecekte alerji, obezite, diyabet ve hipertansiyon gibi kronik hastalıkların gelişme riskini azaltır. Bir doktor, bebeğin kilo ve boy gibi büyüme parametrelerini izleyerek anne sütünün yeterliliğini değerlendirmelidir. Anne sütü mevcut değilse veya yetersizse, hangi mama kullanılması gerektiğine karar vermek için bir doktora danışın. Anne sütü, bir bebeğin ilk altı ay boyunca ihtiyaç duyduğu tüm besinleri sağlar, ancak bu dönemden sonra tamamlayıcı gıdalarla desteklenmesi gerekir. Tamamlayıcı beslenmenin amacı, bebekleri farklı besin gruplarıyla tanıştırmak ve çeşitli tatlara alışmalarını sağlamaktır. Ayrıca, çiğneme ve yutma becerilerini geliştirmelerine ve gerekli besinleri almalarına yardımcı olur. Ancak, anne sütü veya mama, bir yaşına kadar beslenmenin ana kaynağı olmaya devam eder; tamamlayıcı besinler sadece destekleyici bir rol oynar. Bir bebeğin sindirim sistemi altı aydan itibaren katı gıdaları tolere etmeye başlar. Ancak, tamamlayıcı gıdaları çok erken veya çok geç tanıtmak obezite, alerji veya besin eksikliği riskini artırabilir. Örneğin, dördüncü aydan önce tamamlayıcı gıdalar tanıtmak alerji riskini artırırken, yedinci aydan sonra tanıtmak besin eksikliğine neden olabilir (Fewtrell ve ark., 2017). Tamamlayıcı gıdaların verilmesi, anne sütünün yerini almak yerine onu tamamlayıcı nitelikte olmalıdır. Anne sütü, bebeklerin ilk bir yıl boyunca temel besin kaynağı olmaya devam etmelidir. Tamamlayıcı gıdalar, bebeklerin enerji ve mikro besin ihtiyaçlarını karşılamak için kademeli olarak verilmelidir. (Beşer, 2018)

Türkiye'deki kültürel farklılıklar da önemli bir faktördür: Bazı aileler geleneksel olarak erken aşamalarda pirinç unu veya tatlı puding gibi yiyecekleri tercih ederler, bu da beslenme dengesizliğine yol açabilir (Demir ve ark., 2022). Gıda alerjileri, tamamlayıcı gıdalara geçişte en önemli risklerden biridir. Yaygın alerjenler arasında inek sütü, yumurta, fıstık, buğday ve balık bulunur. 2024 verilerine göre, bebeklerin yaklaşık %6'sı gıda alerjisi geliştirir (Sicherer & Sampson, 2024). Alerjik reaksiyonlar cilt döküntüleri, kusma, ishal veya anafilaksi şeklinde ortaya çıkabilir. Bu riski en aza indirmek için, potansiyel alerjenler (örneğin fıstık ezmesi) 6 ila 12 aylıkken kademeli olarak verilmelidir (Togias ve ark., 2017). Hemşireler alerji yönetiminde aktif rol oynarlar. Ebeveynler, yeni bir gıda verirken üç ila beş gün beklemelerinin ve çocukta alerji belirtileri olup olmadığını izlemelerinin önemi konusunda bilgilendirilmelidir. Ayrıca, alerjenler yüksek riskli bebeklere (örneğin, ailede alerji öyküsü olan bebekler) daha dikkatli bir şekilde verilmelidir. Hemşireler ebeveynlere alerji testleri konusunda tavsiyelerde bulunabilir ve onları diyetisyenlere yönlendirebilirler. Hemşireler, ebeveyn kaygılarını azaltmak için birebir danışmanlık yapabilir, besin reddi durumunda alternatif yöntemler (örneğin, oyunla beslenme) önerebilir ve alerji izleme konusunda destek sağlayabilir.

BLW (Bebek Liderliğinde Beslenme), bebeklerin katı gıdaları bağımsız olarak keşfetmelerini sağlayan bir yöntemdir. Bebeklere püre yerine buharda pişirilmiş brokoli ve muz dilimleri gibi parmakla yenebilen yiyecekler sunulur ve kendi hızlarında yemek yemelerine izin verilir. Avantajları arasında motor becerilerin gelişmesi, çeşitli yiyeceklere alışma ve obezite riskinin azalması sayılabilir (Brown ve ark., 2017). Ancak, boğulma riski gibi dezavantajları da vardır ve ebeveynler bu yönteme hazırlıklı hissetmeyebilir. Bu nedenle hemşireler, BLW'yi tercih eden ebeveynlere boğulma riskini azaltmak için uygun yiyecek boyutları ve güvenlik önlemleri hakkında bilgi vermelidir. Bazı ebeveynler, püre haline getirilmiş gıdalarla bebek odaklı beslenme (BLW) yöntemini birleştiren karma bir yaklaşımı tercih ederler. Bu yöntem, bebeklerin kendileri beslenmelerini sağlarken, püre haline getirilmiş gıdalardan besin almalarını da garanti eder. 2024 yılında yapılan bir araştırma, karma yöntemlerin ebeveynlerin memnuniyetini artırdığını göstermiştir (Jones ve ark. 2024).

Güncel trendler arasında gıda çeşitliliğinin artması, alerjenlerin kontrollü bir şekilde verilmesi ve organik beslenme yer almaktadır. Örneğin, alerjenlerin erken verilmesi (örneğin, altı aydan itibaren fıstık ezmesi) artık alerji riskini azalttığı için önerilmektedir. Ayrıca, sürdürülebilir beslenme trendlerine paralel olarak, ebeveynler organik ve yerel kaynaklı ürünleri tercih etmeye başlamıştır. Beslenme takip uygulamaları (örneğin, "Baby's First Foods" uygulaması) ve tele-sağlık hizmetleri, katı gıdalara geçiş sürecinde ebeveynlere destek olmaktadır. Hemşireler, tele-sağlık aracılığıyla ebeveynlere danışmanlık yapabilir ve beslenme planlarını izleyebilir. 2025 yılında yapılan bir araştırma, probiyotik takviyelerin bağırsak sağlığını desteklediğini ve katı gıdalara geçiş sürecinde alerji riskini azalttığını ortaya koymuştur (Smith ve ark. 2025).

SONUÇ VE ÖNERİLER

Tamamlayıcı gıdalara geçiş, bebeklerin sağlıklı gelişimi için kritik bir süreçtir ve hemşireler bu süreci kolaylaştırmada önemli bir rol oynar. Bu derleme, bu geçişin temellerini, ilgili zorlukları, alerji yönetimini, çağdaş yaklaşımları ve hemşirelik stratejilerini ele almaktadır. Bebek Öncülüğünde Beslenme (BLW) ve karma yöntemler gibi mevcut yaklaşımlar ebeveynlere esneklik sağlar ve teknolojinin kullanımı bu süreci daha yönetilebilir hale getirmiştir. Ancak, alerji riskleri ve boğulma gibi güvenlik sorunları hemşirelik müdahalelerini gerektirir. Gelecekte katı gıdalara geçiş konusunda daha fazla araştırma yapılması gerekmektedir. Özellikle, alerji önlemede probiyotiklerin ve mikrobiyom odaklı beslenmenin rolü üzerine daha fazla çalışma yapılmalıdır. Ayrıca, Türkiye'deki kültürel farklılıkların tamamlayıcı gıdalara geçiş üzerindeki etkisi daha ayrıntılı olarak incelenmelidir. Hemşirelik açısından, tele-sağlık hizmetlerinin yaygın olarak benimsenmesi ebeveyn eğitimine erişimi iyileştirebilir.

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REJENERATİF SÜSPANSİYON TASARIMI HESAPLARINDA KULLANILACAK ÇEYREK TAŞIT MODELİNİN DEĞİŞKEN DAMPER KATSAYISIYLA MATLAB ÜZERİNDE OLUŞTURULMASI

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ÖZET
Son yıllarda karbon ayak izinde oluşan artış ve fosil yakıtlı araçların karbon ayak izine ve küresel ısınmaya olan etkilerinden dolayı elektrikli araç kullanımı toplu taşıma araçları için de popüler hale gelmektedir. Elektrikli araçların kullanımı ise yeni teknolojilere kapı açmakta, klasik mekanik sistemlerin de elektronik hale gelerek daha verimli ve daha efektif çalışmaları gerekliliğini ortaya çıkarmaktadır. Toplu taşıma araçlarındaki yakıt tüketim miktarları düşünüldüğünde enerji verimliliği daha da önem kazanmaktadır. Toplu taşımada elektrikli araçlara geçilmesi enerji verimliliğini yükseltmek adına enerji geri kazanımı konusunu gündeme getirmektedir. Enerji geri kazanım potansiyeli bulunan sistemlerden biri de süspansiyon sistemidir. Toplu taşıma araçlarının süspansiyon sisteminde kullanılan damper elemanı genellikle açılma ve kapanma yönünde içinde bulunan hidroliğin akışı sınırlayarak sönümleme kuvveti oluşturur. Sönümlenen enerji damperin içindeki hidroliğin ve damperin kendisinin ısınması ve bu ısının ortama atılmasıyla geri kazanım olmaksızın atıl duruma gelmektedir. Standart bir hidrolik damper yerine enerji geri kazanımı yapılabilecek bir elektrik motorlu damper tasarımı buradaki atıl enerjiyinin geri kazanımını mümkün kılmaktadır. Bu araştırmada bir toplu taşıma aracının ön süspansiyonunda bulunan damper elemanının çalışma kuvvetlerini hesaplamak için Matlab üzerinden bir çeyrek taşıt modeli kurulumu yapılmıştır. Damper elemanının kuvvetlerini hesaplarken kuvvet değeleri genelde yapılanın aksine sabit olarak değil damper hızına ve yönüne göre değişkenlik gösterecek şekilde kullanılarak gerçek kullanıma daha uygun bir model oluşturulmuştur.
Anahtar Kelimeler: Elektrikli araçlar, süspansiyon, enerji geri kazanım, sürdürülebilirlik, değişken damper katsayısı

CREATING A QUARTER VEHICLE MODEL WITH VARIABLE DAMPER COEFFICIENT ON MATLAB TO BE USED IN REGENERATIVE SUSPENSION DESIGN CALCULATIONS

ABSTRACT
In recent years, due to the increase in carbon footprint and the effects of fossil fuel vehicles on carbon footprint and global warming, the use of electric vehicles is also becoming popular for public transportation vehicles. The use of electric vehicles give change to use new technologies and reveals the need for classical mechanical systems to become electronic and work more efficiently and effectively. Considering the fuel consumption amounts in public transportation vehicles, energy efficiency becomes even more important. Switching to electric vehicles in public transportation brings up the issue of energy recovery in order to increase energy efficiency. One of the systems with energy harvesting potential is the suspension system. The

damper used in the suspension system of public transportation vehicles generally creates a damping force by limiting the flow of hydraulics in the bump and rebound directions. The damped energy becomes idle without harvesting due to the heating of the hydraulics inside the damper and the damper itself and the release of this heat to the environment. An electric motor damper design that can be used for energy harvesting instead of a standard hydraulic damper makes it possible to harvest the idle energy here. In this research, a quarter vehicle model was installed via Matlab to calculate the working forces of the damper element located in the front suspension of a public transport vehicle. While calculating the forces of the damper element, the force values were not used as constant, contrary to what is usually done, but were used in a way that would vary according to the damper speed and direction, creating a model more suitable for real use.
Keywords: Electric vehicles, suspension, energy harvesting, sustainability, variable damper coefficient

LNG SOĞUTMALI DÜŞÜK SICAKLIKLI KARBODİOKSİT ÇEVRİMİNİN TERMODİNAMİK PERFORMANS ANALİZİ

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ÖZET
Küresel enerji talebinin giderek arttığı günümüzde hem enerji verimliliğini artırmak hem de sera gazı emisyonlarını azaltmak amacıyla atık ısının geri kazanımı ve yenilikçi çevrim teknolojileri büyük önem kazanmıştır. Özellikle fosil yakıt temelli enerji üretim süreçlerinde ortaya çıkan atık ısının etkin bir şekilde değerlendirilmesi, yalnızca atmosfere salınan karbon miktarının azaltılmasına katkı sağlamakla kalmayıp, aynı zamanda uzun vadede sürdürülebilir ve çevre dostu bir enerji dönüşümünün gerçekleşmesinde de temel ve kritik bir rol üstlenmektedir. Bu bağlamda, çevresel etkileri minimum seviyede tutan ve düşük kritik sıcaklık değerine sahip olmasıyla bilinen karbondioksit (CO_2), özellikle düşük sıcaklık aralığında bulunan atık ısı kaynaklarının geri kazanımı ve enerjiye dönüştürülmesinde tercih edilen öncü bir çalışma akışkanı olarak öne çıkmaktadır. Çevrimin analizi Ebsilon®Professional tarafından yapılmaktadır. Bu çalışma, sıvılaştırılmış doğal gazın (LNG) düşük sıcaklıktaki soğuk enerjisinin, karbondioksit (sCO_2) çevriminin yoğuşma basıncını düşürmek amacıyla kullanılmaktadır. LNG ile entegre edilen bu sistem, yalnızca enerji verimini artırmakla kalmayıp aynı zamanda karbon salımını düşürerek çevresel etkilerin azaltılmasına da katkı sağlar. LNG soğutmalı sCO_2 çevrim, 5 ile 30 arasında değişen basınç oranlarında ve 0 ile 150 °C arasında termodinamik performansı değerlendirilmiştir. Sonuç olarak, LNG soğutmalı sistem 2729,81 kW maksimum net güç üretimi sağlamaktadır. Sistemin maksimum enerji ve ekserji verimi ise sırasıyla %27,21 ve %32,63 olduğu belirlenmiştir.
Anahtar Kelimeler: sCO_2, LNG, enerji, ekserji

THERMODYNAMIC EVALUATION OF A LNG-COOLED LOW-GRADE HEAT RECOVERY SUPERCRITICAL CO_2 CYCLE

ABSTRACT
In today's world, where global energy demand is continuously increasing, waste heat recovery and innovative cycle technologies have gained significant importance both to enhance energy efficiency and to reduce greenhouse gas emissions. The effective utilization of waste heat, particularly that which is released during fossil fuel-based energy production processes, plays not only a supporting role in mitigating the emission of carbon dioxide into the atmosphere but also serves as a fundamental and indispensable component in achieving a long-term, sustainable, and environmentally responsible energy transition. In this context, carbon dioxide (CO_2), which is recognized for its environmentally benign characteristics and notably low critical temperature, emerges as a highly favorable and prominent working fluid, especially for the recovery of low-grade waste heat sources into usable energy. The cycle analysis is

conducted using Ebsilon software. In this study, the cryogenic energy of liquefied natural gas (LNG) is employed to reduce the condensation pressure of a supercritical carbon dioxide (sCO_2) cycle. The integration of LNG into the system not only improves energy efficiency but also helps mitigate environmental impacts by lowering carbon emissions. The thermodynamic performance of the LNG-cooled sCO_2 cycle has been evaluated across pressure ratios ranging from 5 to 30 and temperatures between 0 and 150 °C. As a result, the LNG-cooled system achieves a maximum net power output of 2729.81 kW. The system's maximum energy and exergy efficiencies are determined to be 27.21% and 32.63%, respectively.
Keywords: sCO_2, LNG, energy, exergy

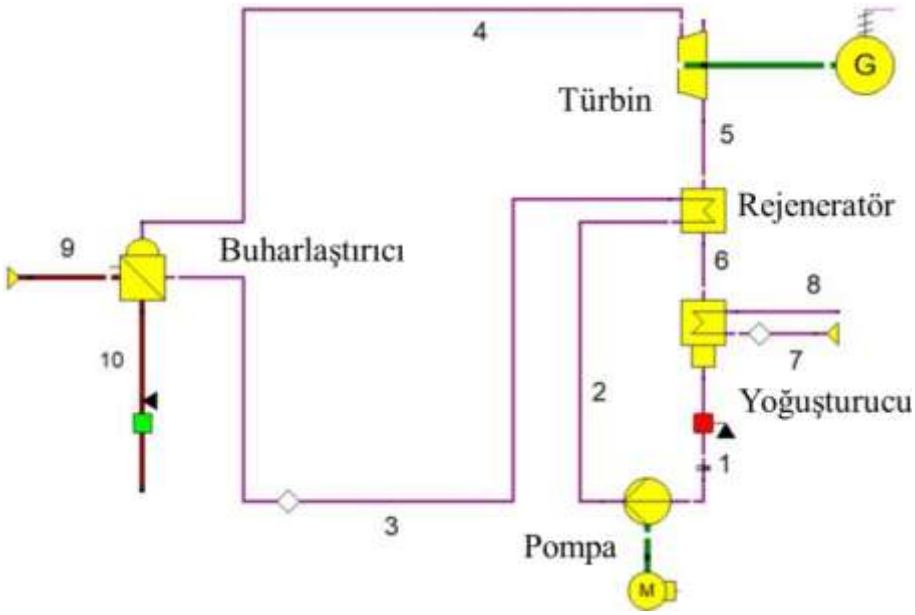
GİRİŞ

Sürdürülebilirlik, verimlilik ve çevre uyumluluğu açısından enerji üretim teknolojilerinin iyileştirilmesi dünya çapında giderek daha önemli hale gelmiştir. Özellikle, endüstriyel proseslerden düşük sıcaklıktaki atık ısının geri kazanılması, enerji sistemlerinin performansını optimize etmekle kalmaz, aynı zamanda karbon emisyonlarının azaltılmasına da katkıda bulunur. Bu bağlamdaki temel çevrim teknolojileri arasında, son yıllarda hem süperkritik (sCO_2) hem de transkritik (tCO_2) konfigürasyonlarında yoğun bir şekilde araştırılan karbondioksit (CO_2) çevrimleri yer almaktadır. Sıvılaştırılmış doğal gaz (LNG), soğutucu olarak kullanıldığında yüksek sıcaklık gradyanları ve düşük çevresel etki gibi avantajlar sunarak CO_2 çevrimlerini daha da çekici hale getirir. LNG'nin yoğuşma ortamı olarak kullanılması, çevrimin verimliliğini artırır ve özellikle küçük modüler reaktörler gibi farklı ısı kaynaklarıyla entegre edildiğinde oldukça ciddi bir avantaj sağlar. Bu çalışmada, LNG ile soğutulan düşük sıcaklıktaki bir CO_2 çevriminin termodinamik performansı analiz edilmiştir. Bu çerçevede, enerji dönüşüm sistemlerinin çoklu kaynaklardan beslenmesini sağlayan bazı çalışmalar aşağıda verilmektedir. Wolf ve ark. (2022) yapılan çalışmada, düşük sıcaklıklı atık ısı kaynaklarının geri kazanımı için farklı transkritik karbondioksit (CO_2) çevrim konfigürasyonlarının termodinamik performansını karşılaştırmalı olarak incelemektedir. Çalışmada, 60–100 °C aralığında atık ısı kaynağı ve 20 °C ısı alıcısı koşullarında on farklı çevrim mimarisi değerlendirilmiştir. Liu ve ark. (2020) tarafından yapılan çalışmada, ağır hizmet tipi dizel motorlardan çıkan egzoz ve motor soğutma suyu atık ısısını geri kazanmak amacıyla, farklı oranlarda CO_2/R134a karışımlarının kullanıldığı deneysel bir transkritik Rankine çevrimi (TRC) çalışmasını sunmaktadır. Dört farklı karışım oranı (CO_2/R134a: 0,85/0,15, 0,7/0,3, 0,6/0,4 ve 0,4/0,6) kullanılarak sistem performansı değerlendirilmiştir. Deneysel sonuçlar, R134a oranı arttıkça sistemin genleşme basınç oranının yükseldiğini, ancak ısı emilim miktarının özellikle rejeneratörde azaldığını göstermektedir. Shi ve ark. (2020) tarafından yapılan çalışmada, motor egzoz gazlarından atık ısı geri kazanımı amacıyla çok modlu çalışan, CO_2 bazlı birleşik soğutma ve güç çevrimi (MM-CRPC) önermektedir. Bu çalışmaya göre ekserji analizleri, en büyük kayıpların türbin ve ısı değiştiricilerde olduğunu ortaya koymaktadır. Yazarların önerdikleri MM-CRPC sistemi, özellikle taşımacılıkta değişken enerji ihtiyaçlarını karşılamak için esnek, verimli ve çevreci bir çözüm sunmakta olduğu söylenmiştir. Cao ve ark. (2017) tarafından yapılan çalışmada, bir gaz türbini ile süperkritik CO_2 Brayton çevrimi ve transkritik CO_2 çevriminden oluşan kademeli bir birleşik çevrim sisteminin termodinamik analizi ve optimizasyonu sunulmaktadır. Çalışmada, sistemin performans değerlendirmesi için yeni bir çözüm yöntemi önerilmekte ve genetik algoritma kullanılarak parametre optimizasyonu gerçekleştirilmektedir. Simülasyon sonuçları, önerilen GT-kademeli CO_2 birleşik çevriminin geleneksel buhar çevrimlerine kıyasla %17'den fazla verim artışı sağlayabildiğini göstermektedir. Çevrimde kullanılan süperkritik CO_2'nin yüksek sıcaklıklı atık ısıyı, transkritik CO_2'nin ise düşük sıcaklıklı ısıyı geri kazanma potansiyeline sahip olduğu vurgulanmaktadır. Çalışmada, ortam sıcaklığının sistem performansı üzerindeki etkisi de incelenmekte ve önerilen çevrimin bu etkiyi dengeleyebildiği ifade edilmektedir. GT-

kademeli CO_2 birleşik çevriminin, gaz türbini atık ısısının geri kazanımı için yüksek verimli ve uygulanabilir bir çözüm sunduğu ortaya konmaktadır. Hou ve ark. (2017) tarafından yapılan çalışmada, denizcilik uygulamalarında gaz türbini atık ısısının geri kazanımı amacıyla önerilen süperkritik CO_2 rekompresyon ve regeneratif çevrimlerinin entegre edildiği bir birleşik çevrimin termodinamik ve ekonomik performansını analiz etmektedir. Çalışmada, çıkış gücü, ekserji verimi, birim güç başına ısı değiştirici alanı ve seviyelendirilmiş enerji maliyeti gibi performans göstergeleri çok amaçlı genetik algoritma ile optimize edilmektedir. Önerilen çevrimin geleneksel süperkritik CO_2 rekompresyon ve regeneratif çevrimlerine kıyasla daha yüksek güç çıktısı, daha düşük APR ve LEC değerleriyle kompaktlık ve ekonomik üstünlük sağladığını göstermekte olduğu ifade edilmiştir.

SİSTEM TANITIMI

Bu çalışmada düşük sıcaklıklı endüstriyel atık ısıyı değerlendirebilmek için LNG soğutmalı süperkritik sCO_2 çevriminin termodinamik performansı analiz edilmektedir. sCO_2 sistemi, dört ana elemandan oluşmaktadır. Bunlar türbin, yoğuşturucu, pompa ve buharlaştırıcıdır. Ancak bu sisteme, verimliliği arttırmak için rejeneratör de eklenmiştir. Sistem tasarımı ve nümerik analizi Ebsilon®Professional tarafından yapılmaktadır. LNG soğutmalı sCO_2 çevrimi aşağıda verilmektedir.



Şekil 1. LNG soğutmalı sCO_2 çevrimi

Şekil 1 de ifade edilen bu sistem, 160 °C atık ısıya sahip bir endüstriyel bir atık ısıyı daha etkin kullanabilmek için, sıvılaştırılmış doğal gazın (LNG) regazifikasyonu sırasında ortaya çıkan düşük sıcaklıklı soğuk enerji kazanımını hedefleyen süperkritik karbondioksit (sCO_2) çevrimi ile entegre edilmiş bir enerji dönüşüm sistemidir. LNG, yaklaşık −120 °C (7) sıcaklıkta sisteme girmektedir. Pompa (1-2) yardımıyla arzu edilen basınca çıkarıldıktan sonra evaporatörden geçen akışkan (3-4) türbine (4) girmektedir. Türbinde akışkan genişleyerek (4-5) basıncı düşmektedir. Bu esnadan mekanik iş üretilmektedir. Ardından akışkan rejeneratöre (5) gönderilmektedir. Akışkanın fazla ısısı kullanıldıktan sonra (5-6) kondenserde LNG'nin soğuk enerjisi kullanılmakta (6-1) ve oldukça düşük yoğuşma basınçlarına inilmektedir.

MATEMATİKSEL MODEL

Kütle dengesi denklemi:

$$\sum \dot{m}_{giriş} = \sum \dot{m}_{çıkış} \quad (1)$$

Enerji dengesi denklemi (Demiryürek ve ark., 2024):

$$\dot{Q} + \dot{W} = \sum \dot{m}_{çıkış} h_{çıkış} - \sum \dot{m}_{giriş} h_{giriş} \quad (2)$$

Bu denklemde $\dot{Q}$ ve $\dot{W}$ sırasıyla ısı ve güç üretimini temsil etmektedir. Bu hesaplamalarda kullanılan ekserji dengesi denklemi aşağıdaki gibidir (Akçalı ve ark., 2024):

$$\dot{E}_{giriş} = \dot{E}_{çıkış} + \dot{E}_{yıkım} \quad (3)$$

Ekserji akışı $\dot{E}$ ile gösterilir ve "giriş", "çıkış" ve "yıkım" alt simgeleri sırasıyla ekserji girişi, ekserji çıkışı ve ekserji yıkımını ifade eder. Ekserji akışı aşağıdaki gibi hesaplanır:

$$\dot{E} = \dot{m}\psi \quad (4)$$

Özgül ekserji için sembol ψ' dir ve aşağıdaki ifade kullanılarak tespit edilebilir:

$$\psi = (h - h_0) - T_0(s - s_0) \quad (5)$$

Ekserji, kullanılabilir işi temsil eder. Bu nedenle, işin ekserjisi %100 olduğu varsayılır. Ancak, ısı için ekserji %100'den azdır. Isı ile ilgili ekserji hesabı aşağıdaki gibidir (Koç ve ark., 2019):

$$\dot{E} = \left(1 - \frac{T_0}{T_{sur}}\right) \dot{Q} \quad (6)$$

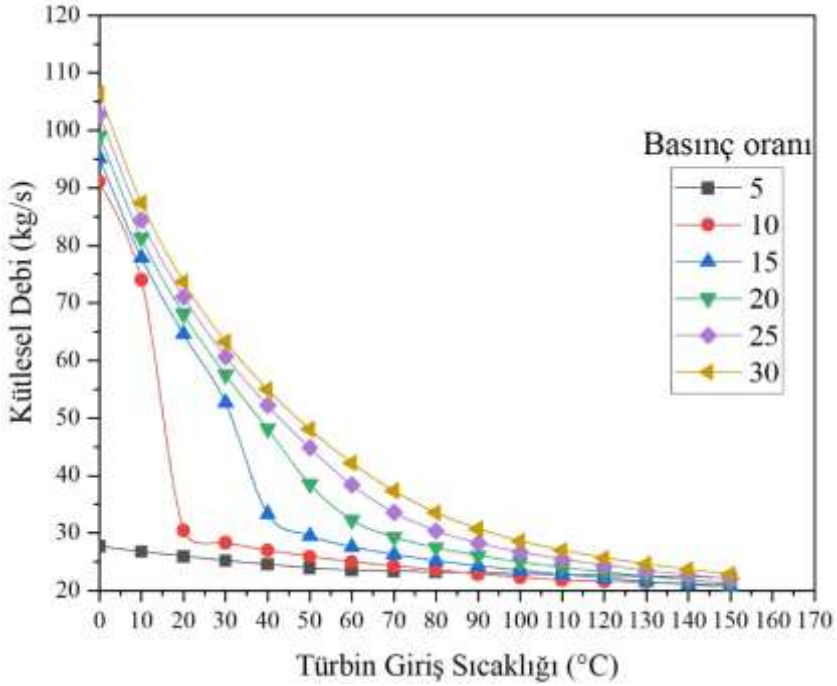
Bu bağlamda, T_0 ortam sıcaklığını ifade ederken, $T_{yüzey}$ ısı transfer yüzey sıcaklığıdır. Hesaplama yapılırken, bir elemanın giriş ve çıkış sıcaklıklarının ortalama değeri ısı transfer yüzeyinin sıcaklığı olarak kabul edilir. T_0'ın 20°C olarak ayarlanmış ortalama ortam sıcaklığını yansıttığı varsayılır. NG soğutmalı sCO_2 sisteminin termal ve ekserji verimleri aşağıdaki formülizasyonlar kullanılarak belirlenmiştir:

$$\eta_{sCO2} = \frac{\dot{W}_{net;sCO2}}{\dot{Q}_{giriş;sCO2}} \quad (7)$$

$$\varepsilon_{sCO2} = \frac{\dot{W}_{net;sCO2}}{\dot{E}_{giriş;sCO2}} \quad (8)$$

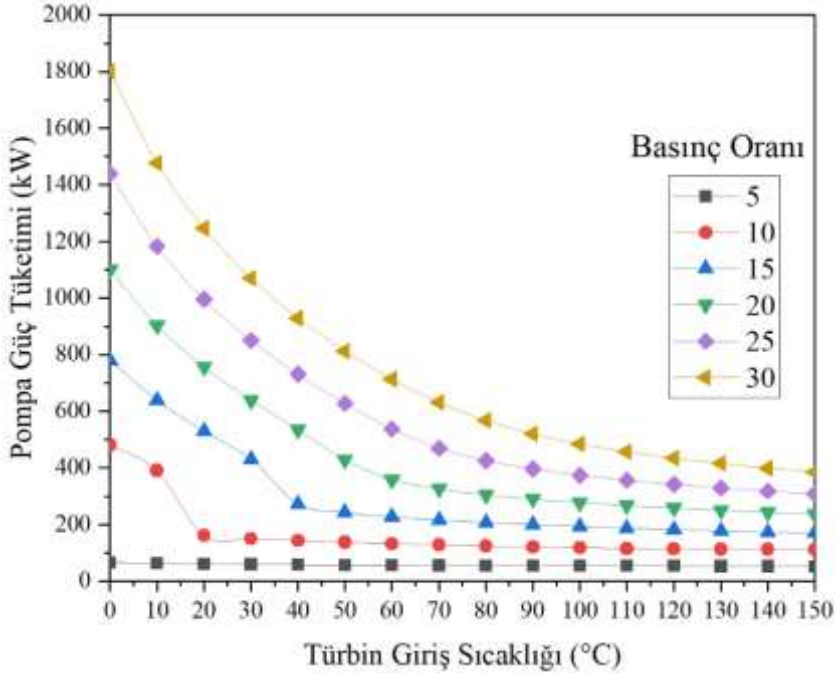
ARAŞTIRMA BULGULARI VE TARTIŞMA

Bu bölümde önerilen sistemin termodinamik performans çıktıları incelenmektedir. Öncelikle, düşük endüstriyel atık ısı sabit sıcaklıkta sisteme verilmektedir. LNG -120°C'de yoğuşturucuya girmektedir. Bu değerler ışığında, sistemin basınç oranı 5-30 arasında değişmekte iken , türbin giriş sıcaklığı 0-150°C arasında belli oranda arttırılarak sistem performans çıktıları alınmaktadır. Nihayetinde, sistemin kütlesel debisi, pompa güç tüketimi, kuruluk derecesi, net güç, enerji ve ekserji analizleri yapılmaktadır. Türbin giriş sıcaklığı ve basınç oranına göre CO_2 kütlesel debi değişimi Şekil 2'de gösterilmektedir.



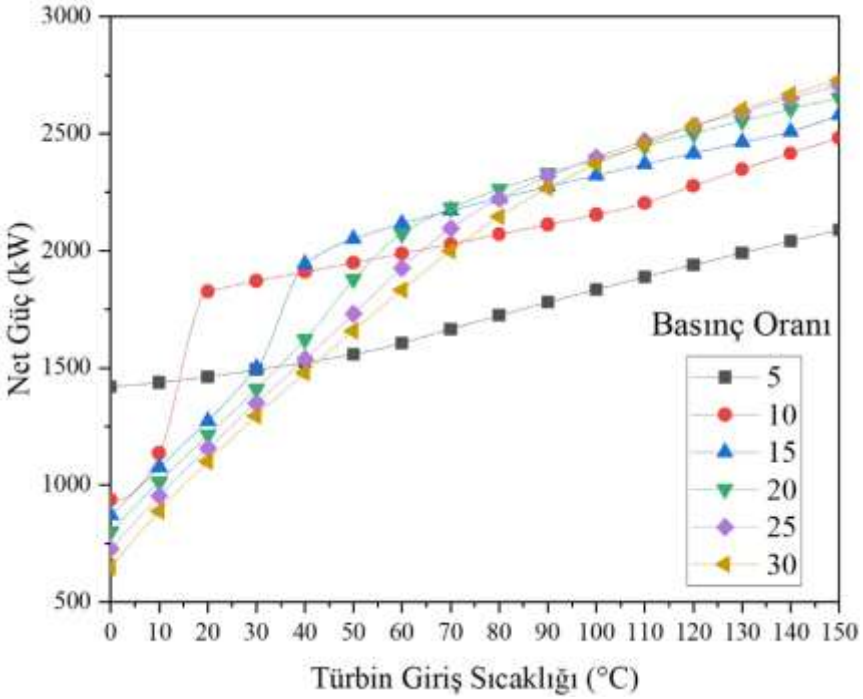
Şekil 2. Türbin giriş sıcaklığı ve basınç oranına göre CO_2 kütlesel debi değişimi

Şekil 2'de farklı basınç oranlarında türbin giriş sıcaklığına ve basınç oranına bağlı olarak sistemin kütlesel debisinin nasıl değiştiğini göstermektedir. Genel olarak, türbin giriş sıcaklığı arttıkça kütlesel debi azalmaktadır. Bu düşüş eğilimi düşük basınç oranlarında (10-20 bar arası) ve düşük sıcaklıklarda (10-20°C arası) oldukça keskin iken yüksek basınç oranlarında (30 bar) daha uyumlu bir şekilde azalmaktadır. En yüksek debi, en düşük sıcaklık ve en yüksek basınç oranında 106,47 kg/s olarak bulunurken, en düşük debi ise en yüksek sıcaklıkta ancak 15 basınç oranında 20,68 kg/s olarak hesaplanmaktadır. Dikkat çekici bir durum, düşük basınç oranlarındaki sıcaklıktaki küçük bir artışın debide ciddi bir düşüşe neden olmasıdır. Bu durum, düşük basınçlı sistemlerin düşük sıcaklıklarda çalıştırılmasının daha avantajlı olduğunu göstermektedir. Türbin giriş sıcaklığı ve basınç oranına göre LNG soğutmalı sCO_2 sisteminin pompa güç tüketimi Şekil 3'te verilmektedir.



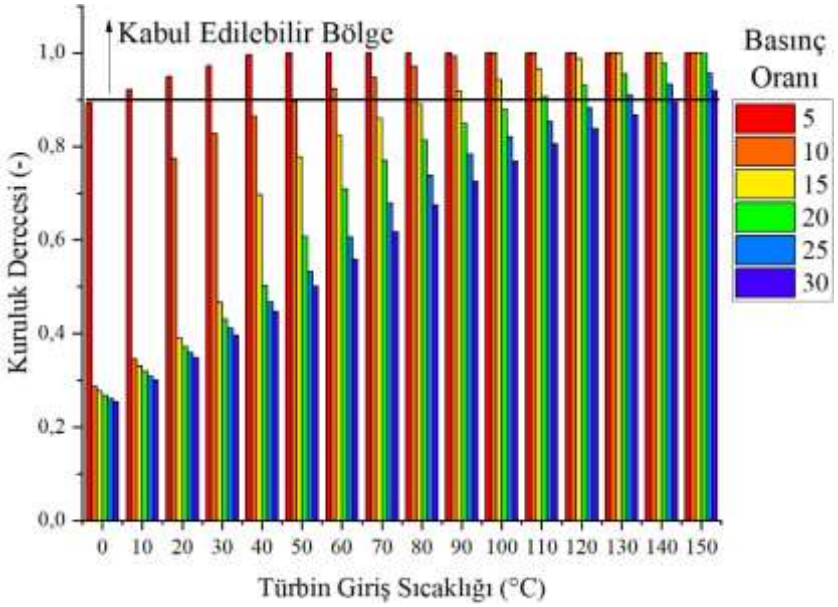
Şekil 3. Türbin giriş sıcaklığı ve basınç oranına göre LNG soğutmalı sCO_2 sisteminin pompa güç tüketimi

Şekil 3, pompa tarafından tüketilen gücün, türbin giriş sıcaklığına ve basınç oranına göre değişimini göstermektedir. Türbin giriş sıcaklığı arttıkça pompa güç tüketimi tüm basınç oranlarında azalma eğilimindedir. Bu azalma, sıcaklıkla birlikte akışkan yoğunluğunun azalmasından ve buna bağlı olarak pompa yükünün düşmesinden kaynaklanmaktadır. En fazla güç tüketimi, düşük sıcaklık (0 °C) ve yüksek basınç oranı (30 bar) durumunda 1800,57 kW olduğu gözlemlenmiştir. En düşük tüketim ise yüksek sıcaklık (150 °C) ve düşük basınç oranında (5) 52,13 kW olarak belirlenmiştir. Bu grafik, yüksek basınç oranı kullanımının sistemde yüksek enerji tüketimine neden olduğunu açıkça göstermektedir. Bu nedenle, sistem verimliliği açısından sadece çıkış gücüne değil, girişteki enerji maliyetlerine de dikkat edilmesi gerektiği ortaya çıkmaktadır. Pompa seçimi ve çalıştırma koşulları, sistemin genel enerji performansı üzerinde belirleyici rol oynamaktadır. Türbin giriş sıcaklığı ve basınç oranına göre LNG soğutmalı sCO_2 sisteminin net güç üretimi Şekil 4'te gösterilmektedir.



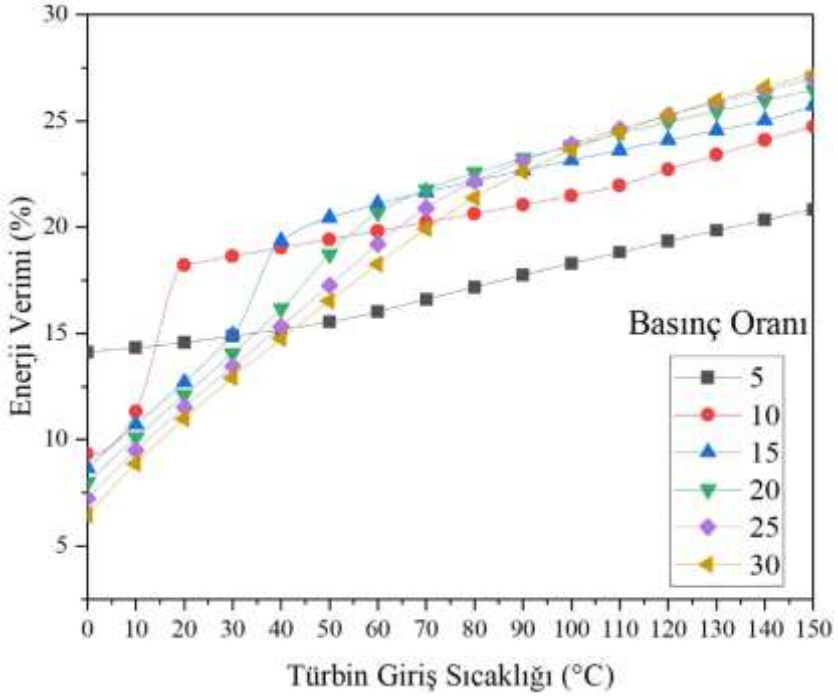
Şekil 4. Türbin giriş sıcaklığı ve basınç oranına göre LNG soğutmalı sCO_2 sisteminin net güç üretimi

Şekil 4, net güç üretiminin türbin giriş sıcaklığına ve basınç oranına bağlı olarak nasıl değiştiğini analiz etmektedir. Genel eğilim, sıcaklık arttıkça net gücün artması yönündedir. Özellikle düşük sıcaklıklarda net güçteki artış daha belirgindir; sıcaklık arttıkça bu artış daha yatay hafif bir artış eğilimi göstermektedir. Maksimum net güç, yüksek türbin giriş sıcaklığı (150 °C) ve yüksek basınç oranında (30) 2729,82 kW olarak elde edilirken, minimum net güç en düşük sıcaklık ve en düşük basınç oranında 648,57 kW olarak bulunmaktadır. İlginç şekilde, basınç oranı 10 olan sistem, düşük sıcaklık aralığında (10–30 °C) kendinden yüksek basınç oranlarından daha yüksek net güç sağlamaktadır. Bu durum, belirli sıcaklık aralıklarında optimum basınç oranının daha yüksek verim sağlayabileceğini göstermektedir. Dolayısıyla, sadece daha yüksek basınç daha yüksek net güç anlamına gelmemekte, sistemin tüm çalışma aralığı dikkate alınarak bir çıkarım yapılması gerekmektedir. Türbin giriş sıcaklığı ve basınç oranına göre LNG soğutmalı sCO_2 sisteminin türbin çıkışında kuruluk derecesi değişimi Şekil 5'te belirtilmektedir.



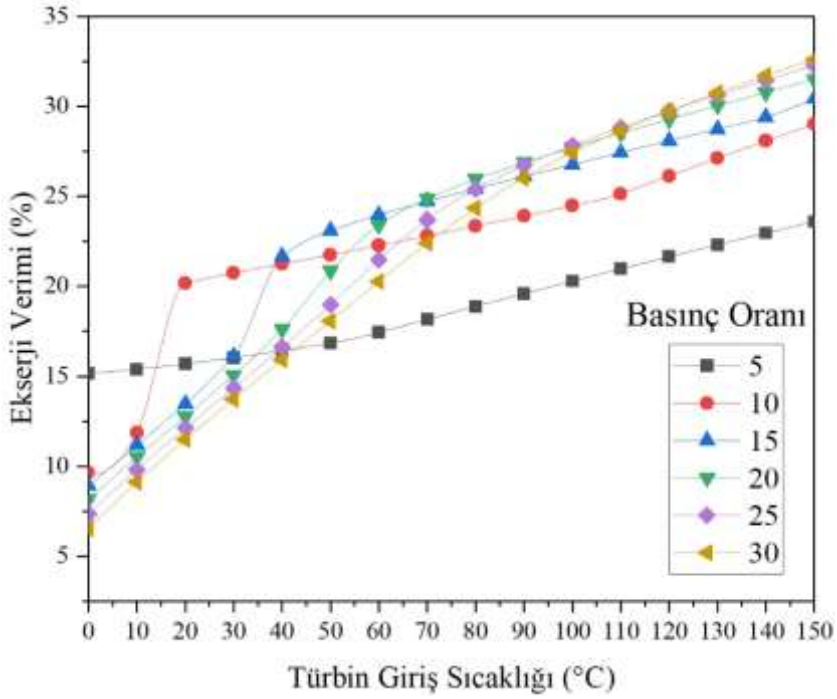
Şekil 5. Türbin giriş sıcaklığı ve basınç oranına göre LNG soğutmalı sCO_2 sisteminin türbin çıkışında kuruluk derecesi değişimi

Farklı basınç oranlarında türbin çıkışındaki buharın kuruluk derecesinin, türbin giriş sıcaklığına bağlı olarak nasıl değiştiği Şekil 5'te göstermektedir. Bilindiği üzere türbin çıkışında kuruluk derecesi 0,9'un altında arzu edilmemektedir. Çünkü, türbin kanatlarında yıpranmalar meydana geleceği gelmektedir. Bu yüzden sistem, kuruluk derecesi kabul edilebilir bölgenin içerisinde çalıştırılmalıdır. Grafik incelendiğinde, düşük giriş sıcaklıklarında (0–50 °C arası) 5 basınç oranı hariç tüm basınç oranları için kuruluk derecesi 0,9'un altındadır. Ancak sıcaklık arttıkça kuruluk derecesi de artmakta ve 50 °C'den sonra diğer basınç oranları da kullanılabilir bölgeye geçmekte, ve maksimum sıcaklıkta (150 °C) tüm basınç oranları kullanılabilir bölgede bulunmaktadır. Basınç oranı arttıkça kuruluk derecesi aynı sıcaklıkta daha düşük kalmaktadır. Türbin giriş sıcaklığı ve basınç oranına göre LNG soğutmalı sCO_2 sisteminin enerji verim değişimi Şekil 6'da verilmektedir.



Şekil 6. Türbin giriş sıcaklığı ve basınç oranına göre LNG soğutmalı sCO_2 sisteminin enerji verim değişimi

Şekil 6, farklı basınç oranlarında enerji veriminin türbin giriş sıcaklığına göre değişimini göstermektedir. Genel olarak, türbin giriş sıcaklığı arttıkça enerji verimi artmaktadır. Basınç oranı düşük olan sistemlerde (örneğin oran 5), enerji verim artışı sınırlıdır ve eğri daha düz ilerlemektedir. Buna karşılık, basınç oranı arttıkça (örneğin oran 30), sıcaklığa bağlı enerji verim artışı daha belirgin hale gelmekte ve 150 °C sıcaklıkta %27,21 seviyesine ulaşmaktadır. Düşük sıcaklıklarda (10–30 °C), basınç oranı 10 için enerji verim kendinden yüksek basınç oranlarına göre daha yüksek iken, bu durum 40 °C'den sonra değişmekte ve yüksek basınç oranları daha yüksek verim sağlamaktadır. Maksimum enerji verimi basınç oranı 30 ve 150 °C sıcaklıkta gözlenmektedir. Minimum enerji verimi ise 0 °C sıcaklık ve basınç oranı 5 koşulunda yaklaşık %6,47'dir. Önemli bir gözlem, düşük sıcaklıklarda orta düzeyde basınç oranının (özellikle 10) daha avantajlı sonuçlar vermesidir. Bu da sistemin başlangıç koşullarında düşük basınçla daha verimli çalışabileceğini, ancak yüksek sıcaklıklarda yüksek basınç oranlarının tercih edilmesi gerektiğini ortaya koymaktadır. Türbin giriş sıcaklığı ve basınç oranına göre LNG soğutmalı sCO_2 sisteminin ekserji verim değişimi Şekil 7'de gösterilmektedir.



Şekil 7. Türbin giriş sıcaklığı ve basınç oranına göre LNG soğutmalı sCO_2 sisteminin ekserji verim değişimi

Bu grafik, enerji verimine benzer şekilde, türbin giriş sıcaklığının ekserji verimine olan etkisini farklı basınç oranlarında ortaya koymaktadır. Sıcaklık arttıkça ekserji veriminde belirgin bir artış gözlemlenmektedir. 10–30 °C arası düşük sıcaklıklarda basınç oranı 10 diğerlerinden daha yüksek ekserji verimi sağlamaktadır. Ancak sıcaklık 40-50 °C arası 15 basınç oranı 70-80 °C arası 20, 120 °C'den sonra 30 basınç oranı olan sistemlerin ekserji verimliliği öne geçmektedir. Maksimum ekserji verimi basınç oranı 30'da ve 150 °C sıcaklıkta %32,63 civarında gerçekleşmektedir. Minimum ekserji verim ise basınç oranı 5 ve 0 °C'de yaklaşık %6,53'tur. Enerji verimiyle paralel olarak ekserji veriminde de düşük sıcaklıklarda orta basınçlı sistemlerin avantajı varken, sıcaklık arttıkça yüksek basınç oranları daha verimli hale gelmektedir. Ekserji açısından sistemin ortam koşullarıyla olan etkileşimi dikkate alındığında, ortam sıcaklığına bağlı olarak verim değerlerinin farklılık göstermesi beklenen bir sonuçtur ve bu grafik bunu açıkça göstermektedir. Ayrıca enerji verimi ile ekserji verimi arasındaki benzer trend, sistemin genel performans kriterlerinde uyumlu bir gelişim sergilediğini göstermektedir.

SONUÇLAR

- Kuruluk derecesi açısından güvenli işletim için türbin giriş sıcaklığı en az 10 °C olmalıdır. Bu sıcaklığın altındaki değerlerde, güveli bölgede çalışmamaktadır. 150 °C'de tüm basınç oranlarında, buharın kuruluk derecesi kabul edilebilir sınır olan 0,9'un üzerinde kalmakta ve türbin kanatlarının zarar görme riski ortadan kalkmaktadır.
- LNG soğutmalı sCO_2 sistemiyle maksimum 2729,82 kW net güç üretimi gerçekleştirilmiştir.
- Enerji ve ekserji verimleri türbin giriş sıcaklığı arttıkça belirgin şekilde artmakta, özellikle 30 basınç oranlarınında ve 150 °C'de maksimum değerlere ulaşmaktadır. Bu da sistemin yüksek sıcaklık ve yüksek basınç koşullarında daha verimli çalıştığını göstermektedir. Maksimum enerji ve ekserji verimleri sırasıyla %27,21 ve %32,63 olarak bulunmuştur.
- Düşük sıcaklıklarda (10–30 °C), orta düzey basınç oranı (özellikle 10) hem enerji hem de ekserji verimi açısından avantaj sağlamaktadır.

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BIOPRINTING IN THE PHARMACEUTICAL INDUSTRY

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abstract:
Bioprinting, a revolutionary advancement in the field of biotechnology, involves the layer-by-layer printing of living cells and biomaterials to create tissue-like structures. In the pharmaceutical industry, bioprinting holds immense potential for transforming drug development and personalized medicine. It enables the creation of 3D tissue models that closely mimic human physiology, providing a more accurate and ethical alternative to traditional animal testing. These tissue models can be used to test drug efficacy and toxicity in a controlled environment, significantly reducing the time and cost of clinical trials.One major application is the development of organ-on-a-chip systems, which simulate the functions of human organs and allow for the observation of drug interactions in real time. This approach enhances predictability in drug responses, thus improving the safety profile of new therapeutic compounds. Additionally, bioprinting supports the creation of patient-specific tissue models, paving the way for personalized medicine by tailoring drug regimens according to individual biological responses.Bioprinting also contributes to regenerative medicine by producing implantable tissues and potentially whole organs in the future, addressing the shortage of organ donors. As the technology evolves, its integration into the pharmaceutical industry is expected to accelerate, enabling more efficient drug discovery, reducing the reliance on animal testing, and improving patient outcomes.
Keywords: Bioprinting, pharmaceutical industry, 3D tissue models, drug testing, organ-on-a-chip, personalized medicine, regenerative medicine, drug efficacy, toxicity screening, clinical trials.

BIOAVAILABILITY AND BIOEQUIVALENCE STUDIES

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ABSTRACT:
Bioavailability and bioequivalence (BA/BE) studies are essential components in the development and approval of pharmaceutical formulations, particularly generic drugs. **Bioavailability** refers to the rate and extent to which an active pharmaceutical ingredient (API) is absorbed from a drug product and becomes available at the site of action. **Bioequivalence**, on the other hand, assesses whether two drug products—typically a brand-name and its generic—show comparable bioavailability under similar conditions. These studies ensure therapeutic consistency, safety, and efficacy of generic formulations, allowing regulatory bodies to approve alternative products without the need for extensive clinical trials. BA/BE studies commonly involve pharmacokinetic parameters such as Cmax (peak plasma concentration), Tmax (time to reach Cmax), and AUC (area under the curve). Regulatory agencies like the USFDA, EMA, and CDSCO have established stringent guidelines for conducting and evaluating such studies. Advances in analytical technologies, including high-performance liquid chromatography (HPLC) and mass spectrometry, have enhanced the accuracy and reliability of BA/BE data. Additionally, novel approaches like in vitro–in vivo correlation (IVIVC) and population bioequivalence are gaining prominence. While BA/BE studies are pivotal for cost-effective healthcare through generics, challenges such as variability in metabolism, food effects, and ethical considerations in human studies remain. Addressing these through improved study designs and modeling techniques will further strengthen the role of BA/BE studies in drug development.
Keywords: Bioavailability, bioequivalence, generic drugs, pharmacokinetics, regulatory guidelines

GƏMİ DİZEL MÜHƏRRİKLƏRİ ÜÇÜN BİODAVAMLI MOTOR YAĞI

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Özət

Bizi əhatə edən müxtəlif inkişaf sahələrində istifadə olunan texnikanın bioloji təsirlərlə qocalması, temperatur və iqlim şəraitindən asılı olaraq xoşagəlməyən proseslərə məruz qalması onların qorunmasını tələb edir. Ona görə də, bu texnikalarda isifadə olunan müxtəlif növ sürtkü yağlarının bioparçalanma prosesindən qorunması hazırda aktual problemdir.

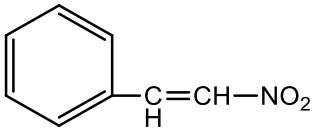
Yağlar və sürtkülərin biozədələnməyə qarşı aparılan tədqiqatları haqqında ədəbiyyatda məlumatlar olduqca azdır. Sürtkü materiallarında mikroorqanızmlər üçün yeganə mənimsəmə mənbəyi karbondur. Onların inkişafı sürtkü materiallarının tərkibində olan suda həll olub emulsiya şəklində olmasından asılıdır.

Sürtkü yağlarının qocalmasının səbəblərindən biri onların mikribioloji zədələnməsidir. Bu proses neft sənayesində neft məhsullarının emalı və istismarı sahəsində yaratdığı problemlərdən biridir. Mikroorqanizmlərin fəaliyyəti neft məhsullarının parçalanmasına, müəyyən müddətdən sonra metalların korroziyasına və metal konstruksiyalarının sıradan çıxmasına səbəb olur.

Müxtəliftəbiətli mikrob və göbələklərin təsiri motor yağlarının baza yağlarını qida mənbəyi kimi qəbul edərək, onları bioparçalanma prosesinə məruz qoyur. Qeyd etmək lazımdır ki, karbohidrogen tərkibi ilə fərqlənən baza yağlarındaki karbohidrogenlər: parafin, naften, aromatik, doymuş və doymamış müxtəlif alifatik zəncirli birləşmələrin bioparçalanma prosesi havanın oksigeni vasitəsi ilə parçalanma prosesindən çox fərqlidir.

İlk dəfə tərəfimizdən bioloji təsirlərin sürtkü yağlarına vurduqları ziyan bir neçə istiqamətdə tədqiq edilmişdir. Birinci növbədə sürtkü yağları, ikinci növbədə onların tərkibində olan

müxtəliftəyinatlı aşqarların hər birini ayrıca və iki, üç sistemli komponent şəklində biodestruksiya xassələrinə təsiri tədqiq edilmişdir.
Müəyyən edilmişdir ki, bütün hallarda aşqarların funksional təsirdən asılı olmayaraq, onların biosid xassəsi yox dərəcəsində olduğundan, bakteriya və göbələklərin tam inkişafı gedir.
Sürtkü yağlarının istifadəsi, tətbiqi kvalifikasiya sınaqlarının aparılması ilə oksidləşmə, korroziya, yeyilmə, yuyuculuq və bir sıra keyfiyyət göstəricilərini müəyyənləşdirmək məqsədilə kompozisiyaya daxil edilən aşqarların biozədələməyə qarşı davamlılıqları α-fenil-β-nitroeten biosidi ilə öyrənilmişdir:



α-fenil-β-nitroeten

Aparılan tədqiqatların müsbət nəticəsi "nitroeten"lər və onların bir sıra törəmələrinin sürtkü yağlarına və aşqarlara tətbiqi, bakteriya və göbələklərin kifayət dərəcədə məhvi ilə tamamlanmışdır.

Cədvəldə gəmi və stasionar dizel mühərrikləri üçün yaradılmış M-12ВБ markalı sürtkü kompozisiyasının mikrobioloji sınaqlarının nəticəsi verilmişdir.

Cədvəl

Kompozisiya	Biosidsiz		α-fenil-β-nitroeten biosid 0,25%, sm	
	bakteriya	göbələk	bakteriya	göbələk
Baza yağı M-10 8,0% ИХП-101 1,5% ИХП-301 1,2% ДФ-11 0,6% Viscoplex 2-670 0,5 % Viscoplex 5-309 0,25 % α-fenil-β-nitroeten 0,003% ПМС -200А	+*	+*	1,7-1,9	2,5-2,7

* (+) mikroorqanizmlərin tam inkişafı

İstər müasir üsulla emal edilən yüksək keyfiyyətli baza yağları, istərsə də aşağı qatılıqda API üzrə istehsal edilən müxtəlif qrup sürtkü yağlarının biodavamlılıq xassələri α-fenil-β-nitroeten biosidi ilə aparılan tədqiqatlar zamanı müşahidə olunmuşdur.
Dövrü ədəbiyyatda biosid xassəli çoxsaylı biosid birləşmələrin yağlarda həll olan nümunələri haqqında məlumat olduqca azdır. Odur ki, tədqiqatlarda mikroorqanizmlərə qarşı davamlılıq xassələrinin təyinində biosid kimi ədəbiyyatda məlum olan və yağlarda həll ola bilən α-fenil-β-nitroeten və onun halogenli törəmələrindən istifadə edilmişdir.

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BIOSUSTAINABLE ENGINE OIL FOR MARINE DIESEL ENGINES

Abstract

The aging of various areas of development in all natural, synthetic, living and inanimate worlds surrounding us, due to biological effects, and exposure to unpleasant processes depending on temperature and climate conditions, requires their protection.

The aging of the equipment used in various development areas surrounding us due to biological effects, exposure to unpleasant processes depending on temperature and climatic conditions requires their protection. Therefore, the protection of various types of lubricants used in these equipment from the biodegradation process is currently an urgent problem.

There is very little information in the literature on the research conducted on the biodegradation of oils and lubricants. The only source of absorption for microorganisms in lubricants is carbon. Their development depends on the fact that they are dissolved in the water contained in the lubricants and are in the form of an emulsion.

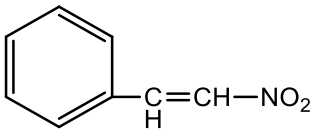
One of the reasons for the aging of lubricants is their microbiological damage. This process is one of the problems created in the oil industry, processing of petroleum products, and exploitation of petroleum products. The activity of microorganisms causes the decomposition of petroleum products, corrosion of metals after a certain period of time and failure of metal structures.

The action of microbes and fungi of various natures perceives the base oils of motor oils as a food source and subjects them to the process of biodegradation. It should be noted that the biodegradation process of hydrocarbons in base oils, which differ in their hydrocarbon composition: paraffin, naphthene, aromatic, saturated and unsaturated, various aliphatic chain compounds, is very different from the process of decomposition by oxygen in the air.

For the first time, we have studied the damage caused by biological effects to lubricants in several directions. First of all, the effect of lubricants, and secondly, the effect of various additives contained in them on the biodestruction properties of each of them separately and in the form of two or three system components was studied.

It was determined that in all cases, regardless of the functional effect of the additives, since their biocidal properties are absent, the full development of bacteria and fungi occurs.

The use of lubricants, application qualification tests, and the resistance of additives included in the composition to biodegradation were studied with the biocide α-phenyl-β-nitroethene in order to determine oxidation, corrosion, wear, detergent, and a number of quality indicators:



α-phenyl-β-nitroethene

The positive result of the conducted studies was the application of "nitroethenes" and a number of their derivatives to lubricants and additives, which resulted in a sufficient destruction of bacteria and fungi.

The table shows the results of microbiological tests of the M-12ВБ brand lubricant composition, created for ship and stationary diesel engines.

Table

Composition	biocide-free		α-phenyl-β-nitroethene biocide 0.25%, cm	
	bacteria	fungi	bacteria	fungi
Base oil M-10 8,0% ИХП-101 1,5% ИХП-301 1,2% ДФ-11 0,6% Viscoplex 2-670 0,5 % Viscoplex 5-309 0,25 % α-phenyl-β-nitroethene 0,003% ПМС -200А	+*	+*	1,7-1,9	2,5-2,7

* (+)full development of microorganisms

The bioresistance properties of both high-quality base oils processed by modern methods and various groups of lubricants produced according to low API viscosity were observed during studies conducted with the biocide α-phenyl-β-nitroethene.

There is very little information in the current literature about oil-soluble samples of numerous biocidal compounds with biocidal properties. Therefore, in the studies, α-phenyl-β-nitroethene and its halogenated derivatives, which are known in the literature and can be dissolved in oils, were used as biocides to determine the resistance properties against microorganisms.

BOKASHI COMPOSTING AS AN EMERGING BIOTECHNOLOGICAL APPROACH FOR WASTE VALORIZATION: A COMPARATIVE STUDY OF SUSTAINABLE BIOFERTILIZER AND BIOPESTICIDE PRODUCTION

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Abstract
In the face of growing global concerns over organic waste accumulation and declining soil health, innovative and sustainable waste treatment methods have become imperative. This study presents Bokashi composting as a novel anaerobic biotechnological process for the treatment and valorization of organic waste, emphasizing its dual potential for producing both biofertilizers and biopesticides. Originating from Japan, Bokashi utilizes a consortium of Effective Microorganisms (EM)—including lactic acid bacteria, photosynthetic bacteria, yeasts, and actinomycetes—capable of accelerating fermentation, suppressing pathogens, and enhancing nutrient retention. Despite its expanding application in local farming systems, Bokashi remains underexplored in scientific literature, particularly when compared to conventional methods such as thermophilic composting and vermicomposting. This research provides a comparative assessment of these techniques, focusing on key indicators such as degradation kinetics, nutrient bioavailability, pathogen reduction, and secondary metabolite (biopesticide) generation. Experimental trials and analytical profiling demonstrate that Bokashi offers rapid waste stabilization with minimal energy input, lower greenhouse gas emissions, and high-value end-products suitable for sustainable agriculture. The findings highlight Bokashi's promise as a low-tech, cost-effective, and ecologically sound solution for integrated waste management and soil health restoration. The study advocates for its broader implementation and further investigation within circular bioeconomy frameworks.
Keywords: Bokashi, Anaerobic composting, Organic waste valorization, Effective Microorganisms, Biofertilizer, Biopesticide, Circular bioeconomy.

CERRAHİ ALAN ENFEKSİYONLARINI ÖNLEMEYE YÖNELİK KANIT TEMELLİ UYGULAMALAR

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Özet
Cerrahi alan enfeksiyonları (CAE), hastanede kazanılan enfeksiyonlar arasında önemli bir yere sahiptir ve hasta morbiditesini, mortalitesini ve sağlık hizmeti maliyetlerini artırmaktadır. Bu nedenle CAE'lerin önlenmesi, hasta güvenliği açısından kritik öneme sahiptir. Son yıllarda yapılan çalışmalar, CAE'lerin büyük ölçüde önlenebilir olduğunu göstermekte ve bu doğrultuda kanıt temelli uygulamaların önemi artmaktadır.
Bu makalede, CAE'leri önlemeye yönelik en güncel ve kanıta dayalı uygulamalar incelenmiştir. Başlıca uygulamalar arasında preoperatif hasta hazırlığı, antibiyotik profilaksisi, el hijyeni, cilt hazırlığı, steril cerrahi tekniklerin uygulanması ve postoperatif yara bakımının etkin yapılması yer almaktadır. Özellikle ameliyat öncesinde hastaların duş alması, kıl temizliğinin uygun şekilde yapılması, zamanında ve uygun dozda antibiyotik uygulanması enfeksiyon riskini azaltmada etkili bulunmuştur.
Ayrıca, ameliyathane ortamının kontrolü, personel eğitimi ve multidisipliner ekip yaklaşımı enfeksiyon oranlarının düşürülmesine katkı sağlamaktadır. Kanıta dayalı rehberler doğrultusunda hazırlanan protokollerin sistematik şekilde uygulanması, hem hasta sonuçlarını iyileştirmekte hem de sağlık sistemine olan mali yükü azaltmaktadır.
Sonuç olarak, cerrahi alan enfeksiyonlarının önlenmesi için kanıt temelli uygulamaların rutin klinik uygulamalara entegre edilmesi gerekmektedir. Bu yaklaşım, enfeksiyon oranlarını azaltmanın yanı sıra hasta memnuniyetini ve yaşam kalitesini artırmada da önemli rol oynamaktadır.
Anahtar Kelimeler: Cerrahi alan enfeksiyonları, kanıt temelli uygulamalar, hemşirelik

EVIDENCE-BASED PRACTICES TO PREVENT SURGICAL SITE INFECTIONS

Abstract
Surgical site infections (SSI) have a significant place among hospital-acquired infections and increase patient morbidity, mortality and healthcare costs. Therefore, preventing SSIs is of critical importance for patient safety. Studies conducted in recent years have shown that SSIs are largely preventable, and the importance of evidence-based practices is increasing accordingly.
This article examines the most up-to-date and evidence-based practices for preventing SSIs. The main practices include preoperative patient preparation, antibiotic prophylaxis, hand hygiene, skin preparation, application of sterile surgical techniques and effective postoperative wound care. In particular, showering patients before surgery, proper hair cleaning and timely and appropriate doses of antibiotics have been found to be effective in reducing the risk of infection.

In addition, control of the operating room environment, staff training and a multidisciplinary team approach contribute to reducing infection rates. Systematic implementation of protocols prepared in line with evidence-based guidelines both improves patient outcomes and reduces the financial burden on the healthcare system.
In conclusion, evidence-based practices need to be integrated into routine clinical practice to prevent surgical site infections. This approach plays an important role in reducing infection rates as well as improving patient satisfaction and quality of life.
Keywords: Surgical site infections, evidence-based practices, nursing

GİRİŞ

Cerrahi alan enfeksiyonları modern teknolojideki ilerlemelere rağmen cerrahinin önemli bir sorunu olmaya devam etmektedir (Mengistu DA. et. al. 2023; Kalkan N, Karadağ M. 2017). CAE'lerin önlenmesinde kurumlarda birçok faktör değerlendirilerek önleme uygulamaları yürütülmektedir. Sağlık kuruluşunun veya hastanın durumuna göre bu uygulamalarda farklılıklar olsa da temelde yürütülen uygulamalar benzer özellikler taşımaktadır. CAE'lerin yaklaşık olarak yarısının kanıta dayalı stratejiler kullanılarak önlenebilir olduğu tahmin edilmektedir. Yapılan geniş örneklemli bir kohort çalışmasına göre CAE önleme protokollerinin gelir düzeylerine bakılmaksızın tüm ülkelerde uygulanabilir olduğu belirtilmektedir (Allegranzi B. et. al. 2016).
Literatürde CAE'yi önlemeye yönelik DSÖ, CDC, Perioperatif Kayıtlı Hemşireler Derneği (AORN), Amerikan Perianestezi Hemşireleri Derneği (ASPAN), Cerrahi Sonrası Hızlandırılmış İyileşme (ERAS), Ulusal Sağlık ve Klinik Mükemmellik Enstitüsü (NICE), Türk Anesteziyoloji ve Reanimasyon Derneği (TARD) ve Türk Cerrahi ve Ameliyat Hemşireleri Derneği tarafından yayınlanan rehberler ve protokoller bulunmaktadır (CDC 2017; WHO 2018; NICE 2020; ERAS; , Hooper VD. et. al. 2010; TARD 2013; Berríos-Torres SI. Et. al. 2017; TCAD 2018). Bu rehberlerden DSÖ ve CDC kanıt kalitesi sınıflandırmasını GRADE'e (Grading of Recommendations Assessment, Development and Evaluation) göre yapmış, ancak her bir önerinin kanıt kalitesini farklı şekilde sınıflandırmıştır. DSÖ kanıt kalitesini çok düşük, düşük, orta ve güçlü olarak sınıflandırırken; CDC, IA, IB, IC, II ve öneri yok/çözümlenmemiş öneri olarak belirtmiştir (WHO 2018; Berríos-Torres SI. Et. al. 2017;). NICE'ın ise tanımlanmış bir kanıt kalitesi sınıflandırması bulunmamaktadır (NICE 2020). Bu rehberlere göre CAE önlenmesinde yer alan uygulamalar kanıt düzeylerine göre aşağıdaki çizelgede verilmiştir (CDC 2017; WHO 2018; NICE 2020; ERAS; , Hooper VD. et. al. 2010; TARD 2013; Berríos-Torres SI. Et. al. 2017; TCAD 2018; AORN 2024).

Çizelge 1.Cerrahi Girişim Öncesi Kanıt Temelli Öneriler

Bileşenler	Rehber	Öneri
Antiseptikli duş aldırılması	DSÖ (2018)	-Cerrahi girişim öncesi sabun ya da antiseptik sabunla duş alınmalı (Kanıt düzeyi: Orta, koşullu öneri)
	CDC (2017)	-Cerrahi girişimden bir gece önce sabun ya da antiseptik bir madde ile duş alınmalı (Kanıt düzeyi: IB)
	NICE (2020)	-Cerrahi girişimden bir gün önce ya da ameliyat günü sabun ile duş veya banyo yapılmalı
	DSÖ (2018)	Gerekmiyorsa, tüy temizliği yapılmamalı (Kanıt düzeyi: Orta, güçlü öneri) -Tüy temizliği gerekiyorsa elektrikli tıraş makinası/clipper kullanılarak, ameliyattan hemen önce, ameliyat salonu dışında bir odada tüy temizliği yapılmalı (Kanıt düzeyi: Orta, güçlü öneri)

Tüy temizliği	CDC (2017	-Ameliyata engel olmayacaksa ameliyat öncesi tüy temizliği yapılmamalı (Kanıt düzeyi: IA) -Tüy temizliği yapılacaksa, ameliyattan hemen önce elektrikli cerrahi tıraş makinası kullanılarak yapılmalı (Kanıt düzeyi: IA)
	NICE (2020)	- Rutin tüy temizliği yapılmamalı - Gerekli ise, ameliyat günü tek kullanımlık elektrikli tıraş makinası/clipper kullanılarak, ameliyat günü yapılmalı, jilet CAE riskini artırdığı için kullanılmamalı
	AORN (2018)	- Hastalar ameliyat öncesinde tıraş bıçağı veya tüy dökücü krem kullanmamaları yönünde uyarılmalı (Güçlü öneri) -Tüy dökücü kremler alerjik reaksiyona yol açarak ameliyatın ertelenmesine neden olabileceğinden, uygulanmadan önce cilt üzerinde test yapılmalı (Güçlü öneri) -Tüy temizliği ameliyathane odası dışında yapılmalı (Güçlü öneri) -Tüy temizliği gerekiyorsa tek kullanımlık başlığı olan elektrikli cerrahi tıraş makinası ile yapılmalı (Güçlü öneri)
Antibiyotik profilaksisi	DSÖ (2018)	-Antibiyotik kullanımı endike olduğunda (cerrahi girişimin türüne göre) cerrahi girişim öncesi uygulanmalı (Kanıt düzeyi: Düşük, güçlü öneri) - Antibiyotiğin yarılanma ömrü göz önünde bulundurularak, insizyondan önceki 120 dakika içinde intravenöz olarak uygulanmalı (Kanıt düzeyi: Orta, güçlü öneri)
	CDC (2017)	-Antibiyotikler sadece endike olduğunda uygulanmalı (Kanıt düzeyi: IB) -Cilt kesisinden önce uygun parenteral ajanlar kullanılmalı (Kanıt düzeyi: IA) -Ameliyathanede cilt kesisi kapatıldıktan sonra, temiz ya da temiz kontamine yaralarda ve dren konulan hastalarda cerrahi girişim sonrası ek antibiyotik uygulaması yapılmamalı (Kanıt düzeyi: IA)
	NICE (2020)	Rutin profilaksi yerine; protez veya implant ameliyatlarında, temiz-kontamine ve kontamine cerrahilerde ameliyat öncesinde antibiyotik profilaksisi uygulanmalı -Anesteziye başlarken intravenöz tek doz antibiyotik profilaksisi yapılmalı -Antibiyotik profilaksisinde, antibiyotiğin zamanlama ve farmakokinetiği (örneğin, serum yarılanma ömrü) ile uygun infüzyon süresi göz önünde bulundurulmalı - Ameliyat süresinin antibiyotiğin yarılanma süresinden uzun olması durumunda, tek doz antibiyotik tekrar yapılmalı -Kirli veya enfekte yarası olan cerrahi girişim uygulanmış hastalara antibiyotik profilaksisine ek olarak antibiyotik tedavisi verilmeli

Çizelge 2.Cerrahi Girişim Sırası Kanıt Temelli Öneriler

Bileşenler	**Rehber**	**Öneri**
Cerrahi el yıkama	DSÖ (2018)	-Cerrahi el hazırlığı steril eldiven giymeden önce su ve antimikrobiyal bir sabunla fırçalama ya da alkol bazlı
	NICE (2020)	-Cerrahi ekip, ilk ameliyattan önce su bazlı antiseptik solüsyonla, tek kullanımlık fırça veya tırnak fırçasıyla ellerini yıkamalı, - Sonraki ameliyatlardan önce eller alkollü el dezenfektanı ya da antiseptik solüsyonla yıkanmalı

		-Ellerin ve tırnakların temiz olduğundan emin olunmalı, eller kirliyse antiseptik solüsyonla tekrar yıkanmalı
Cilt hazırlığı	DSÖ (2018)	-Kloreheksidin glukonat solüsyonları cilt iritasyonuna neden olabileceğinden beyin, beyin zarları, göz ya da orta kulakla temas etmesine izin verilmemeli
	CDC (2017)	Kontraendike değilse, alkol bazlı antiseptikle cilt hazırlığı yapılmalı (Kanıt düzeyi: IA)
	NICE (2020)	-Kontraendikasyon yoksa veya cerrahi bölge mukozaya yakın değilse cilt hazırlığında ilk tercih olarak alkol bazlı klorheksidin glukonat (%0,2 klorheksidin, %70 alkol) kullanılmalı -Cerrahi bölge mukozaya yakınsa su bazlı klorheksidin glukonat (%0,4 klorheksidin) kullanılmalı - Klorheksidin kontrendikasyonu varsa alkol bazlı povidon iyot (%10 povidon iyot) kullanılmalı - Her ikisi de uygun değilse su bazlı povidon iyot (%7,5 povidon iyot) kullanılmalı -Alkol bazlı solüsyonlar yenidoğanlarda kullanılmamalı, mukoza ya da gözlere temas ettirilmemeli ve yanıcı özelliğinden dolayı dikkatli kullanılmalı
	AORN (2019)	-Kullanılacak ajan multidisipliner bir ekip tarafından seçilmeli (Kanıt düzeyi: Güçlü) -Ameliyathane hemşiresi ameliyat öncesi antiseptiklere karşı alerji açısından hastayı değerlendirmeli (Kanıt düzeyi: Orta)
Oksijenasyonun sağlanması	DSÖ (2018)	-Endotrakeal entübasyonla genel anestezi uygulanan yetişkin hastalara, ameliyat sırasında ve mümkünse ameliyat sonrası 2-6 saat boyunca %80 oksijen (FiO2) uygulanmalı (Kanıt düzeyi: Orta, güçlü öneri)
	CDC (2017)	-Normal solunum fonksiyonu olan ve endotrakeal entübasyon ile genel anestezi uygulanan hastalara, ameliyat sırasında ve ekstübasyonu takiben ameliyattan hemen sonra yüksek oranda oksijen (FiO2) uygulanmalı (Kanıt düzeyi: IA) -Dokulara optimal oksijen iletimini iyileştirmek için normotermi ve normovolemi sürdürülmeli (Kanıt düzeyi: IA)
	NICE (2020)	-Hastanın oksijen saturasyonunun %95'in üzerinde olması için yeterli düzeyde oksijenasyon sağlanmalı
Normoterminin sağlanması	DSÖ (2018)	-Ameliyathane ve ameliyat sırasında hastanın ısıtılması için ısıtma cihazları kullanılmalı (Kanıt düzeyi: Orta, koşullu öneri) -Kanıtlar yetersiz olsa da hedef beden sıcaklığı 37°C olmalı
	CDC (2017)	-Cerrahi süreçte normotermi sürdürülmeli (Kanıt düzeyi: IA)
	NICE (2016)	-Perioperatif süreçte normotermi sürdürülmeli (Kanıt düzeyi: IA) - Beden sıcaklığı 36°C olan hastalarda ise anestezi indüksiyonundan en az 30 dakika önce aktif ısıtmaya başlanmalı ve ameliyat boyunca aktif ısıtma sürdürülmeli -Beden sıcaklığı ≥36°C ise hasta servise nakledilmeli - İntravenöz sıvı (≥ 500 ml) ile kan ve kan ürünleri ısıtma cihazları kullanılarak 37oC'ye kadar ısıtılmalı - Tüm irrigasyon sıvıları termostatik olarak kontrol edilen bir kabin içinde 38-40 oC sıcaklığa kadar ısıtılmalı -Hasta servise nakledildikten sonra beden

		sıcaklığı ölçülerek kaydedilmeli ve her hastaya en az bir pamuklu çarşaf/2 battaniye/yorgan temin edilmeli
Kan glukoz düzeyinin kontrolü için protokol kullanılması	DSÖ (2018)	-Diyabeti olan/olmayan yetişkin cerrahi hastalarında perioperatif kan glukoz kontrolü için protokoller kullanılmalı (Kanıt düzeyi: Düşük, koşullu öner
	CDC (2017)	-Cerrahi süreçte glisemik kontrol sağlanmalı, diyabeti olan/olmayan tüm hastalarda kan glukoz düzeyi 200

Çizelge 2 Cerrahi Girişim Sonrası Kanıt Temelli Öneriler

Bileşenler	Rehber	Öneri
Cerrahi girişim sonrası antibiyotik profilaksisinin süresi	DSÖ (2018)	- Cerrahi girişim tamamlandıktan sonra antibiyotik profilaksisi uzatılmamalı (Kanıt düzeyi: Orta, güçlü öneri)
	NICE (2020)	- Cerrahi girişim öncesi tek doz antibiyotik profilaksisi uygulanmalı - CAE'yi önlemek içim antibiyotik profilaksisi uzatılma
Pansuman sırasında aseptik teknik uygulanması	DSÖ (2018)	-Postoperatif süreçte standart pansuman yöntemlerinin dışına çıkılmamalı, varsa drenlerin en kısa sürede çıkarılmalı - Pansuman sırasında aseptik teknik uygulanmalı (Koşullu öneri, kanıt düzeyi orta)
Ameliyat sonrası yaranın açılmaması	DSÖ (2018)	-Ameliyat sonrası gerekli olmadıkça 48 saat yara üzerindeki pansumanın açılmaması önerilmektedir (güçlü öneri, kanıt düzeyi orta)

AMELİYAT ÖNCESİ İLE İLGİLİ KANIT TEMELLİ UYGULAMALAR

Ameliyat öncesi duş/banyo yapılması: Ameliyat öncesi duş/banyo uygulaması; ciltteki kir, debris, artıklar ve cerrahi uygulama alanındaki mikrobiyal florayı azaltmak ve CAE'yi önlemeye yardımcı olmak amacıyla uygulanmaktadır (Hergül FK. Yavuz M. 2016; Balkan A, Çelebi C. 2020; Bashaw MA. 2019) .CDC hastalara ameliyat gününden en az bir gece önce sabunla ya da antiseptik solüsyonla (antimikrobiyal ya da antimikrobiyal olmayan) duş/banyo yapmasını önermektedir (CDC 2017).

Ameliyat öncesi tüy temizliği: CAE riskini artıran ameliyat sürecindeki faktörlerden birisi de ameliyat öncesi tüy temizliğidir. CAE önlenmesine yönelik yapılan çalışmalarda enfeksiyon oranının azaltılması için tüy temizliğine gerek olmadığı belirtilmekte, ancak sağlık çalışanları için cerrahi bölgeye ulaşmak ve görüş alanını genişletmek amacıyla tercih edilmektedir. NICE, AORN, IHI ortak önerilerine bakıldığında; gerekmedikçe tüy temizliğinden kaçınılmalı, tüy temizliği gerekliyse tüy dökücü krem ya da tıraş makinesi kullanılmadır (NICE 2020; ,AORN 2024; IHI 2024). Tüy temizliği yapılan bölgede küçük de olsa çiziklere neden olabileceği için jilet kullanılması önerilmemektedir (Uslu Y, Yavuz M. 2015; Arslan S. 2021).

Antibiyotik profilaksisi: Perioperatif dönemde antibiyotik profilaksisi, neredeyse tüm cerrahi prosedürler için bakım standardıdır (Anesi JA. Blumberg EA. Abbo LM. 2018). İnsizyon öncesi uygulanan profilaktik intravenöz antibiyotikler CAE riskini azaltmada yararlıdır. CAE için yüksek risk taşıyan hastalarda antibiyotik profilaksisinin yaygın olarak izole edilen organizmaları hedef alacak şekilde uyarlanması önerilmektedir (Liu Z. et. al. 2018). Elektif ameliyatlarda, temiz ve temiz kontamine yaralarda antibiyotik profilaksisi uygulanmalı, kirli yaralarda ve enfeksiyon varlığında önce enfeksiyon tedavi edilmeli, sonra ameliyat planlanmalıdır. Doğru antibiyotik profilaksisi uygulaması; anestezi indüksiyonu sırasında ve intravenöz yolla tek doz, gerektiğinde ameliyat sırasında doz tekrarı yapılan ve düşünülen

mikroorganizmaya karşı etkin bir antibiyotiğin uygulanmasıdır (Allegranzi B. et al. 2016; , Balkan A, Çelebi C. 2020; Bashaw MA 2019, Alkaaki A. et. al. 2019).

AMELİYAT SIRASI İLE İLGİLİ KANIT TEMELLİ UYGULAMALAR

Cerrahi El Yıkama: Rehberler cerrahi el hazırlığının steril eldiven giymeden önce uygun bir antimikrobiyal sabun ve su ile ovularak veya uygun bir alkol bazlı el antiseptiği kullanılarak yapılmasını önermektedir. Böylelikle sağlık profesyonellerinin ellerinde ve kollarında geçici floranın (kontamine flora) tamamen uzaklaştırılması, kalıcı floranın ise mümkün olabildiğince azaltılması sağlanır. Cerrahi el hazırlığının ameliyat sırasında steril eldivenin delinmesi gibi durumlarda, cerrahi alanın mümkün olan en düşük kontaminasyonunu sağlamak için hayati önem taşıdığı belirtilmektedir. Eller ve ön kollar, üretici firma tarafından önerilen süre boyunca, genellikle 2-5 dakika, antimikrobiyal sabunla ovulmalıdır. Ayrıca cerrahi ekibin tırnak uzunluğunun ideal olması, cilt bütünlüğünün sağlanması ve takı kullanmaması, doğru teknik ve sürede el hijyeni sağlaması da önemlidir (Liu LQ, Mehigan S. 2016; Aygın D, Yaman Ö. 2020; Çelik S, Karahan E, Aydım A. 2022; Güngör S. 2023). CAE riskini azaltmak için DSÖ, AORN ve NICE gibi kuruluşlar ameliyathanelerde cerrahi el yıkama fırçalama protokolleri önermektedir (WHO 2018; NICE 2020; AORN 2024).

Ameliyat Süresi: Yaranın mikroorganizmalarla kontaminasyonu, immün sistemin baskılanması ve doku hasarında artış gibi faktörler nedeniyle sürenin uzaması CAE riskini oldukça arttırmaktadır. Ayrıca sürenin uzaması sterilite önlemlerinde aksaklıklar yaşanmasına da sebep olabilmektedir (Aktaş YY, Saraydemir Ö. 2024).

Cilt Hazırlığı: CAE'de majör faktörlerden biri de hastanın cilt florasıdır. Cilt hazırlığının yetersiz olması yara kontaminasyonuna sebep olabilmektedir (Aktaş YY, Saraydemir Ö. 2024). DSÖ cerrahi işlem geçiren hastalarda cerrahi bölge cilt hazırlığında alkol bazlı klorheksidin solüsyonların kullanılmasını önermektedir (WHO 2018).

Normoterminin Sürdürülmesi: Ameliyat olan hastalar istenmeyen hipotermi gelişimi açısından risk altındadır. Ayrıca ameliyat esnasında hastanın hipotermik olması ameliyatın başarısını olumsuz olarak etkileyebilir ve ameliyat sonrası komplikasyonlara yol açabilir. Bu nedenle hastanın ameliyat öncesi, sırası ve sonrasında vücut sıcaklığının kontrolü sağlanmalı ve hipotermi önlenmelidir (Çakır G, Çilingir D. 2018).

***Oksijenizasyonun Sağlanması*:** DSÖ'nün CAE önleme rehberine göre; cerrahi işlem sırasında endotrakeal entübasyon ile genel anestezi alan hastanın oksijenizasyonunun %80 olması gerekmektedir (WHO 2018) . Ameliyattan sonraki ilk 2-6 saat oksijen tedavisinin CAE'yi azalttığı belirtilmektedir (Balkan A, Çelebi C. 2020).

AMELİYAT SONRASI İLE İLGİLİ KANIT TEMELLİ UYGULAMALAR

Pansuman sırasında aseptik teknik ve el hijyenine uyum: Yara bakım yönetimi CAE gelişmesinin önlenmesi bakımından önemlidir. Bu nedenle iyi bir bakım protokolü yapılmalıdır. Yaraya her müdahale öncesi ve sonrası mutlaka el hijyeni sağlanmalı, pansuman için kullanılan malzemelerin steril olduğundan emin olunmalı ve steril eldiven ile pansuman yapılmalıdır (WHO 2018). DSÖ postoperatif süreçte standart pansuman yöntemlerinin dışına çıkılmamasını, varsa drenlerin en kısa sürede çıkarılmasını önermektedir (WHO 2018).

Postoperatif erken (4 saat) oral alıma başlanması: Cerrahi hastalarda postoperatif 4. saatte başlayan oral diyetin güvenli olduğu bildirilmektedir. Major cerrrahiden sonra oral diyete başlanmasındaki gecikmenin artmış enfeksiyöz komplikasyonlar ve gecikmiş iyileşmeyle ilişkili olduğu düşünülmektedir (ERAS 2025).

Ameliyat sonrası 48 saat içinde pansumanın açılmasından kaçınılması: Ameliyat sonrası gerekli olmadıkça 48 saat yara üzerindeki pansumanın açılmaması önerilmektedir (WHO 2018).

Cerrahi insizyona antimikrobiyal maddeler uygulanmasından kaçınma: CAE'nin önlenmesi için cerrahi insizyona antimikrobiyal maddeler (örneğin merhemler, solüsyonlar veya tozlar) uygulamadan kaçınılması önerilmektedir (WHO 2018).

Güncellenen rehberlere göre CAE'lerin önlenmesinde gereksiz olduğu belirlenen stratejiler şu şekildedir: Cerrahi kapatma sonrası antimikrobiyal profilaksi (temiz ve temiz kontamine prosedürler için), cerrahi insizyona uygulanan topikal antimikrobiyal ajanlar, otolog, trombositten zengin plazma, ameliyat sırası cilt hazırlığını takiben antimikrobiyal örtücü ve antisepsi için plastik yapışkan örtüler, prostetik eklem artroplastisi geçiren hastalar için gerekli kan ürünlerinin transfüzyonunun durdurulmasıdır (O'Hara LM, Thom KA, Preas MA. 2018). Sonuç olarak literatür incelendiğinde CAE uygun önlenme yöntemleri kullanılarak azaltılabilmektedir. CAE önlenebilir bir durum olduğu için sağlık çalışanlarının CAE önleme stratejileri konusunda bilgilerini düzenli olarak güncellemeleri önerilmektedir (Altun Uğraş. G Bozkul, G Kanat. 2024).

SONUÇ

Cerrahi alan enfeksiyonları, hasta güvenliğini tehdit eden ve sağlık hizmetlerinde ciddi sonuçlara yol açabilen komplikasyonlar arasında yer almaktadır. Ancak yapılan bilimsel araştırmalar, bu enfeksiyonların büyük ölçüde önlenebilir olduğunu ortaya koymuştur. Kanıt temelli uygulamaların klinik pratiğe entegre edilmesi, cerrahi sonrası enfeksiyon riskini önemli ölçüde azaltmakta; hasta iyileşme sürecini hızlandırmakta ve sağlık hizmetlerinin etkinliğini artırmaktadır.

Preoperatif, intraoperatif ve postoperatif dönemlerde uygulanan kanıta dayalı stratejiler; uygun antibiyotik kullanımı, el hijyeni, sterilizasyon ve yara bakımı gibi temel ilkeleri kapsamaktadır. Bu uygulamaların başarıya ulaşabilmesi için sağlık çalışanlarının güncel bilgi ve rehberlerle donatılması, ekip çalışması bilincinin artırılması ve kurumsal düzeyde sürekli eğitimlerin sağlanması büyük önem taşımaktadır.

Sonuç olarak, cerrahi alan enfeksiyonlarının önlenmesinde bireysel çabaların ötesinde, sistematik ve disiplinler arası bir yaklaşım gereklidir. Kanıta dayalı uygulamaların standart hale getirilmesi, hem hasta sağlığını korumak hem de sağlık sisteminin yükünü azaltmak açısından vazgeçilmez bir adımdır.

KAYNAKLAR

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CHICORY PLANT: EXTRACTION, PURIFICATION, AND USES IN HERBAL DRUG TECHNOLOGY

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ABSTRACT:
The chicory plant (Cichorium intybus L.) is a versatile plant with a long history of culinary and medicinal applications. This abstract will outline common methods for the extraction of valuable compounds from chicory, including solvent extraction (e.g., using water, ethanol) from various plant parts like roots, leaves, and flowers, often optimized for specific targets like inulin, sesquiterpene lactones, or polyphenols. Purification techniques such as filtration, liquid-liquid extraction, chromatography, and ultrafiltration are employed to isolate and concentrate these bioactive constituents.The uses of chicory and its extracts are diverse. The root is well-known as a coffee substitute and a significant source of inulin, a prebiotic dietary fiber widely used in the food industry. Other extracts exhibit antioxidant, anti-inflammatory, antimicrobial, and potentially antidiabetic and anticancer properties. Different parts of the plant are also used in traditional medicine for various ailments, including digestive issues and liver disorders. This abstract will provide an overview of the extraction and purification processes used to obtain valuable compounds from the chicory plant and highlight the broad range of their applications in food, nutraceuticals, and potentially pharmaceuticals.
Keywords: Cichorium intybus, chicory, extraction, purification, inulin, uses, medicinal properties.

CHROZOPHORA TINCTORIA (L.) A. JUSS.'UN FARKLI BITKI KISIMLARININ ANTIOKSIDAN AKTIVITESININ VE TOPLAM FENOLIK MADDE MIKTARLARININ KARŞILAŞTIRILMASI

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ÖZET
Bu çalışma, Türkiye florasında doğal olarak yetişen ve geleneksel tıpta kullanılan *Chrozophora tinctoria* (L.) A. Juss. bitkisinin farklı kısımlarının (toprak üstü, tohum ve kök) antioksidan potansiyelini ve toplam fenolik madde miktarını araştırmıştır. Malatya'dan toplanan bitki örnekleri üzerinde Folin-Ciocalteu yöntemiyle toplam fenolik madde miktarı (TFMM) ile DPPH ve ABTS yöntemleri ile antioksidan aktivite testleri uygulanmıştır.
Elde edilen bulgular, bitkinin farklı kısımlarının biyolojik aktivite açısından önemli farklılıklar gösterdiğini ortaya koymuştur. En yüksek fenolik madde içeriği (587.64 mg GAE/100 g) ve antioksidan aktivite (DPPH: 843.69 mg TEAC/100 g; ABTS: 1483.79 mg TEAC/100 g) toprak üstü kısımlarda tespit edilmiştir. Tohum ve kök kısımları ise bu değerlerde daha düşük sonuçlar sergilemiştir. Bu durum, bitkinin güneş ışığına maruz kalan kısımlarında ikincil metabolit sentezinin daha yoğun olabileceğini düşündürmektedir.
Çalışmada ayrıca, Clevenger apareyi ile elde edilen yağ altı sularının antimikrobiyal aktivitesi incelenmiş, ancak belirgin bir etki gözlenmemiştir. Bu sonuç, diğer literatür çalışmalarıyla bazı farklılıklar gösterse de, ekstraksiyon yönteminin bitkinin antimikrobiyal bileşiklerini çözme kapasitesindeki rolünü vurgulamaktadır. Genel olarak, *C. tinctoria*'nın fenolik bileşikler açısından zengin olduğu ve güçlü antioksidan özelliklere sahip olduğu bulguları, bitkinin geleneksel kullanımlarını desteklemekte ve farmasötik ile nutrasötik alanlarda potansiyel uygulamalara zemin hazırlamaktadır. Gelecekte yapılacak *in vivo* ve izole bileşik çalışmaları, bitkinin terapötik potansiyelini daha net ortaya koyacaktır.
Anahtar Kelimeler: *Chrozophora tinctoria,* Antioksidan aktivite, Toplam fenolik madde miktarı, DPPH, ABTS

CHROSOPHORA TINCTORIA (L.) A. JUSS. COMPARISON OF THE ANTIOXIDANT ACTIVITY OF DIFFERENT PLANT PARTS OF FLOUR AND THE TOTAL AMOUNTS OF PHENOLIC SUBSTANCES

ABSTRACT

This study investigated the antioxidant potential and total phenolic content of different parts (aerial parts, seeds, and roots) of *Chrozophora tinctoria (L.) A. Juss.*, a plant naturally growing in the Turkish flora and traditionally used in medicine. Total phenolic content (TPC) was determined using the Folin-Ciocalteu method, and antioxidant activity was evaluated using DPPH and ABTS assays on plant samples collected from Malatya.

The findings revealed significant differences in the biological activity among various parts of the plant. The highest phenolic content (587.64 mg GAE/100 g) and antioxidant activity (DPPH: 843.69 mg TEAC/100 g; ABTS: 1483.79 mg TEAC/100 g) were observed in the aerial parts. Seed and root parts exhibited lower values in these parameters. This suggests that secondary metabolite synthesis might be more intense in the parts of the plant directly exposed to sunlight.

Additionally, the study examined the antimicrobial activity of sub-oil waters obtained via a Clevenger apparatus, but no significant effect was observed. While this result shows some discrepancies with other literature, it highlights the role of the extraction method in the solubility of the plant's antimicrobial compounds. Overall, the findings indicating *C. tinctoria*'s richness in phenolic compounds and strong antioxidant properties support its traditional uses and lay the groundwork for potential applications in pharmaceutical and nutraceutical fields. Future *in vivo* and isolated compound studies will provide a clearer understanding of the plant's therapeutic potential.

Keywords: *Chrozophora tinctoria*, Antioxidant activity, Total phenolic content, DPPH, ABTS

INTRODUCTION

The growing interest in the biological activities of natural products provides a basis for the development of alternative treatment approaches in the health sector. In this context, phytochemical properties such as phenolic compounds and antioxidant capacity play a critical role in determining both the functional and therapeutic value of plant-derived products. Antioxidants contribute to the prevention of many chronic diseases (cancer, cardiovascular diseases, aging) by reducing the harmful effects of free radicals (Maurya, 2018). Therefore, these studies pave the way for future research. Compounds with low antioxidant capacity are harmful to human health, and their use is always avoided.

Chrozophora tinctoria (L.) A. Juss. is an annual, herbaceous plant belonging to the Euphorbiaceae family. This species is naturally widespread in the flora of Turkey and is also found in warm climate zones such as Southern Europe, North Africa, the Middle East, and India. In Turkey, it is frequently encountered, especially in the Central Anatolia, Southeastern Anatolia, and Eastern Anatolia regions. It tends to grow in arid and semi-arid lands, fallow fields, roadsides, and stony areas, preferring sunny environments and loose, permeable soils (Abdallah et al., 2015; Marzouk et al., 2015; Maurya, 2018).

C. tinctoria is generally a hairy-stemmed plant, 30-60 cm tall. Its leaves are alternately arranged, egg-shaped, and slightly wavy at the edges. It has small, greenish, and usually unisexual flowers. When mature, the plant produces fruits that secrete a characteristic blue-purple pigment; due to this property, it has been traditionally used as a natural dye (Maurya, 2018).

Known as "siğilotu" or "çivit otu" among the public, *Chrozophora tinctoria* has been used for various purposes in traditional medicine in Anatolia for centuries. It is particularly known for

its topical applications against skin diseases, eczema, wounds, and insect bites. The plant has been traditionally used to treat warts, as an emetic and cathartic, and to reduce fever (Ugurlu & Secmen, 2008; Viegi et al., 2003). In some regions, it is also used internally for its diuretic, antipyretic, or analgesic effects. The plant's ability to produce dark blue dye in water makes it important in traditional dye production (Abdallah et al., 2015; Maurya, 2018). In many regions, its internal use has been avoided due to its perceived toxicity. There are also animal studies indicating its harmful effects. Histopathological examinations in experimental animals have shown significant abnormalities in liver, kidney, spleen, and small intestine tissues (AlAhmady et al., 2025). However, toxic plants have an important place, especially in cancer treatments. In such plants, toxic and harmful compounds can be removed by forming fractions or evaluating different parts of the plants.

Total phenolic content (TPC), DPPH, and ABTS tests were applied to *C. tinctoria* samples collected from Büyükgüney, Konak town, Yeşilyurt district, Malatya province, to determine their antioxidant potentials.

The main objective of this study is to determine the antioxidant capacities of different plant parts of *C. tinctoria* (aerial parts, seeds, and roots) and to evaluate its usability in pharmaceutical and nutraceutical fields accordingly. The chemical content of the plant has been shown to contain various flavonoids, such as biflavone and amentoflavone (Hashim et al., 1990; Hawas, 2007). Among the main compounds isolated from *C. tinctoria* are apigenin and quercetin glycosides, and acetylated flavone glycosides (Delazar et al., 2006). Additionally, rutin, acacetin 7-O-rutinoside, apigenin 7-O-β-d-[(6-p-coumaroyl)]-glucopyranoside, apigenin 7-O-β-d-glucopyranoside, and apigenin 7-O-β-d-[6-(3,4-dihydroxybenzoyl)]-glucopyranoside (chrozoferin) are also important compounds isolated from *C. tinctoria* (Abdallah et al., 2015; Betancur-Galvis et al., 2002; Hawas, 2007).

MATERIAL AND METHOD

Plant Material

The *C. tinctoria (L.) A. Juss.* plant material used in the study was collected on July 11, 2020, from Büyükgüney, Konak town, Yeşilyurt district, Malatya province. The aerial parts (leaves and flowers), seeds, and root sections of the plant were isolated separately and used in the studies. The collected plants were dried in the shade and ground into a homogeneous powder for analysis. The herbarium specimen was registered under number TK 1268 in the İnönü University Faculty of Pharmacy Herbarium.

Extract Preparation

0.5 grams of dry plant material from each sample were extracted with 10 mL of methanol. The extraction process was carried out at room temperature, in a dark environment, for 24 hours. The samples were mixed every 8 hours for 5 minutes in a vortex mixer. After extraction, the filtered samples were centrifuged, and the supernatant was used in the analyses.

Determination of Total Phenolic Content (TPC)

The Folin-Ciocalteu method was used for TPC determination. For plant extracts, 10 µL were added, followed by 20 µL Folin-Ciocalteu, 200 µL distilled water, and finally 100 µL 15% Na2CO3 solution. The mixture was then left in the dark at room temperature for 2 hours, and the absorbance was measured at 765 nm using a spectrophotometer. The obtained data were expressed as mg GAE/100 g dry plant using a gallic acid standard curve (Hwang et al., 2001). The standard deviation of the results obtained from at least 3 replicates was calculated.

Determination of DPPH Free Radical Scavenging Activity

For the determination of antioxidant activity by the DPPH method, 10 µL of extracts were added to 190 µL of DPPH reagent. After a 30-minute reaction period, the loss of color was measured at 517 nm with a spectrophotometer. The results were calculated as Trolox equivalents in mg

TEAC/100 g dry plant (Floegel et al., 2011; Prior et al., 2005). The standard deviation of the results obtained from at least 3 replicates was calculated.

Determination of ABTS Radical Cation Scavenging Capacity

In the ABTS method for antioxidant activity analysis, 190 µL of diluted ABTS solution and 10 µL of extracts were added and incubated in the dark at room temperature for 30 minutes. The samples were then measured at 734 nm with a spectrophotometer. The obtained results were evaluated as mg TEAC/100 g dry plant (Floegel et al., 2011). The standard deviation of the results obtained from at least 3 replicates was calculated.

Obtaining Sub-Oil Water with Clevenger Apparatus

A sufficient amount of plant sample was ground using a mill just before use. 50 grams of the plant sample were transferred to 1000 mL balloons, and distilled water was added up to a maximum of half the volume. Distillation was performed using a Clevenger apparatus for 3 hours. The sub-oil waters were collected and transferred to amber bottles and stored at +4°C in the refrigerator until analysis.

Determination of Antimicrobial Activity

Antimicrobial effects were investigated using 100 µL samples taken from the sub-oil waters. Additionally, ampicillin was used as an antibacterial control and ketoconazole as an antifungal control. Sample discs were prepared by impregnating filter paper with the samples. Microorganisms to be used for the antimicrobial test were taken from -80 ºC stocks.

Tested bacteria: *Bacillus cereus* (ATCC 14579), *Escherichia coli* (ATCC 25922), *Klebsiella pneumoniae* (ATCC 13883), *Staphylococcus aureus* (ATCC 25923), *Salmonella typhi* (ATCC 19430), *Pseudomonas aeruginosa* (ATCC 27853), *Enterococcus faecalis* (ATCC 29212). These bacteria were incubated overnight at 37 ºC in Mueller Hinton Agar (MHA) medium.

Tested fungi: *Candida krusei* (ATCC 6258) and *Candida albicans* (ATCC 24433).

These fungi were prepared by overnight incubation (16-24 hours) at 30 ºC in a stove in Sabouraud Dextrose Agar (SDA) medium (Hudzicki, 2009; Murray & Zeitinger, 1983). The prepared microorganisms were inoculated with 3 mL sterile FTS (Physiological Saline Solution, 0.9% NaCl) and mixed with a vortex until homogeneous. 100 µL of the culture adjusted to 0.50 concentration in a McFarland device was taken and inoculated into MHA or SDA media by spread plating. Samples impregnated onto discs were placed on the MHA or SDA media inoculated with the culture. As a control group, Ampicillin discs for bacteria and Ketoconazole discs for yeasts were placed on each petri dish. After waiting approximately 1-2 hours for the media to absorb the samples, bacteria were incubated at 37°C and yeasts at 30°C for 24 hours to measure inhibition zone diameters. At the end of the incubation period, the inhibition effect of the extracts on microorganisms was measured with a millimeter ruler and zone diameters were recorded (Çakmen, 2019; Kırımer et al., 2012).

Statistical Analysis

All analyses were performed in at least triplicate. The obtained data were evaluated using Microsoft Excel software and presented as mean ± standard deviation (SD).

RESULTS AND DISCUSSION

In this study, total phenolic content (TPC), DPPH, and ABTS antioxidant activity levels of different parts of *C. tinctoria* plant were determined. The results are presented in the tables below as mean ± standard deviation (SD).

Total Phenolic Content (TPC)

As a result of the analyses, the highest phenolic content was found in the aerial parts (587.64 mg GAE/100 g), and the lowest in the root part (254.31 mg GAE/100 g).

Table 1. Total phenolic content of different parts of *C. tinctoria*

Used Part	TPC (mg GAE/100 g)
Aerial Parts	587.64 ± 33.21
Seed	464.31 ± 20.53
Root	254.31 ± 3.28

DPPH Free Radical Scavenging Activity

In the DPPH analysis, the highest antioxidant activity was observed in the aerial parts (843.69 mg TEAC/100 g). The activity of the root part was found at lower levels.

Table 2. DPPH activities of different parts of *C. tinctoria*

Used Part	DPPH (mg TEAC/100 g)
Aerial Parts	843,69 ± 89,71
Seed	489,36 ± 83,17
Root	230,69 ± 42,45

ABTS Radical Cation Scavenging Capacity

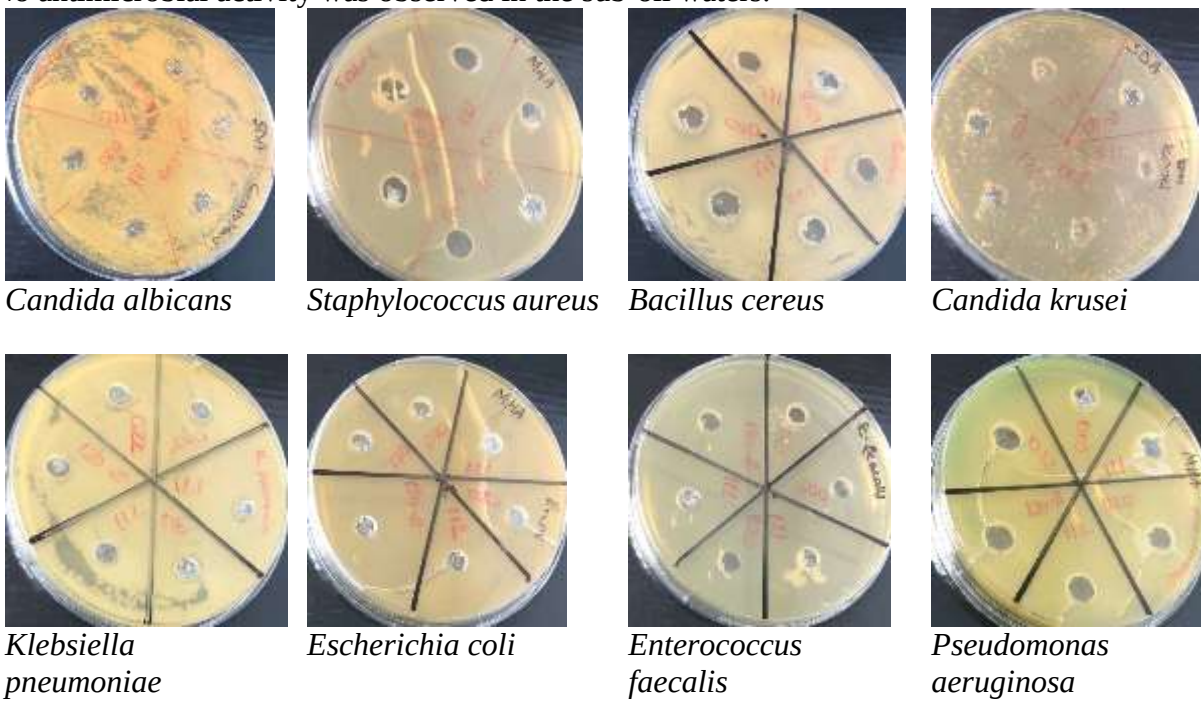
According to ABTS results, the aerial parts had the highest antioxidant capacity (1483.79 mg TEAC/100 g), while the root part had the lowest values.

Table 3. ABTS activities of different parts of *C. tinctoria*

Used Part	ABTS (mg TEAC/100 g)
Aerial Parts	1483,79 ± 35,08
Seed	1217,68 ± 50,79
Root	786,60 ± 24,30

Antimicrobial Activity

No antimicrobial activity was observed in the sub-oil waters.



Candida albicans | *Staphylococcus aureus* | *Bacillus cereus* | *Candida krusei*

Klebsiella pneumoniae | *Escherichia coli* | *Enterococcus faecalis* | *Pseudomonas aeruginosa*

Fig 1: No inhibitory zone diameters were formed in the antimicrobial activity results with *C. albicans, S. aureus, B. cereus, C. Krusei, K. Pneumoniae, E. coli, E. faecalis*, and *P.s aeruginosa* microorganisms.

This study evaluated the phenolic compound amounts and antioxidant activities of different parts of the *C. tinctoria* plant. The findings indicate that the aerial parts of the plant, in particular, possess a high antioxidant capacity. The high TPC and high values obtained in both DPPH and ABTS analyses for the aerial parts reveal that these parts are rich in biologically active compounds. This situation suggests that secondary metabolite production might be more intense in the parts of the plant directly exposed to sunlight.

When compared to the seed and root parts, the significantly higher antioxidant capacity in the aerial parts increases the potential for using this part of the plant in pharmaceutical and nutraceutical applications. The lower antioxidant activity levels in the root part indicate that this part has limited biological activity potential. When compared with similar studies, these results are consistent with the literature. A strong positive correlation between phenolic content and antioxidant activity has been demonstrated in many studies. In the current study, a general agreement was also observed between TPC, DPPH, and ABTS results. Flavonoids such as amentoflavone, apigenin, and quercetin glycosides, and rutin contained in the plant, may underlie its high antioxidant activity.

Other studies on *C. tinctoria* in the literature have also reported similar antioxidant properties. A study by Hazrati et al. (2019) determined that the oil extracted from *C. tinctoria* had a total phenolic content of 151.70 mg GAE /100 g oil and a total flavonoid content of 1.17 mg QE oil. In the same study, the antioxidant activity of this oil, measured by DPPH, was expressed as 45%. The oil yield obtained from seeds was approximately 26% (Hazrati et al., 2019).

A study conducted in Iran by Sharifi-Rad et al. (2015) examined leaf and stem extracts of *C. tinctoria*. It was reported that leaf extracts contained higher polyphenol (leaf: 1.6--4.9 mg GAE/g DW; stem: 0.9--3.3 mg GAE/g DW) and flavonoid (leaf: 6.5--8.6 mg CE/g DW; stem: 0.2--1.1 mg CE/g DW) concentrations compared to stem extracts. Sharifi-Rad et al.'s findings are parallel to this study; both studies show that the leaf-containing parts of the plant are richer in bioactive compounds (Sharifi-Rad et al., 2015).

Additionally, the study by Sharifi-Rad et al. (2015) also demonstrated that *C. tinctoria* extracts possess antibacterial activity. This study reported that methanol and acetone extracts showed significant antimicrobial activity against various Gram-positive and Gram-negative bacteria such as *Staphylococcus aureus, Bacillus subtilis, Klebsiella pneumoniae,* and *Pseudomonas aeruginosa* (Sharifi-Rad et al., 2015).

Maurya (2018) also stated that the methanol extract of the aerial parts of the plant showed a low level of free radical scavenging activity (antioxidant activity) (IC50 = 2.24 x 10-1 mg/mL). It was emphasized that this antioxidant activity originates from the presence of phenolic groups in the structures and from the redox properties of phenolic natural products, i.e., their ability to act as reducing agents, hydrogen donors, and singlet oxygen quenchers, and to some extent, their metal chelating potential. Furthermore, Maurya (2018) reported the in-vitro antimicrobial activity of *C. tinctoria*'s methanol extract against Gram-positive organisms (*Bacillus subtilis* and *Staphylococcus aureus*) and Gram-negative organisms (*Escherichia coli, Pseudomonas aeruginosa*, and *Salmonella typhi*) as well as fungal strains (*Candida albicans, Aspergillus flavus*, and *Aspergillus niger*). These results contradict the finding of no antimicrobial activity in the sub-oil waters in the current study. This situation suggests that different extraction methods (methanol/acetone extracts vs. sub-oil water) may lead to significant differences in the ability to dissolve the plant's antimicrobial compounds, or that the antibacterial compounds are not volatile, and therefore not present in the sub-oil water obtained by distillation.

A study by Khan et al. (2021) evaluated the anticancer potential of polar extracts of *C. tinctoria*. In this study, the methanol extract of the plant was fractionated with water, butanol, ethyl acetate, chloroform, and n-hexane. Maximum phenolic and flavonoid content were detected in the chloroform and ethyl acetate fractions. Particularly, the ethyl acetate fraction

(71.18 ± 0.01%) and chloroform fraction (45.81 ± 0.06%) showed high antioxidant potential in DPPH free radical scavenging activity (Khan et al., 2021).

In a recent study by Ayaz Ali Sher et al. (2024), the methanol extract and n-butanol fraction of *C. tinctoria* were investigated. Both samples were found to show significant antioxidant potential with DPPH radical scavenging analysis. The methanol extract showed the highest free radical scavenging activity with the lowest IC50 value of 31 μg/mL, while the n-butanol fraction had an IC50 value of 67 μg/mL. This antioxidant activity was attributed to phytochemicals present in the methanol extract such as pentadecanoic acid, 14-methyl-, methyl ester; hexadecanoic acid, methyl ester; 10-octadecenoic acid, methyl ester; and 1-monolinoleoylglycerol trimethylsilyl ether. The activity in the n-butanol fraction was stated to come from compounds such as pentadecanoic acid, 14-methyl-, methyl ester, and 1-monolinoleoylglycerol trimethylsilyl ether. Additionally, the study highlighted that Pentadecanoic acid, 14-methyl-, methyl ester, detected in the study, possesses both antibacterial and antifungal properties (Sher et al., 2024).

These comparisons demonstrate that *C. tinctoria* exhibits a consistent antioxidant potential across different geographies and with different extraction methods, and may also possess antimicrobial properties.

CONCLUSIONS

This study on the antioxidant capacity of *C. tinctoria* revealed that the aerial parts of the plant, in particular, show a significant level of biological activity. The high phenolic content and free radical scavenging capacity indicate that this part can be evaluated for the development of antioxidant support products.

The obtained findings scientifically support the traditional use of *C. tinctoria*. It is believed that the plant, especially emphasizing its antioxidant property, can be used in the development of natural protective or complementary health products.

Future studies will involve a more detailed evaluation of the biological effects of isolated compounds from *C. tinctoria* and their testing in *in vivo* studies, which will provide a clearer understanding of the plant's pharmacological potential. Furthermore, although no antimicrobial activity was observed in the sub-oil waters, additional studies with different extraction methods or concentrations could be conducted.

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CLAUDE DEBUSSY'NİN PİYANO MÜZİĞİ

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ÖZET
İzlenimcilik, resim sanatında 19. yüzyıl sonlarında Monet, Degas, Renoir gibi bu akıma ışık tutan başlıca ressamlar tarafından ortaya çıkmıştır. Işık oyunlarıyla belirsiz hatları ön plana çıkararak, su damlacıklarının ya da sis perdesinin ardından resmettikleri görüntüler, bestecilere de ilham olmuştur. Aynı dönemlerde, şiir sanatında ortaya çıkan sembolizm de, semboller kullanılarak dış dünyanın kişi üzerindeki etkilerini ve izlenimlerini anlatan bir akımdır. Claude Debussy bu iki akımın müzikteki temsilcisi olarak, 20. yüzyıl müzik tarihinin önemli bir mihenk taşıdır. Resim, mimari ve edebiyata olan ilgisi, kendine özgü müzikal yaratıcılığını beslemiştir. Romantik dönemin yoğun duygusallığından uzaklaşmış, klasik armoninin katı kurallarını gevşeterek, fonksiyon kaygısı gütmeden, pentatonik ve tam ton dizilerini kullanarak, müziğine buğulu bir tını kazandırmıştır. Tam ton gamlarını alışılagelmişin aksine dikey değil, yatay olarak kullanmıştır. Doğu kültürüne olan ilgisi ve keşifleri sayesinde doğu- batı müzik öğelerinin birlikte kullanılmasından yana olmuştur. Debussy çoğunlukla piyano için besteler üretmiştir. Piyanoda pedal kullanımını sanatsal bir boyuta taşımıştır. Onun piyano yazısında kullandığı pedal, armonik katmanları harmanlayarak adeta resimdeki fırça darbelerinin yumuşak geçişlerini andıran bir etki oluşturur. İlk kez üç porteli piyano yazısını, Debussy bestelemiş ve piyano tekniğine yeni bir yön vermiştir. Sanatı küçük detaylar içinde işlemeyi sevmesinden dolayı, müziğinde küçük duraklamalara ve oldukça yumuşak dinamiklere önem vermiştir. Müziğin ses kadar sessizliği de vurgulamasından yana olmuştur. Ritmik kalıplar yerine doğal ve dalgalı ritimleri kullanmıştır. Piyanoya kattığı yenilikçi armoni dili, pedal kullanımı ve melodik işleyişi hem kendi döneminde hem de sonrasında pek çok besteciyi derinden etkilemiştir. Debussy, piyano müziginde o zamana kadar bilinen müzikal cümle yapisini değiştirmiştir. Ondan önce müzikal cümle, armonik bağlantilarla anlam kazanırken, Debussy sayesinde her cümle, her akor, her motif kendi içinde bir anlam sahibi olmuştur.
Anahtar Kelimeler: İzlenimcilik, Debussy, Piyano

CLAUDE DEBUSSY'S PIANO MUSIC

ABSTRACT
Impressionism emerged in the art of painting in the late 19th century, led by major painters such as Monet, Degas, and Renoir. By bringing out vague lines with plays of light, the images they depicted behind water droplets or fog also inspired composers. During the same period, symbolism emerged in poetry as a movement that used symbols to describe the effects and impressions of the outside world on individuals. Claude Debussy, who represented both movements in music, is an important milestone in 20th-century music history. His interest in painting, architecture, and literature nourished his unique musical creativity. Moving away from the intense emotionality of the Romantic period, he relaxed the strict rules of classical harmony, used pentatonic and whole tone scales without concern for function, and gave his music a hazy tone. He used whole tone scales horizontally rather than vertically, contrary to convention. Thanks to his interest in and exploration of Eastern culture, he favored the use of both Eastern and Western musical elements. Debussy composed mostly for the piano. He

elevated the use of the pedal on the piano to an artistic dimension. The pedal he used in his piano writing blends harmonic layers, creating an effect reminiscent of the soft transitions of brushstrokes in a painting. Debussy was the first to compose for a three-pedal piano, giving a new direction to piano technique. Because he loved to work on his art in small details, he emphasized small pauses and very soft dynamics in his music. He emphasized the silence of music as much as its sound. He used natural and undulating rhythms instead of rhythmic patterns. The innovative harmonic language he brought to the piano, his use of the pedal, and his melodic approach deeply influenced many composers both during his own time and afterwards. Debussy changed the musical sentence structure that had been known in piano music up until that time. Before him, musical sentences gained meaning through harmonic connections, but thanks to Debussy, each sentence, each chord, and each motif gained meaning in and of itself.

Keywords: İmpressionism, Debussy, Piano

ASSESSING PEARL MILLET'S HEALTH BENEFITS IN SEMI-ARID REGIONS: IMPACT OF TRICKLING FILTER-TREATED WASTEWATER IRRIGATION

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Abstract
The goal of this work was to investigate the effect of treated wastewater irrigation on the physiological and agronomic properties of *Millets area major source human food and are an excellent source of all essential nutrients like protein ,carbohydrates, fat, minerals,and bioactive compounds*. An experimental reuse study was performed using raw (RWW) and treated urban wastewater (TWW) by Trickling Filter (TF) process to irrigate Millet in comparison to well water (WW) as a control over a period of 5 months. The water quality was determined for irrigation based on sodium adsorption ratio (SAR), sodium percentage (Na %) and residual sodium carbonate (RSC) indicating that all treatments were suitable for irrigation purposes. In this study, we also assessed the agro-physiological and biochemical proprieties of the crops. Hence, the highest productivity of millet and leaf area were obtained in response to irrigation with RWW and TWW compared to WW; while macro-elements (TP, TKN, and K) were also affected in millet irrigated with RWW compared to TWW and WW. However, the plants irrigated with well water accumulate more Ca, Na, and Mg than those irrigated with RWW and TWW. All the crops irrigated with three water treatments showed a relatively similar concentration of micro-nutriments. The prevalence of total chlorophyll content in the plants increased with well water irrigation. Nevertheless, the biochemical parameters (protein and sugar content) were adversely affected in millet irrigated with RWW as compared to TWW and WW. Moreover, the use of treated urban wastewater improves the physicochemical properties and fertility of the soil compared to well water and enhances crop productivity.
Keywords: *Millet;* irrigation; treated wastewater reuse; physiological proprieties; Trickling Filter.

PROCESSES FOR OLIVE MILL WASTE WATER TREATMENT

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Abstract
The olive mill waste water (OMWW) are effluents issued from the extraction of olive oil, these effluents are cloudy-looking liquids with a reddish-brown color, their pH varies from 4 to 5. They are very rich in polyphenols, which causes many environmental problems, such as water pollution, Currently, on an industrial scale, there is no reliable, efficient, and less expensive technique for OMWW treatment. OMWW are evaporated in watertight basins or discharged into watercourses. Several techniques have been studied to treat these industrial effluents. The objective of this work was to compare these studies to formulate the recommendations that can be adopted for an effective and cheaper treatment of these effluents which constitute a major environmental problem for water resources. Indeed, it can be concluded that it is very difficult to treat OMWW by conventional methods due to its non-biodegradability and high cost of others methods like distillation and oxidation. In the end, it was concluded that for a better OMWW treatment, it is necessary to start firstly by the adsorption of phenolic compounds which are responsible for the non-biodegradability of OMWW while using cheaper adsorbents namely clays, bio-adsorbents or apatites, then dilute the OMWW with domestic wastewater. The dilution of OMWW by urban wastewater leads to good mineralization of organic matter by enriching the medium with microorganisms, which facilitates the elimination of the organic load and then we use the usual techniques as a plant filter or active sludge for mixture treatment.
Keywords: OMWW, phenolic compounds; organic matter; treatment; adsorption.

COSMALYZE: YAPAY ZEKA DESTEKLİ KOZMETİK ANALİZ UYGULAMASI

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ÖZET

Kozmetik alanındaki pek çok uygulama yalnızca ürün içerik listesini, markanın cruelty-free veya vegan olup olmadığını göstermeye odaklanmaktadır. Kullanıcıların kozmetik ürün içeriklerini daha iyi anlamalarını, değerlendirmelerini ve bilinçli tercihler yapmalarını sağlamak amacıyla mobil tabanlı yapay zeka (YZ) destekli bir uygulama olan Cosmalyze geliştirilmiştir. Cosmalyze; Barkod Tarama, Metin Tanıma ve YZ ile Ürün İçerik Açıklama ismindeki üç ana modülün entegre bir biçimde çalıştırılmasıyla derinlemesine ürün içerik analizi sunmaktadır.

Barkod Tarama modülünde Google ML Kit kullanılarak mobil cihaz kamerası üzerinden elde edilen barkod verisi, Kotlin ile geliştirilen mobil uygulama aracılığıyla .NET 9 tabanlı RESTful API'ye iletilmektedir. Bu API, yüksek performanslı SQLite veritabanı üzerinden ürün bilgilerini hızlı ve güvenilir şekilde sunmaktadır. Metin Tanıma modülü, ürün ambalajlarındaki içerik listesini algılar ve metne çevirmektedir. Bu içerik daha sonra Gemini AI destekli modülüne aktarılır sonuçlar kullanıcıya uygulama üzerinde gösterilmektedir. Uygulama içerisine entegre edilen sohbet botu, klasik bilgi gösteriminin ötesine geçerek kullanıcı ile etkileşim kurmakta, içeriklerin potansiyel alerjen özelliklerini ve içerdiği zararlı mikroplastiklerin sağlık üzerindeki etkilerini değerlendirmeli biçimde açıklamaktadır. Açıklamalı bir şekilde tüm içeriklere değinme diğer uygulamalarda olmayan bir özelliktir.

Cosmalyze'ın en özgün yönlerinden biri, cruelty-free ve vegan etiketlerinin doğruluğunu Leaping Bunny ve PETA gibi uluslararası sertifikasyon kuruluşlarının sonuçları ile karşılaştırarak analiz edebilmesidir. Bu yönüyle, sadece bilgilendirici değil, aynı zamanda onaylı ve güvenilir bir analiz sunmaktadır. Uygulama ayrıca kullanıcıların ürünleri içerik, marka veya barkod bazlı aramasına ve önceki sorgularını kolayca yeniden görüntülemesine olanak tanımaktadır. Gerçekleştirilen performans testlerinde barkod aramada ortalama 68 ms yanıt süresi elde edilmiş; Metin Tanıma doğruluk oranı %94, sohbet modülünde içerik tanımlama başarısında ise %92 oranı görülmüştür.
Sonuç olarak Cosmalyze, özellikle sağlık ve etik değerlere önem veren kullanıcılar için hızlı, güvenilir ve şeffaf bilgi sağlayan yenilikçi bir karar destek sistemi olarak geliştirilmiştir. YZ teknolojilerinin bu düzeyde entegrasyonu, piyasadaki uygulamalardan farklı olarak sadece bilgi sunmakla kalmayıp aynı zamanda analizler ve uyarılarla daha sağlıklı tercihler yapılmasını sağlamaktadır.
Anahtar Kelimeler: Kozmetik, Yapay Zeka, Barkod Tarama, Metin Tanıma, REST API, SQLite, Gemini AI, Ürün İçerik Analizi, Mobil Uygulama

COSMALYZE: AN AI-SUPPORTED COSMETIC ANALYSIS MOBILE APPLICATION

ABSTRACT
Many applications in the cosmetics field focus primarily on displaying product ingredient lists or indicating whether a brand is cruelty-free or vegan. To help users better understand cosmetic product ingredients, evaluate them, and make informed decisions, Cosmalyze, a mobile artificial intelligence (AI) supported application, has been developed. Cosmalyze offers detailed product content analysis by integrating three core modules: Barcode Scanning, Text Recognition, and AI-supported product Ingredient Explanation.
In the Barcode Scanning module, barcode data captured using Google ML Kit through the mobile device camera is sent via a mobile application developed in Kotlin to a RESTful API built with .NET 9. This API efficiently retrieves product data from a high-performance SQLite database. The Text Recognition module extracts the ingredient list from product packaging and converts it into text, which is then processed by the Gemini AI-supported module. The results are displayed to the user within the application. A built-in chatbot provides interactive and interpretive explanations, particularly focusing on potential allergens and harmful microplastics, offering a comprehensive ingredient overview not available in similar applications.
One of Cosmalyze's most distinctive features is its ability to verify cruelty-free and vegan labels by cross-referencing data from international certification bodies such as Leaping Bunny and PETA. The application also allows users to search for products by ingredient, brand, or barcode and to easily revisit previous queries. Performance evaluations revealed an average barcode scanning response time of 68 ms, 94% accuracy in text recognition, and 92% success in ingredient explanation via the chatbot.
In conclusion, Cosmalyze has been developed as an innovative decision support system that provides fast, reliable, and transparent information, particularly for users who prioritize health and ethical values. Unlike conventional applications that just display product data, Cosmalyze leverages advanced AI integration to deliver in-depth analyses and proactive alerts, empowering users to make significantly healthier and more conscious choices.
Keywords: Cosmetics, Artificial Intelligence, Barcode Scanning, Text Recognition, REST API, SQLite, Gemini AI, Ingredient Analysis, Mobile Application

Introduction

Cosmetic products today have become an important part of many people's daily self-care routines. But with so many options available, choosing the right product can be confusing and even risky, especially for those with allergies or specific skin concerns. The presence of various chemicals, potential allergens, or ingredients unsuitable for specific skin types may lead to adverse dermatological effects or health complications. This situation underlines the need for intelligent guidance systems that can support users in making informed and safe decisions. This study explores how an AI-supported chatbot, along with barcode scanning and text recognition features, integrated into the Cosmalyze mobile application addresses this need.

Our chatbot module within our Cosmalyze app is a solution designed to help users manage their makeup routine, analyze product ingredients, and identify products that are suitable for their individual skin sensitivities. The AI chatbot developed within the app serves as an interactive digital assistant that offers both informative and instructive guidance. Especially, the addition of the allergen testing feature transforms the app into an application that can also provide guidance on health. Furthermore, barcode scanning operations are critical for certain applications in mobile app development, enabling users to quickly access product information. The mobile application Cosmalyze was also created to include text recognition technology, allowing users to quickly examine the ingredient lists of cosmetic products. By scanning product labels, users can quickly determine whether any potential allergens or undesirable substances are present.

In this context, the main research questions addressed in this study are as follows:

- To what extent can an AI chatbot assist users in selecting cosmetic products?
- Can allergen tests conducted via chatbot enhance user safety?
- How might such a system transform users' makeup routines?
- How do barcode scanning and text recognition capabilities enhance user interaction and product information retrieval in a cosmetic application?
- What are the performance implications of integrating ML Kit, SQLite, and ASP.NET 9 for these features?

The chatbot feature of the application was developed using Kotlin Generative AI SDK and the Gemini AI framework. The system works through predefined initial prompts that direct the chatbot to user inputs. The goal of this feature in the app is to provide targeted results to the user. The barcode scanning and text recognition features were implemented using ML Kit for Android, with backend data management handled by ASP.NET 9 and SQLite.

In the process of developing these features of our project and writing the documentation, we used the documentation of the Gemini API, Kotlin Generative AI libraries, Google ML Kit, and Android Developers.

Related Studies

In the last few years, beauty technology apps have changed and now focus more on what people need. These changes often involve using data to give better suggestions. AI recommendation systems are commonly used to personalize skincare and cosmetic product suggestions. While many tools analyze skin types or use visual recognition, few explore how product ingredients relate to individual health needs or allergies. Additionally, beauty apps often use rule-based chatbots that offer limited, non-personalized responses and cannot fully understand users' needs. Many platforms also provide only general ingredient info, without evaluating how those ingredients may affect each user personally.

Mobile applications have long used text recognition (Optical Character Recognition, or OCR) technology for tasks like content analysis, document scanning, and information delivery. Tesseract OCR and Firebase Vision are two of the most popular apps on the Android platform. Despite being a multilingual, open-source library, Tesseract can be difficult to integrate in mobile settings and may cause performance problems on modern devices. Additionally,

compatibility issues with newer frameworks have resulted from the end of version updates. When selecting libraries for barcode scanning, compatibility with the Android platform, seamless operation on existing Android versions, and continuous support through security patches and performance improvements were prioritized.

The chatbot, barcode scanning, and text recognition extensions developed within the Cosmalyze application address these shortcomings. While we tried different methods for this, such as using API instead of SDK for the chatbot, that option didn't store and count the previous messages, so we chose SDK as it checks the previous messages and helps consider those as well. As for AI, we chose Gemini as it is easier to implement using the SDK and it costs less than the other AI APIs while developing. Powered by the Kotlin Generative AI SDK and Gemini AI integration, the system enables natural and informative conversations, offering insights into cosmetic product ingredients relating to users' personal needs. One special feature of the system is that it can perform allergen testing according to specific user problems or the user's specified product within the chatbot. This feature distinguishes our chatbot from existing systems in the literature. For barcode scanning and text recognition, Google's actively maintained ML Kit library was chosen following the beginning of Tesseract testing because of its smooth Android ecosystem integration. The decision to use Kotlin to build the system natively was additionally affected by an evaluation of the compatibility and performance problems that hybrid solutions like React Native caused when used for OCR tasks. Using an on-device and user-centric approach, the Cosmalyze project offers a modern and useful example of how text recognition technology can be effectively integrated into modern Android applications.

Cosmetic Analysis Platform Comparison

This analysis compares four major platforms in the cosmetic safety and analysis space with Cosmalyze's AI-supported approach to ingredient analysis and product recommendations.

PETA Beauty Without Bunnies Program

PETA's Beauty Without Bunnies operates as a basic certification database covering over 6,300 companies across four countries. The platform provides simple barcode scanning through their "Bunny Free" mobile app that links to company certification status rather than analyzing individual products.

The system offers binary certification status without ingredient-level analysis or personalization features.

Compared to Cosmalyze, PETA's approach represents a static database lookup versus dynamic AI-supported analysis. While PETA provides cruelty-free verification, Cosmalyze's Gemini AI integration enables real-time ingredient analysis, personalized allergen testing, and comprehensive safety assessment regardless of certification status.

Leaping Bunny Certification (CCIC)

The Coalition for Consumer Information on Cosmetics maintains the gold standard for cruelty-free certification with 2,300+ certified companies and rigorous third-party auditing processes. The program requires annual recommitment, supplier monitoring, and independent audits for larger companies.

The certification process demonstrates thoroughness with fixed cut-off dates, supply chain verification, and comprehensive documentation requirements. However, technological capabilities remain limited, with basic mobile apps providing simple barcode scanning and company searches.

Cosmalyze's ML Kit integration enables evaluation of any product through real-time analysis, while Leaping Bunny cannot offer personalized allergen testing or predictive safety assessments that define next-generation platforms.

Beat the Microbead Campaign (Plastic Soup Foundation)

The Plastic Soup Foundation's Beat the Microbead campaign focuses specifically on microplastic detection, achieving 19 country legislative bans and commitments from 448+ brands.

The platform utilizes advanced OCR technology with real-time ingredient scanning. The four-step scanning process provides practical functionality for microplastic identification.

Despite technological competence, significant limitations include scanning accuracy issues, limited database coverage for international products, and a single issue focus that constrains broader application. Cosmalyze's comprehensive approach addresses these constraints by enabling simultaneous analysis of safety concerns, allergens, effectiveness, and ethical considerations through integrated AI technologies.

By Smart Shield App

Based on available research, the "By Smart Shield" app appears to be part of the broader competitive landscape that includes major platforms like Yuka (55+ million users), OnSkin, Think Dirty, and SkinSAFE. These platforms typically focus on basic ingredient scanning and database lookup functions.

Current market leaders demonstrate sophistication in barcode scanning technology and maintain large product databases with scientific research backing. However, critical gaps persist, including limited conversational AI interfaces, basic personalization through simple questionnaires, and dependence on pre-populated databases rather than live analysis.

Technology integration represents the key differentiator. While competitors use single-technology approaches such as basic barcode scanning or photo analysis, Cosmalyze's integration of Kotlin Generative AI SDK, Gemini AI, ML Kit, ASP.NET 9, and SQLite creates unprecedented analytical capabilities within a unified platform.

Methodology / Approach

In this section, we present the architecture, technologies, integration process, and experimental setup of the AI chatbot, barcode scanning, and text recognition features developed for the Cosmalyze mobile application. The chatbot was designed to assist users in managing their makeup routines, analyzing product ingredients, and supporting allergen testing. The barcode scanning and text recognition features aim to provide quick product information and ingredient analysis.

To achieve these goals, a large language model with natural language processing (NLP) capabilities, Gemini AI, was integrated into the mobile application via the Kotlin Generative AI SDK. The primary functions of the chatbot can be summarized as follows: it provides personalized recommendations based on the user’s skin type, preferences, and daily needs; offers step-by-step guidance for specific makeup looks; and informs and guides users regarding allergen tests. ML Kit was integrated for on-device barcode scanning and text recognition. The backend for product information was developed using ASP.NET 9 and SQLite.

Technologies and Models Used

The chatbot uses the gemini-1.5-flash model, configured with the following system instructions and safety settings:

Pseudocode:

```
INITIALIZE GenerativeModel WITH:
  modelName: "gemini-1.5-flash"
  apiKey: <API_KEY>
  systemInstruction:
    "You are Cosmalyze, a virtual makeup assistant dedicated to helping users...
    ...Always prioritizing the user’s safety and satisfaction."
  safetySettings:
    - Block Harassment: MEDIUM_AND_ABOVE
```

- Block Hate Speech: MEDIUM_AND_ABOVE
- Block Sexually Explicit: MEDIUM_AND_ABOVE
- Block Dangerous Content: MEDIUM_AND_ABOVE

The objective of the model configuration is to deliver a safe and empathetic user experience. Robust safety settings have been implemented to prevent the generation of harmful, offensive, or unsafe content.

For barcode scanning and text recognition, ML Kit from Google was used. This library offers on-device processing, ensuring low latency and offline functionality, which were key requirements for Cosmalyze.

Application Details

The chatbot functionality is implemented through a ViewModel layer, specifically in a class named AssistantViewModel. This class maintains the chat history and handles the communication between the user and the Gemini AI model. The user interface is connected to this structure via StateFlow, enabling real-time updates.

Pseudocode for Chatbot:

DEFINE AssistantViewModel:
  INITIALIZE chat WITH predefined welcome message
  STORE chat history AS StateFlow
  ON user sends message:
    - Append message to UI state
    - Send message to Gemini chat
    - Append AI response to UI state

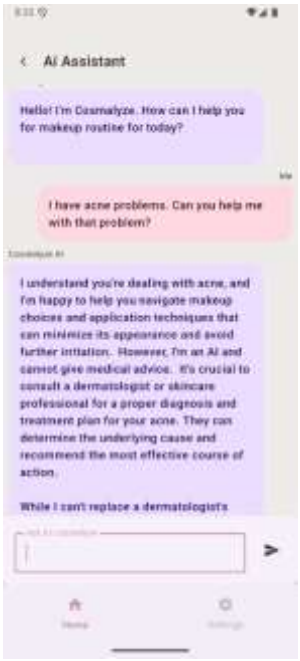

Figure 3.1: Cosmalyze in-app chatbot

The model processes each user message and generates meaningful, context-aware responses. Error states are communicated transparently to ensure a reliable and user-friendly interaction.

Barcode Data Recognition Process

The application is configured to continue scanning all detected barcodes as long as the camera is open. This allows users to perform the scanning process without manual intervention for each new barcode. The scanned barcode data transmits information to the user, provided by the database created using .NET Entity Framework.

SQLite Preference in Cosmalyze

Cosmalyze prioritizes SQLite for its data management due to the application's need for instantaneous data storage following operations like barcode scanning and text recognition. SQLite's lightweight, embedded, and file-based nature facilitates easy and rapid integration, enabling high read/write performance and ensuring immediate data processing. Its ACID compliance further guarantees data integrity and reliability. While SQLite is an ideal solution for smaller applications like Cosmalyze, given its efficiency and low resource consumption, larger projects with more extensive demands might consider alternatives such as PostgreSQL or MySQL.

Cosmalyze Backend Architecture: ASP.NET 9 Usage

Cosmalyze's backend architecture is built on ASP.NET 9 because it offers a powerful and modern foundation for web and API applications. This choice provides several key advantages: high performance for faster and more efficient operations, a strong security framework utilizing the latest protocols for data protection, and a modular and flexible architecture that simplifies custom component development. Furthermore, ASP.NET 9 ensures low latency for real-time data processing, scalability to handle increasing user loads, and a developer-friendly structure thanks to its large community and comprehensive documentation, making maintenance straightforward.

UPC Search on Backend and Database Side

The endpoint api/Products/SearchByUPC?upc=productUPC takes a UPC (Universal Product Code) by the query string and first searches for a product that exactly matches this UPC in the Products table. If a product with a UPC field matching the scanned UPC is found, this product is converted to a DTO and returned with a 200 OK response.

If no matching product is found, a search is then performed using the UPCPrefix field in the Brands table, and it is checked whether the incoming UPC starts with any brand's defined prefix. This allows the brand to be identified even if a specific product is not in the database. If a matching brand is found, this is also converted to a DTO and returned.

If neither a product nor a brand is found, the endpoint returns a 404 Not Found response. If an unexpected error occurs during the process, this error is logged, and a 500 Internal Server Error response is given.

UPC Product or Brand Search Algorithm (Pseudo Code)

The following algorithm describes the logic of a web API that checks whether a product exists in the system based on its UPC (Universal Product Code) value and returns the result. If the product is not found, it attempts to identify the brand based on the UPC prefix.

```
FUNCTION SearchProductByUPC(upc: string) RETURNS BrandDto OR HTTP Response
  TRY
    // 1. Search for the product with the exact UPC
    product := FIND FIRST Product WHERE Product.UPC == upc
    IF product IS NOT null THEN
      RETURN HTTP 200 OK WITH product DTO
    // 2. If no product, search for brand by UPC prefix
    brand := FIND FIRST Brand WHERE upc STARTS WITH Brand.UPCPrefix
    IF brand IS NOT null THEN
      RETURN HTTP 200 OK WITH brand DTO
    // 3. If no match found
    RETURN HTTP 404 Not Found
  CATCH exception
    // 4. Log the error and return a system error
    LOG the exception with message "Error occurred while searching product by UPC"
```

RETURN HTTP 500 Internal Server Error
END FUNCTION

Product or Brand Search Algorithm with UPC mobile site (Pseudo Code)

The findByUpc function fetches product details by UPC, capitalizing the product and brand names and handles errors by returning null if something goes wrong. The BarcodeScannerViewModel class manages loading and product data states. It has an isLoading state to track the loading status and a content state to store the product details. The findProduct function launches a coroutine to fetch the product data using findByUpc, setting isLoading to true during the fetch and false once done.

Define function "findByUpc" to request a product by UPC:
  Input: UPC (string)
  Try:
    Call API client to fetch product data using the given UPC
    Modify the result:
      - Capitalize the first letter of the product name
      - Capitalize the first letter of the brand name (if exists)
    Return the modified result.
  Catch errors:
    Print the error message
    Return null
Define "BarcodeScannerViewModel" class:
  Declare a private state variable "_isLoading" to indicate loading status (Boolean)
  Declare a public state variable "isLoading" to expose the loading status
  Declare a private state variable "_content" to store the fetched product details (FindProps?)
  Declare a public state variable "content" to expose the product details
  Define function "findProduct" to fetch a product based on UPC:
    Input: UPC (string)
    Launch a coroutine in the viewModelScope:
      Set _isLoading to true (start loading)
      Call the "findByUpc" function with the given UPC and store the result in "_content"
      Set _isLoading to false (end loading)



Figure 3.2: Cosmalyze barcode scanner in app screenshot

Text Recognition Process

The Text Recognition module from Google's ML Kit library is used in the Cosmalyze application to perform text recognition. The application was created using Kotlin, and the following pseudocode encapsulates the system's main workflow:

1. Initialize text recognition engine textRecognizer = TextRecognitionClient.defaultOptions()
2. Load image from an in-app resource imageBitmap = LoadImageFromResources("örnek_görsel")
3. Convert image to a format compatible with the recognition engine inputImage = ConvertToInputImage(imageBitmap)
4. Process the image and extract text

```
textRecognizer.process(inputImage)
if success:
  recognizedText = ExtractRecognizedText()
  DisplayTextToUser(recognizedText)
else:
  LogError()
```



Figure 3.3: Cosmalyze in-app text recognition

The method involves using the InputImage class to transform bitmap data from an image source into a format that can be recognized, and then using ML Kit to analyze the data. The user is then instantly presented with the identified text within the application.

AI Chatbot Integration with Text Recognition

An AI chatbot built on the Google Gemini API has been incorporated into the system to offer a contextual analysis of the scanned content. After analyzing the detected content, this chatbot warns users of possible allergens and dangerous materials. As a result, the system offers an analysis of the content in addition to text recognition.

Experimental Setup

The chatbot system was integrated into a Kotlin-based mobile application framework. The experimental implementation involved the following stages. The Gemini AI model was configured using the Kotlin SDK and successfully tested in a controlled environment. Initial Prompt Testing: predefined welcome messages and sample interactions were tested for correctness and user alignment. Various user scenarios, like daily makeup for sensitive skin, glam look recommendation, were used to evaluate the model’s contextual response quality. The model's ability to inform users about allergen risks was analyzed in terms of compliance with health protocols. Barcode scanning functionality was tested across various product types and

lighting conditions. Text recognition was tested with different fonts, sizes, and image qualities to assess accuracy.

In conclusion, the developed system demonstrates that AI-supported, personalized experiences, alongside efficient data retrieval and analysis, are feasible within the domain of cosmetic technology. The success of the chatbot, barcode scanning, and text recognition features was evaluated based on user feedback and test results, both of which yielded positive outcomes.

Results

Chatbot Performance

To understand how well the Cosmalyze chatbot performs, we looked at data from Google Console. We focused on how fast the system responded (latency), how much it was used (traffic), and how often errors happened.

Response Time

The chatbot had a median response time of 1572 milliseconds, and 95% of the responses were under 4057 milliseconds. While there were some delays early on, the system became faster over time. The responses were almost instant, showing that the system had been optimized well.

Usage (Traffic)

There were 37 requests sent to the chatbot during the test period. Usage was steady, with more activity seen. This helped us test the chatbot under different levels of use.

Errors

The overall error rate was 13%. Most of the errors happened in the early days of testing, with one day showing a 100% error rate. However, the error rate dropped to nearly zero by the end of the testing period, showing that the system became more stable with improvements.

In summary, the Cosmalyze chatbot responded quickly, handled requests smoothly, and showed fewer errors over time. These results suggest that the system is working well and is ready for future use.

Barcode Scanning and Backend Performance

The architecture used in the Cosmalyze project serves as a guide for barcode scanning applications by providing low latency and fast responses. On the backend, there is a dataset stored in an SQLite database containing thousands of product and brand records. This enables high accuracy in barcode matching and allows instant information delivery to users.

Table 4.2: Cosmalyze API Response Performance Metrics

Endpoint	Status	Size	Response
Find?name=pure&pageNumber=1&pageSize=10	200	18.0 kB	207 ms
Find?name=pure&pageNumber=1&pageSize=100	200	30.8 kB	455 ms
Products/SearchByUPC?upc=867	200	399 B	68 ms
Products?pageNumber=1&pageSize=10	200	13.5 kB	299 ms
Products?pageNumber=1&pageSize=100	200	118 kB	347 ms
Products?pageNumber=1&pageSize=1000	200	1.1 MB	996 ms

We were able to obtain substantial speed increases in all operations during the performance tests, especially when filtering and pagination, and it was due to some optimizations facilitated on the .NET API. Using the right Entity Framework calls, like FirstOrDefaultAsync, AsNoTracking, Take, Skip, and Select, drastically limited the memory footprint for each call and the time taken to retrieve that data. After applying filters at the Find endpoint, we achieved fast and high-performance responses with small data sets. Direct queries, such as Products/SearchByUPC for barcode-based product searches, returned results in an exceptionally fast 67 ms. In our pagination tests, when we paged with size ten, we were

approximately 250 ms; for size 100, it was approximately 400 ms; and for size 1000, it was around 996 ms. As demonstrated with these test results, we are performing in a balanced and stable manner with both small and larger data sets. This also shows how well-managed pagination and optimized database queries contribute positively to performance. (All times and performance measurements are indicated by the tests performed in the live API hosted on an AWS server.)

Text Recognition Performance

The application does not currently have any numerical performance metrics available for text recognition. But according to developer testing, the on-device version of ML Kit offers successful outcomes and high text recognition accuracy, particularly for content that is clear and easy to read. By automating the process of understanding content, the AI chatbot integration has also greatly improved the user experience.

Discussion

This study investigated the integration of an AI chatbot, barcode scanning, and text recognition into a domain focused on makeup and skin health products. Findings show that the chatbot significantly contributes to user guidance, product selection, and allergen awareness. The barcode scanning and text recognition features further enhance the user experience by providing quick access to product information and detailed ingredient analysis. However, it is crucial to critically evaluate the technical parts used in the direction of these results, acknowledge potential limitations, and identify areas for future development.

Interpretation of Results

Analyses show that users found the Cosmalyze chatbot's recommendations both useful and trustworthy. In particular, the use of empathetic language and personalized guidance positively influenced user experience. By limiting the initial prompt we use in our natural process language model and providing extra information, we aimed to reduce the error rate as low as possible in sensitive issues such as allergen testing.

The barcode scanning functionality, coupled with the efficient ASP.NET 9 backend and SQLite database, delivered low latency and fast responses, significantly improving the user's ability to retrieve product information instantly. The strong performance metrics confirm the effectiveness of this architecture.

The text recognition system, powered by ML Kit, also proved successful in accurately extracting text from product labels, enabling on-the-spot ingredient analysis and allergen identification. The seamless integration of the AI chatbot with this feature further enhances the utility by providing contextual and informed feedback on the scanned content.

Limitations and Threats to Validity

Several limitations must be considered: The user testing for the chatbot involved a limited number of scenarios and user profiles, raising questions about the model's ability to generalize across diverse skin types and makeup preferences. The chatbot currently operates only in English, which may limit its performance across different cultural understandings of beauty and product preferences. The system does not provide medical diagnosis or treatment, and its guidance on allergen testing is purely informational and susceptible to misinterpretation. OCR accuracy is particularly impacted by decreased image clarity in low light or with complex fonts, which could affect the reliability of text recognition. The system might produce unrelated content when users scan texts other than product labels, which could result in inaccurate information if not properly filtered by the chatbot. These limitations represent potential threats to the generalizability of the results.

Implications and Applications

The success of this system demonstrates the practical value of AI in health-integrated personal care applications: The chatbot extends beyond traditional customer service by offering real-time, context-aware suggestions. Users may develop greater sensitivity to product ingredients,

promoting preventive awareness, especially among allergy-prone individuals. The system serves as a valuable guide for users lacking access to professional expertise. Barcode scanning provides an immediate and efficient way for users to learn about products. On device text recognition with ML Kit allows for quick analysis of ingredients even without an internet connection.

Future Work

Based on this study, future directions may include expanding the chatbot and text recognition to serve in various languages to reach a broader and more diverse user base. Incorporating camera-based skin analysis could enable more personalized and visual recommendations. User feedback could be used to continuously improve the system's performance, particularly for the AI model. Syncing with real-time product information from external APIs could improve the accuracy and breadth of recommendations and barcode search results. Implementing more sophisticated image processing methods to enhance text recognition performance in challenging lighting conditions. Developing more robust mechanisms for the chatbot to filter out irrelevant or out-of-context inputs from text recognition.

Conclusion

The Cosmalyze mobile application integrates Google's ML Kit with a mobile application developed with Kotlin. Text recognition, efficient barcode scanning, and a Gemini AI-supported chatbot represent a major advancement in combining real-time AI-driven analysis with personal care technology. Built using Gemini AI and the Kotlin Generative AI SDK, the system delivers personalized recommendations based on users' skin type, preferences, and needs, thereby enabling a more informed and user-centered product selection process. Moreover, by offering guidance on health-related aspects such as allergen testing and providing quick access to product information via barcode scanning and ingredient analysis through text recognition, it significantly contributes to user safety and convenience.

The approach presented by Cosmalyze demonstrates that AI chatbot systems, combined with effective data management and mobile vision technologies, can deliver useful application-specific targeted results thanks to predefined prompts and robust integration. In the context of beauty and personal care, there is a growing demand for interactive, customized, and reliable digital assistants. Early developer evaluations indicate promising functionality in terms of speed and accuracy across all integrated features. To increase robustness and usability in subsequent work, user assessments and performance benchmarking will be essential.

In conclusion, the key message of this study is that AI chatbot systems, when integrated with efficient data processing and mobile vision capabilities within an appropriate and ethical framework, can become informative, safe, and enriching digital assistants. Their wider adoption has the potential to meaningfully transform digital personal care and health technologies.

The Cosmalyze application offers a comprehensive user experience that goes beyond existing ethical and environmental awareness platforms. Unlike the static information-based approach of the Plastic Soup Foundation regarding microplastic awareness, Cosmalyze utilizes Gemini AI technology to deeply analyze the potential health effects of microplastics found in product ingredients. Moreover, rather than focusing solely on cruelty-free and vegan product certifications as seen in applications such as PETA and Leaping Bunny, Cosmalyze provides real-time, personalized, and explanatory feedback through features such as barcode scanning, text recognition for ingredient analysis, and an AI chatbot. In this way, Cosmalyze distinguishes itself from competitors not only by presenting product data but also by delivering an interactive and multi-layered analytical experience.

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NUMERICAL EVALUATION OF REINFORCED CONCRETE BEAM–COLUMN CONNECTIONS UNDER MONOTONIC LOADING WITH VARIABLE REINFORCEMENT AND CONCRETE STRENGTHS

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Abstract
This study presents a comprehensive numerical investigation into the monotonic structural response of reinforced concrete (RC) beam–column joints by evaluating the influence of varying concrete compressive strengths and reinforcement grades. Finite element models were developed using ANSYS Mechanical APDL 2020 R2 and validated against experimental results from the literature. A parametric study was conducted by varying the concrete strength (31.6 MPa and 40 MPa) and three types of longitudinal reinforcement (HRB400, ASTM A1035, and B500B). Stress and strain distributions, load–displacement behavior, and energy dissipation capacities were analyzed. The results indicate that the combined use of higher-strength concrete and advanced reinforcement significantly improves joint performance in terms of strength, ductility, and energy absorption. The findings contribute to a deeper understanding of material-level design choices in enhancing the monotonic performance of RC joints, offering valuable guidance for performance-based seismic retrofit and design strategies.
Keywords: Reinforced Concrete, Beam–Column Joints, Finite Element Modeling, Monotonic Loading, Concrete Strength, Energy Dissipation

Introduction

The structural behavior of reinforced concrete (RC) beam-column connections has been extensively investigated due to their critical role in the overall seismic and lateral load resistance of frame structures. Numerous experimental and numerical studies have shown that the joint region is highly susceptible to brittle shear failures, particularly under inadequate detailing or non-seismic design provisions [1]–[3]. Recent research has highlighted that joint shear strength is influenced not only by material properties and geometric configurations but also by the interactions of axial loads and bending moments in the adjoining members [1].

Several studies have developed predictive frameworks using mechanics-based models, empirical relationships, and artificial intelligence techniques to estimate the shear strength and failure modes of RC joints. For example, implicit models grounded in design code recommendations have been formulated to estimate strut width and joint shear strength [1], while gene expression programming (GEP) has been employed to improve shear strength prediction accuracy under uniaxial and biaxial loadings [2]. Other works have examined the variability in predictions across different international seismic codes and proposed modifier-based approaches to harmonize them with experimental outcomes [3].

In recent years, the integration of machine learning (ML) into structural engineering has gained prominence. Adaptive simulations and hybrid data-driven approaches have shown significant promise in accurately predicting both shear strength and failure mechanisms of beam-column joints [4], [5]. Data-driven models such as multigene genetic programming (MGGP) and random forest regressors have outperformed conventional design equations in predictive accuracy, especially when trained on large experimental datasets [5].

From a practical design perspective, finite element simulations and parametric studies have been essential tools for evaluating the influence of reinforcement configurations, diagonal bar

placements, and axial load ratios on joint performance [6]–[8]. Several studies have demonstrated that novel reinforcement details—such as diagonal bars wrapped with steel tubes or unbonded diagonal reinforcements—can enhance seismic performance by improving energy dissipation, stiffness, and delaying the onset of shear cracking [6], [14].

Moreover, artificial neural network (ANN)-based prediction models have successfully estimated joint shear strength with higher accuracy compared to traditional methods [9], [10]. These models utilize various influencing parameters including reinforcement indices, joint dimensions, and concrete strength, and have shown strong correlation coefficients and low error metrics in validation stages.

Another important area of investigation has been the behavior of beam-column joints under degraded bond conditions or poor reinforcement detailing. It has been shown that external strengthening with FRP and techniques like grooving or anchorage improvement can recover or enhance the ductility and load-bearing capacity of deficient joints [11], [12].

Finally, multiple experimental studies have verified the effectiveness of high-strength materials such as high-strength steel (HSS) and steel fiber-reinforced concrete (SFRC) in mitigating failure risks and improving joint behavior under lateral loads [13], [15].

In the context of the present study, a monotonic loading scenario was adopted to evaluate the performance of RC beam-column joints with various reinforcement configurations, and the results were validated using finite element simulations conducted in ANSYS 2020 R2 [16]. The modeling approach was guided and benchmarked against previous experimental data, particularly that of Chalioris [17], to ensure the reliability of numerical outputs.

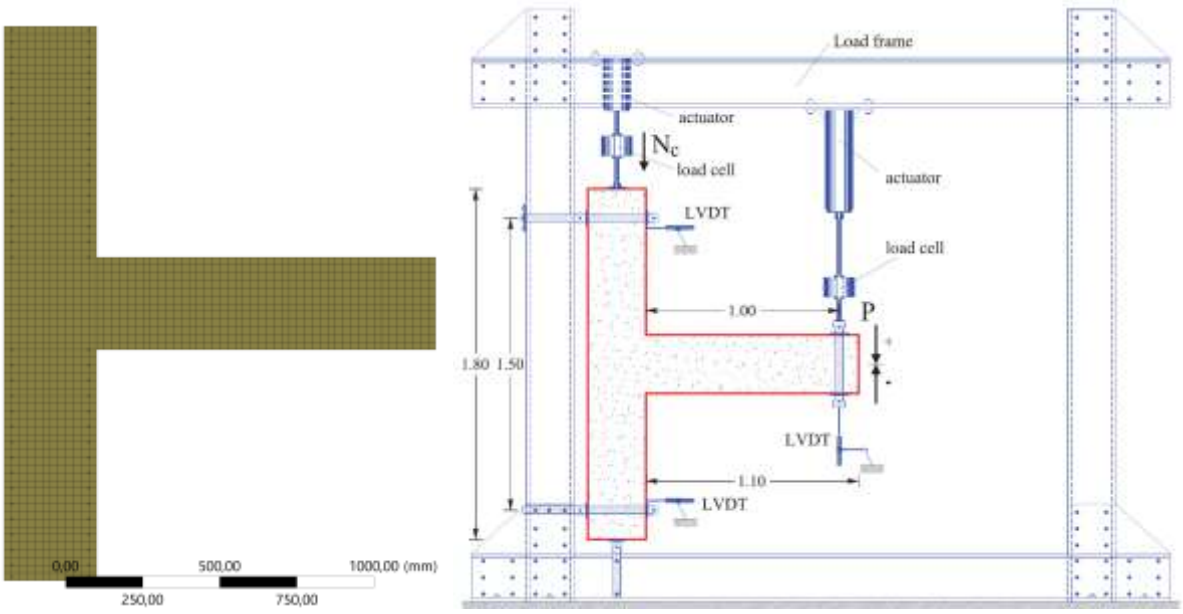
Numerical Modeling and Validation

In this study, three-dimensional finite element (FE) models of reinforced concrete beam-column connections were developed using ANSYS Mechanical APDL (2020 R2) [1]. The concrete material was modeled using a concrete plasticity model with softening behavior, while the longitudinal and transverse reinforcements were idealized as bilinear kinematic hardening steel. Material properties and geometrical dimensions were defined in accordance with the experimental setup reported by Chalioris [2].

The specimen geometry included a 1100 mm long reinforced concrete beam and a 1800 mm high column with rectangular cross-sections measuring 200 mm × 300 mm. Reinforcement detailing was defined based on experimental configurations, and the layout was modeled using embedded elements for the bars and discrete solid elements for the surrounding concrete.

Mesh discretization was performed using hexahedral elements with linear interpolation order, applying a uniform mesh size of 25 mm. A multi-zone meshing method was adopted to ensure mesh quality and compatibility across different regions of the model. The boundary conditions and load application were defined to replicate the experimental monotonic loading scenario. The column base was fully restrained, while the beam end was subjected to a gradually increasing lateral displacement to induce flexural and shear demand on the joint region.

Figure 1 presents (a) the finite element mesh topology across the joint region and (b) the boundary conditions and loading configuration applied to the model. The model's validity was assessed by comparing the numerical force-displacement response with the experimental results reported in the literature. The monotonic nature of the applied loading reflects the actual test conditions and ensures that the comparison remains consistent in both magnitude and deformation trends. The reinforcement detailing used in the numerical model, including longitudinal and transverse bar diameters for both the beam and the column, is illustrated in Figure 2.



a) a)

Figure 1. Shows (a) the mesh configuration and (b) the applied boundary conditions.

Validation of the numerical model was performed by comparing the finite element analysis (FEA) results with the experimental data reported by Chalioris [2]. As illustrated in Figure 3, the numerical model successfully captures the initial stiffness, peak load, and general shape of the load–displacement response. The slight deviation observed in the post-peak region can be attributed to idealizations in the model, such as the assumption of perfect bond and the absence of localized cracking effects. Despite these simplifications, the overall agreement confirms the reliability of the finite element approach for simulating the structural behavior of beam–column joints under monotonic loading.

The mechanical properties of concrete used in the numerical analyses are presented in Table 1, where two different compressive strength levels, C30 and C40, are considered. These material parameters were defined using the Drucker–Prager plasticity model in ANSYS.

The corresponding mechanical properties of the reinforcing steel bars, including different yield strengths and modulus of elasticity values, are listed in Table 2.

Table 1. Mechanical properties of concrete used in the numerical model.

Property	**C30**	**C40**
Concrete Grade	C30	C40
Elastic Modulus (MPa)	20000	30000
Poisson's Ratio	0,2	0,2
fuc (MPa)	31,6	42,1
fbc (MPa)	36,34	48,3
fut (MPa)	3	4
Rt	1	1
D	40000	40000
sigVc	-35	-35
R	2	2
gamt0	0	0
gamc0	0,00002	0,00002
betat	3000	3000
betac	2000	2000

Table 2. Mechanical properties of reinforcement steels used in the analyses.

Property	**B420C**	**B500C**
Rebar Grade	B420C	B500C
Elastic Modulus (MPa)	200000	200000
Poisson's Ratio	0,3	0,3
Yield Strength (MPa)	420	500
Ultimate Strength (MPa)	540	625

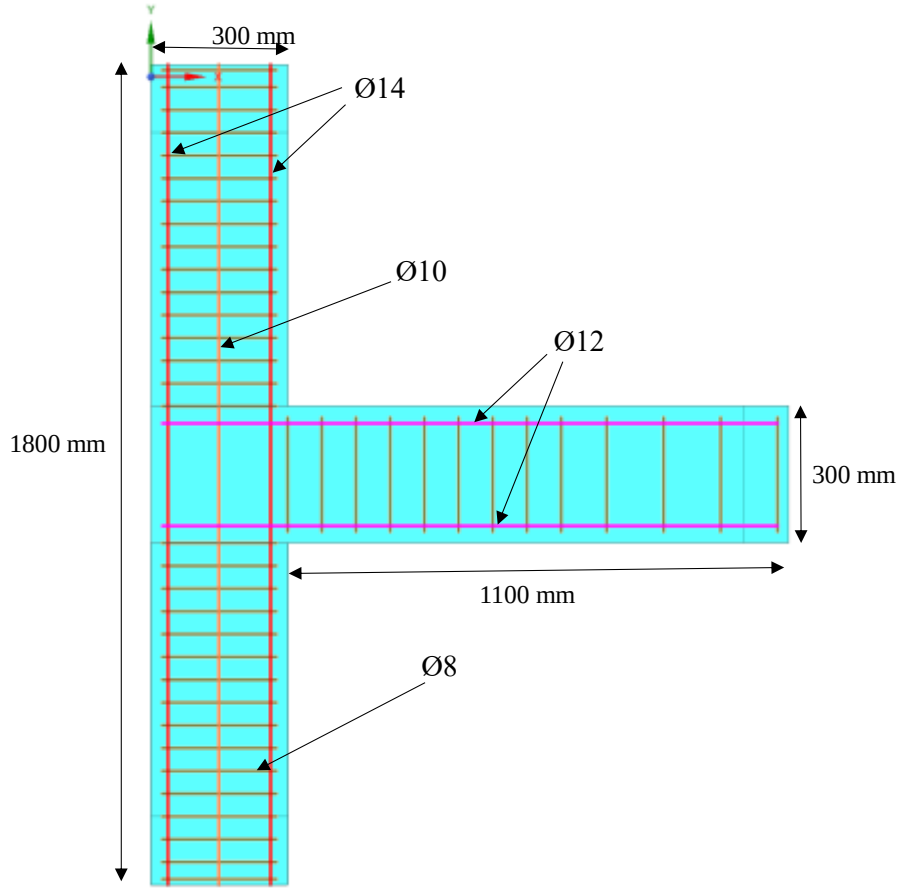


Figure 2. Reinforcement layout and bar diameters.

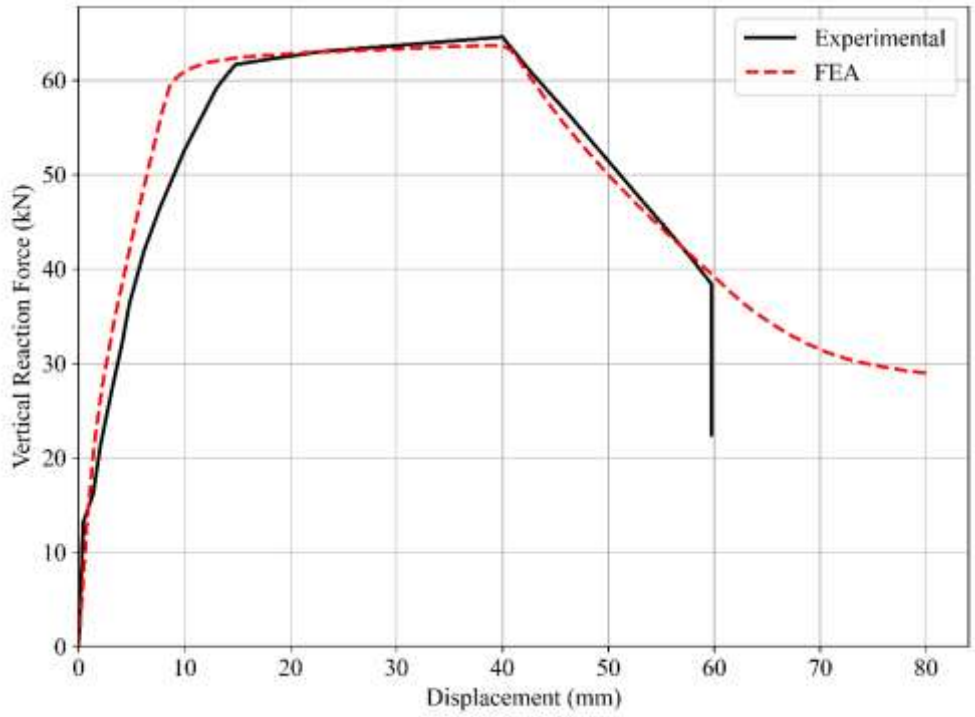


Figure 3. Comparison of experimental and numerical load–displacement curves.

Evaluation of Numerical Results

The finite element simulations provided detailed insights into the nonlinear behavior of the beam–column joint specimens under monotonic lateral loading. The distribution of stresses and strains enabled the identification of critical regions associated with joint degradation and failure. Stress concentration zones were observed primarily within the joint core and along the diagonal load paths between the beam and column faces, indicating the development of diagonal strut mechanisms.

In configurations with lower concrete strength (31.6 MPa) and conventional reinforcement (HRB400), earlier stress localization and higher strain accumulation occurred at lower displacement levels. In contrast, specimens incorporating higher-strength materials such as ASTM A1035 and B500B reinforcement, combined with 40 MPa concrete, exhibited more uniform stress distribution and delayed onset of plastic deformation, suggesting enhanced ductility and energy dissipation.

The equivalent von Mises stress plots confirmed that maximum stress values emerged near the beam–column interface and within the joint core. Principal strain contours demonstrated the gradual spread of inelastic deformation, crack initiation, and joint distortion, particularly in the tension zone of the beam and the upper joint region. These observations are consistent with experimental findings reported in the literature and validate the sensitivity of the numerical model to changes in material properties and reinforcement layout.

The overall response of each configuration reflected the combined influence of reinforcement grade and concrete compressive strength on the joint's ability to resist lateral deformation and maintain structural integrity. Increased material capacity contributed to improved stress redistribution and delayed cracking, particularly in the joint panel. Figure 4 and Figure 5 present the stress and strain analysis results for all simulated configurations, clearly illustrating the differences in mechanical response and damage development patterns. In addition to stress and strain evaluations, the overall mechanical performance of each configuration was quantified through their force–displacement behavior and corresponding energy absorption capacity. Figure 6 presents the area under the load–displacement curve for each specimen, serving as an indicator of ductility and energy dissipation potential. Figure 7 shows the full load–

displacement curves for all six configurations, clearly demonstrating the influence of both concrete compressive strength and reinforcement grade on structural stiffness, peak strength, and post-peak softening characteristics.

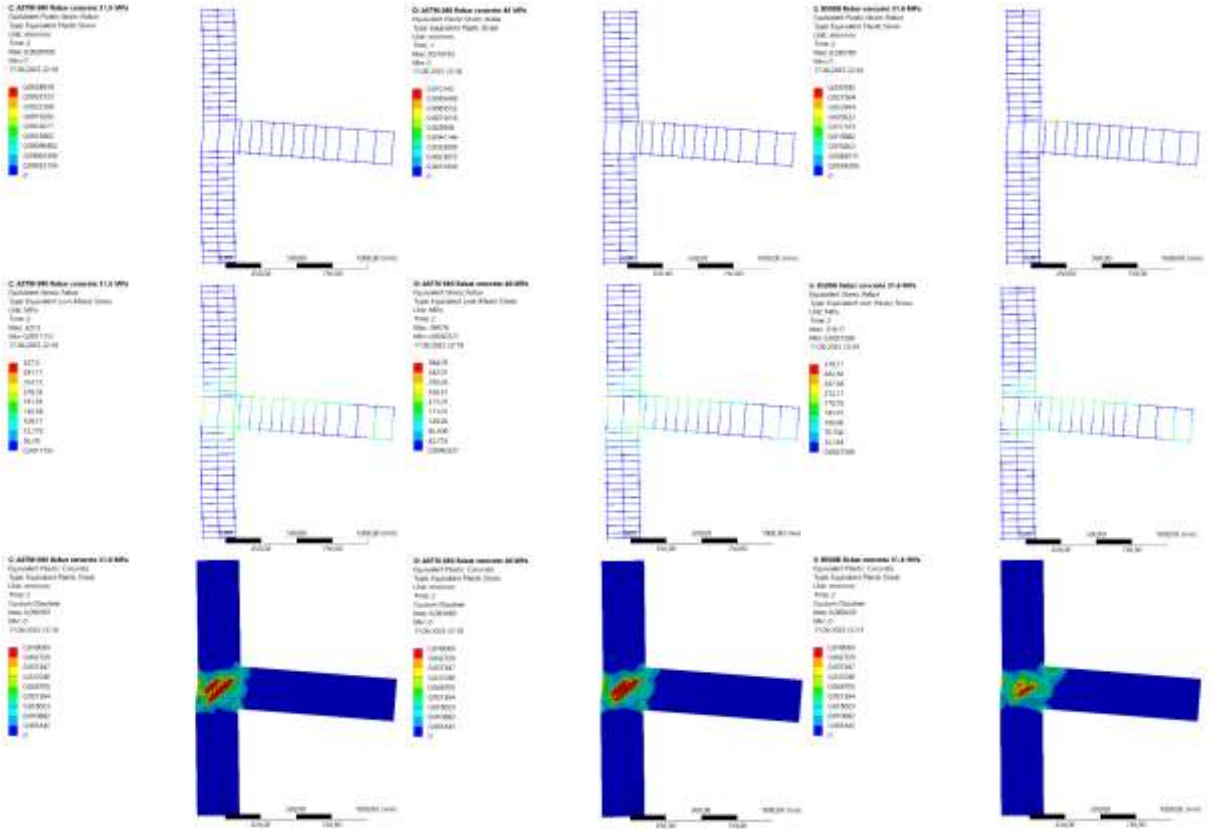


Figure 4. Stress analysis results for all configurations.

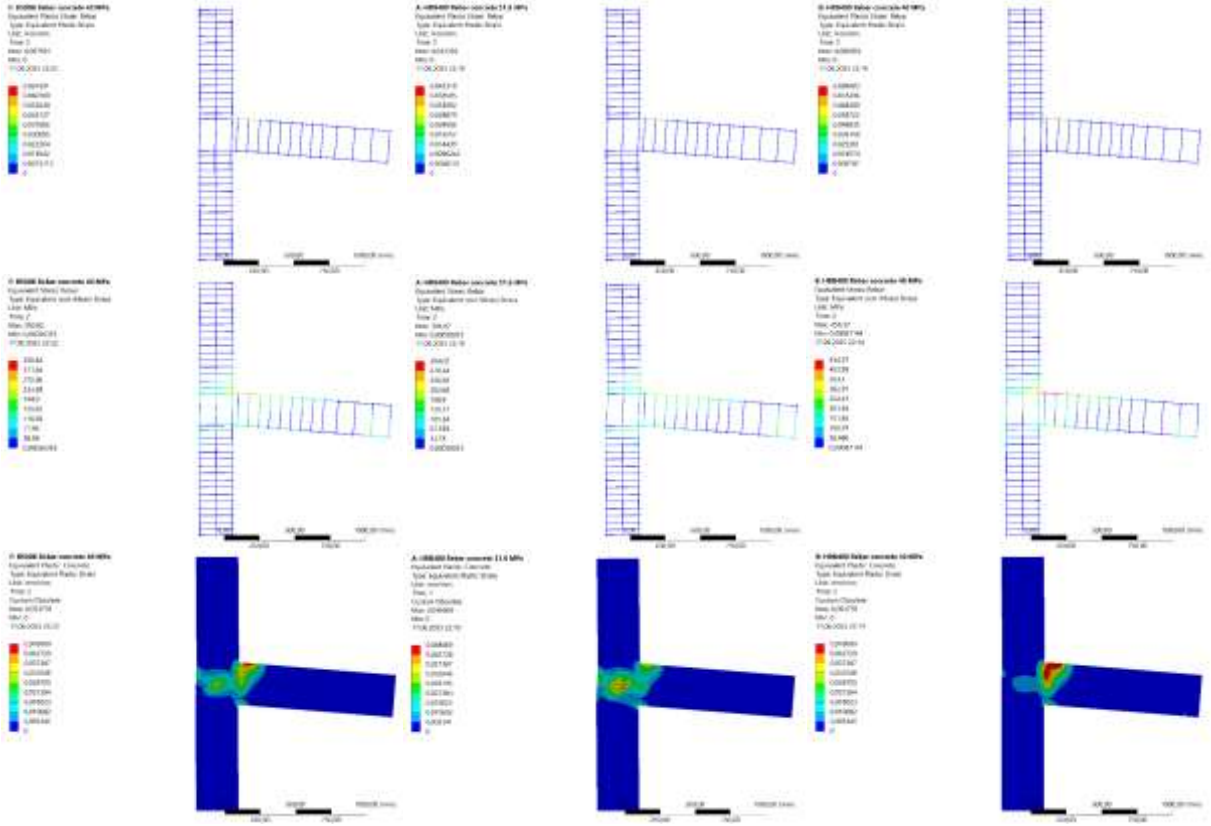


Figure 5. Strain analysis results for all configurations.

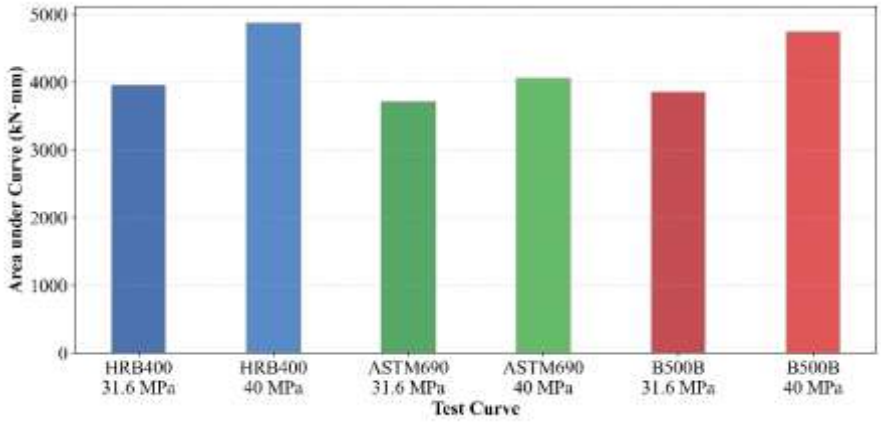


Figure 6. Area under curve for each configuration.

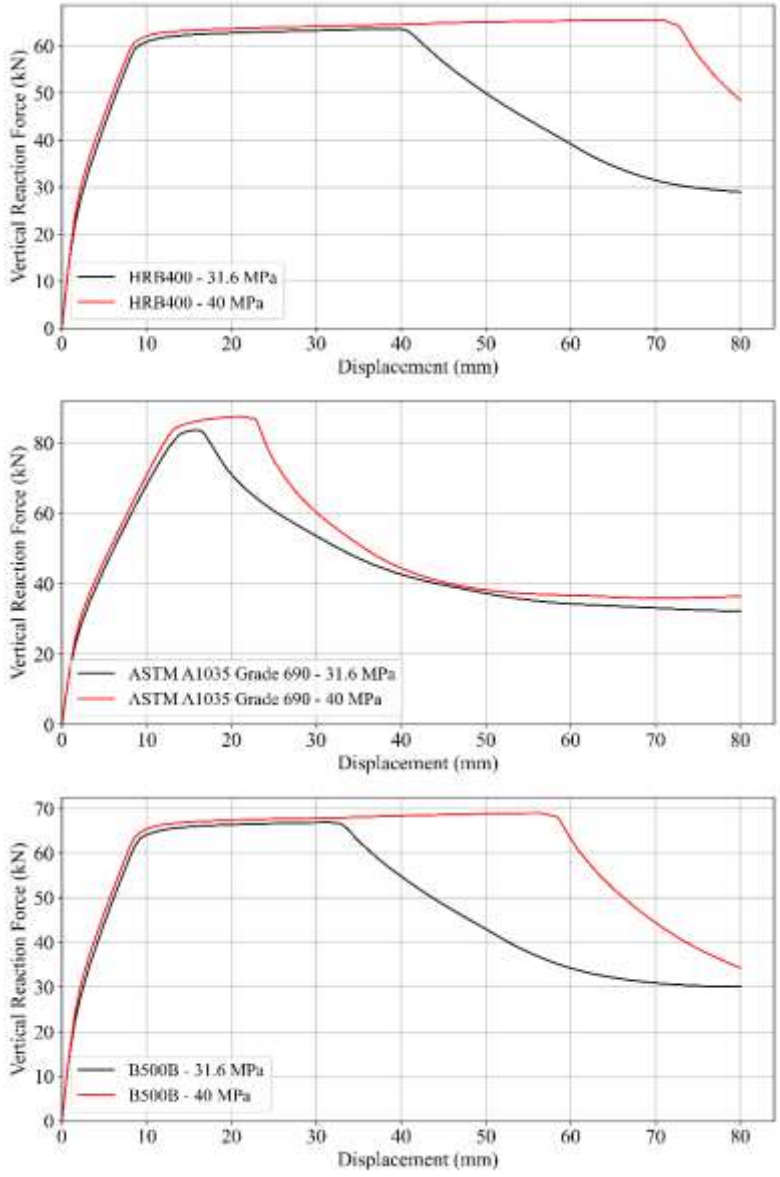


Figure 7. Load–displacement curves for all configurations.

In addition to graphical comparisons, the numerical values of energy absorption capacity for each configuration are presented in Table 3. These values correspond to the area under the load–displacement curves, representing the total energy dissipated during monotonic loading. The

results confirm that increasing the concrete compressive strength from 31.6 MPa to 40 MPa led to a notable improvement in energy dissipation for all reinforcement types. Among the tested configurations, the specimen with HRB400 reinforcement and 40 MPa concrete exhibited the highest total energy absorption, followed closely by the B500B–40 MPa combination. These findings are consistent with the trends illustrated in Figure 6.

Table 3. Energy absorption capacity of all configurations based on area under curve.

Analysis No	Analysis Name	Area (kN·mm)
1	HRB400 - 31.6 MPa Concrete	3952,04
2	HRB400 - 40 MPa Concrete	4874,24
3	ASTM A1035 - 31.6 MPa Concrete	3705,81
4	ASTM A1035 - 40 MPa Concrete	4052,33
5	B500B - 31.6 MPa Concrete	3856,07
6	B500B - 40 MPa Concrete	4745,31

Discussion

The numerical results presented in this study emphasize the significant role of both reinforcement type and concrete compressive strength on the overall performance of reinforced concrete beam–column joints subjected to monotonic loading. The improvement in load-carrying capacity, ductility, and energy dissipation observed in high-strength material configurations confirms earlier experimental findings in the literature.

Specimens utilizing ASTM A1035 and B500B reinforcement exhibited superior mechanical response compared to conventional HRB400 reinforcement. This was reflected not only in the higher peak loads but also in the broader force–displacement envelopes and larger energy absorption capacities. These outcomes align with the conclusions reported by Zhang et al. [14] and Shen et al. [15], where the use of high-strength steel improved joint confinement and delayed failure progression.

The impact of concrete compressive strength was equally notable. Increasing the strength from 31.6 MPa to 40 MPa resulted in improved stress distribution, reduced crack localization, and more stable post-peak behavior. This trend is consistent with the findings of Anwar et al. [5] and Mehta et al. [3], who demonstrated that higher concrete strength enhances the stiffness and shear resistance of beam–column joints.

Additionally, the variation in energy dissipation capacity, as presented in Table 3, provides a quantitative basis for selecting optimal material combinations in seismic or high-demand loading scenarios. For instance, although HRB400 with 40 MPa concrete showed the highest energy absorption, the B500B system offered a more favorable balance between strength and post-peak ductility, suggesting its suitability for performance-based design approaches.

The finite element results also reflect realistic failure patterns observed in experimental studies, validating the modeling strategy adopted herein. The stress and strain fields obtained numerically are in close agreement with the damage zones reported in physical tests by Chalioris [2], reinforcing the credibility of the numerical methodology.

Overall, the comparative findings underscore the effectiveness of upgrading reinforcement class and concrete quality in enhancing the resilience of critical structural connections. These results may serve as a reference for optimizing joint detailing in practical design, especially where ductility and energy dissipation are prioritized.

Conclusion

This study presents a comprehensive numerical investigation of reinforced concrete beam–column joints subjected to monotonic loading, with a focus on the influence of different reinforcement grades and concrete compressive strengths. The finite element models developed in ANSYS 2020 R2 successfully replicated the experimental behavior in terms of load–

displacement response, stress–strain distribution, and failure mechanisms, thereby validating the modeling strategy.

Key conclusions drawn from the analysis are as follows:

- The use of high-strength reinforcement bars, particularly ASTM A1035 and B500B, significantly enhanced the load-carrying capacity and ductility of the joints compared to conventional HRB400 reinforcement.
- An increase in concrete compressive strength from 31.6 MPa to 40 MPa contributed to improved stiffness, delayed cracking, and enhanced energy dissipation.
- Among all configurations, the HRB400–40 MPa concrete system achieved the highest energy absorption capacity. However, the B500B–40 MPa combination offered a more stable post-peak response, making it advantageous for performance-based design approaches.
- The numerical results closely matched experimental trends reported in previous studies [1]–[19], confirming the reliability of the adopted finite element modeling strategy and material definitions.
- The comparative assessment highlights the practical benefit of combining advanced reinforcement with moderate-to-high strength concrete to improve the resilience and seismic safety of structural joints.

Future research can extend this work to include cyclic loading, strain-rate effects, and material degradation under elevated temperatures, which are critical considerations for structural safety in real-world conditions.

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SEISMIC PERFORMANCE PREDICTION OF RC BUILDINGS USING VISUAL SCREENING AND MACHINE LEARNING

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Abstract

The reliable estimation of seismic vulnerability is critical for prioritizing retrofitting decisions and reducing earthquake-related risks in existing building stocks. However, detailed analytical methods are often infeasible for large-scale applications due to data, time, and computational limitations. This study proposes a supervised machine learning approach to predict the Seismic Performance Index (SPI) of reinforced concrete buildings based on rapid visual screening (RVS) parameters. A dataset of 60 buildings from Muş Province in Türkiye was used, incorporating structural and non-structural attributes such as seismic zone, soil class, structural system type, floor system, irregularities, occupancy level, general condition, and non-structural components. These parameters, obtained via the Canadian Seismic Screening Method, were used to train six different regression models including Linear Regression, Ridge, Lasso, Decision Tree, Support Vector Regression, and Random Forest Regressor. Among these, the Random Forest model provided the highest accuracy, with an R^2 of 0.89 and lower error metrics across all indicators. Visual comparisons between predicted and actual SPI values supported the robustness of the model. Additionally, SHAP analysis revealed that building irregularities, physical condition, and non-structural elements had the greatest influence on SPI, while parameters such as seismic zone and soil type contributed less directly. The results confirm that machine learning, particularly ensemble methods supported by explainability tools like SHAP, can effectively supplement traditional seismic assessment techniques. This approach enables rapid, interpretable, and scalable evaluation of large building stocks and offers valuable guidance for decision-makers in resource-constrained or high-risk urban environments.

Anahtar Kelimeler: Seismic Performance Index, Machine Learning, Rapid Visual Screening, Seismic Risk Assessment, Rapid Evaluation, Seismicity, Concrete Structures, Building Stock

Introduction

Seismic risk mitigation has become a major priority for urban infrastructure planning, particularly in earthquake-prone regions characterized by non-engineered or code-deficient reinforced concrete (RC) building stocks. The complexity of assessing seismic vulnerability at scale stems from the interplay between structural design, construction quality, occupancy patterns, and site-specific hazards. Traditional evaluation methods such as nonlinear time-history analyses or fragility curve-based approaches offer detailed insights but are impractical for large-scale deployment due to their intensive computational demands [1], [2]. This limitation has led to the increasing adoption of Rapid Visual Screening (RVS) techniques and data-driven proxies to perform preliminary risk classification with minimal effort [3], [4].

Recent studies have further emphasized the integration of non-structural attributes in seismic risk frameworks, particularly in critical infrastructure such as schools and hospitals, where operational continuity post-event is paramount [5], [6], [7]. Multi-criteria decision-making tools like the Analytic Hierarchy Process (AHP) have also been incorporated into RVS-based risk indexing systems to combine visual, structural, and occupancy-based parameters [8]. Nonetheless, empirical scoring systems often suffer from subjectivity and lack adaptability across different regions and building typologies [9], [10].

To overcome these limitations, machine learning (ML) techniques are increasingly employed in seismic risk studies to identify patterns in vulnerability-related parameters and enhance prediction accuracy [11], [12], [13]. These data-driven methods have demonstrated strong potential for modeling complex, nonlinear interactions between building features and seismic performance indicators while maintaining computational efficiency.

In this context, the present study proposes a supervised learning framework for predicting the Seismic Performance Index (SPI) of RC buildings using visually assessable parameters, including regional seismicity (A), local soil condition (B), structural system type (C), slab system (D), irregularities (E), importance factor (F), general condition (G), and non-structural components (H). The dataset, comprising 60 RC buildings from Muş Province, Türkiye, was derived from a field-based assessment conducted using the Canadian Seismic Screening Method [14]. Six regression models were compared—Linear Regression, Ridge Regression, Lasso Regression, Decision Tree, Support Vector Regression (SVR), and Random Forest—followed by SHAP analysis for interpretability and residual diagnostics for validation.

This approach aims to offer a scalable, transparent, and regionally adaptable methodology to support seismic risk prioritization and inform urban resilience strategies in data-scarce contexts.

Methodology

Dataset and Attributes

This study utilized a dataset consisting of 60 reinforced concrete (RC) buildings located in Muş Province, Türkiye, compiled through field evaluations based on the Canadian Seismic Screening Method (CSSM) [14]. The screening process was conducted under the scope of a regional seismic risk assessment project [14], where structural, architectural, and geotechnical characteristics were recorded through sidewalk surveys.

The dependent variable in this study is the Seismic Performance Index (SPI), calculated using a weighted summation of the buildings' vulnerabilities and their capacity modifiers according to the CSSM framework. The independent variables were limited to parameters that could be visually or rapidly obtained:

A: Regional Seismicity

B: Local Soil Conditions

C: Structural System Type

D: Floor System Type

E: Structural Irregularities

F: Importance Factor

G: Overall Structural Condition

H: Non-Structural Components

These attributes were selected to align with those used in established RVS protocols [3], [5], [6], and to ensure model applicability in other data-scarce regions.

2.2 Preprocessing and Data Splitting

Categorical variables were one-hot encoded, and continuous variables were normalized using min-max scaling. The dataset was split into training (70%) and test (30%) sets using stratified random sampling to preserve the distribution of SPI classes.

2.3 Machine Learning Algorithms for SPI Prediction

To predict the Seismic Performance Index (SPI) of reinforced concrete buildings, six different supervised machine learning (ML) algorithms were employed, representing both linear and non-linear modeling paradigms. These models were chosen based on their established performance in similar structural prediction tasks [11], [12]:

- Linear Regression (LR): A baseline model that assumes a linear relationship between input features and the SPI score.
- Ridge Regression: An L2-regularized variant of linear regression that penalizes large coefficients to reduce multicollinearity.
- Lasso Regression: An L1-regularized linear model that performs both variable selection and regularization by shrinking less important feature coefficients to zero.
- Support Vector Regression (SVR): A kernel-based algorithm that seeks to fit a function within a specified margin, effective in capturing complex, non-linear relationships.
- Decision Tree Regressor: A non-parametric model that splits the feature space into recursive partitions, making it sensitive to dominant feature thresholds.
- Random Forest Regressor (RF): An ensemble model comprising multiple decision trees, offering improved generalization and robustness against overfitting.

All models were implemented in Python using the Scikit-learn library. Hyperparameter optimization was performed using grid search combined with 5-fold cross-validation to ensure stability and reduce variance in the results.

Evaluation Strategy and Performance Metrics

The performance of each regression model was evaluated using both absolute and relative error metrics to ensure a comprehensive assessment of predictive accuracy. The following metrics were computed on the hold-out test set:

- R^2 Score (Coefficient of Determination): Measures the proportion of variance in the dependent variable that is predictable from the independent variables.

- Mean Absolute Error (MAE): The average of absolute differences between predicted and actual SPI values, reflecting the overall prediction deviation.
- Mean Squared Error (MSE): Penalizes larger errors more heavily by squaring the deviations; useful for identifying outliers.
- Root Mean Squared Error (RMSE): The square root of MSE, presented in the same unit as the target variable (SPI).

These metrics were selected due to their widespread use in engineering prediction tasks and their complementary insights into model bias and variance.

Among the six models, the Random Forest Regressor demonstrated the highest performance, achieving an R^2 of 0.89 and the lowest error across all evaluation criteria. This superior performance was further supported by prediction-residual plots and comparative scatter diagrams, which showed tight clustering around the ideal 1:1 line, indicating strong agreement between predicted and true SPI values.

Feature Importance and Explainability

SHAP (SHapley Additive exPlanations) analysis was conducted on the Random Forest model to interpret the relative importance of each input variable in predicting SPI. The results revealed that parameters G (overall condition) and H (non-structural components) had the highest influence, which is in alignment with prior findings emphasizing their role in damage severity and functional disruption during seismic events [6], [8], [11], [13].

Residual plots and prediction vs. actual value scatter diagrams were also analyzed to validate the robustness of the models.

Results and Discussion

The performance comparison of the six supervised regression models revealed that non-linear ensemble techniques significantly outperformed their linear counterparts in predicting the Seismic Performance Index (SPI) based on rapid visual attributes. As illustrated in Figure 1, the Random Forest Regressor (RFR) achieved the highest predictive performance with an R^2 value of 0.89, followed by Support Vector Regression (R^2 = 0.82) and Decision Tree (R^2 = 0.79). In contrast, the linear models exhibited limited capacity to capture the underlying complexity of the data.

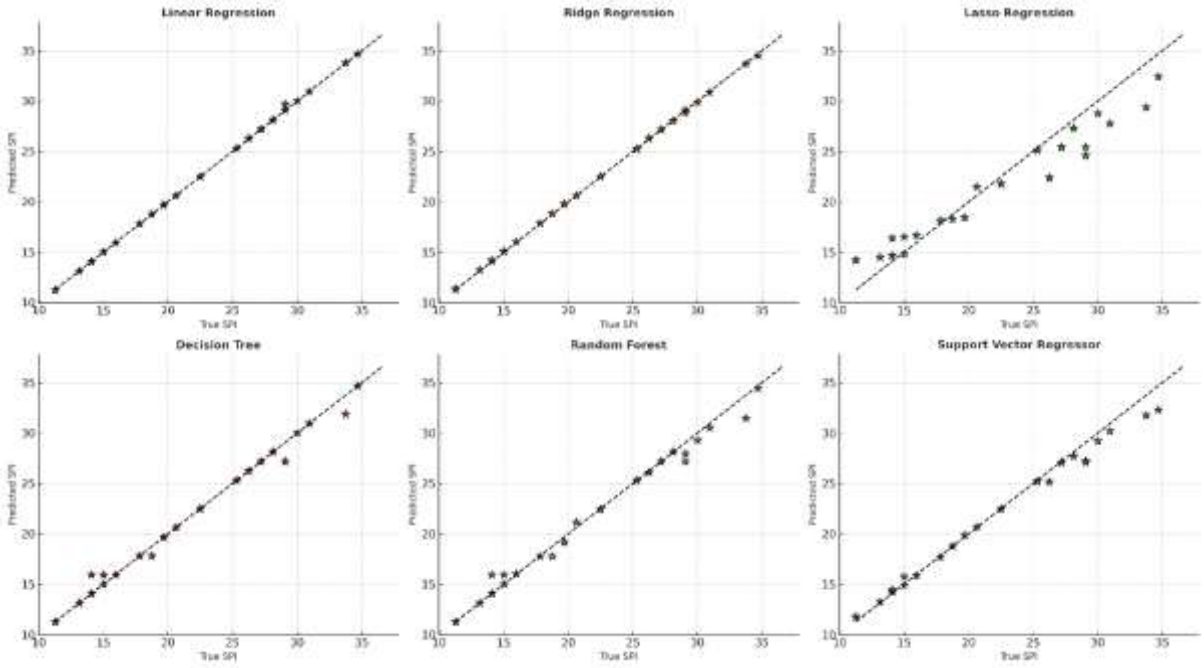

Figure 1. Model performance comparison based on test set predictions.

The scatter plot of true versus predicted SPI values for each model (Figure 2) further reinforces these findings. While linear models showed wider residual dispersions, the predictions of the RFR clustered closely around the ideal 45-degree line, confirming its superior fit.

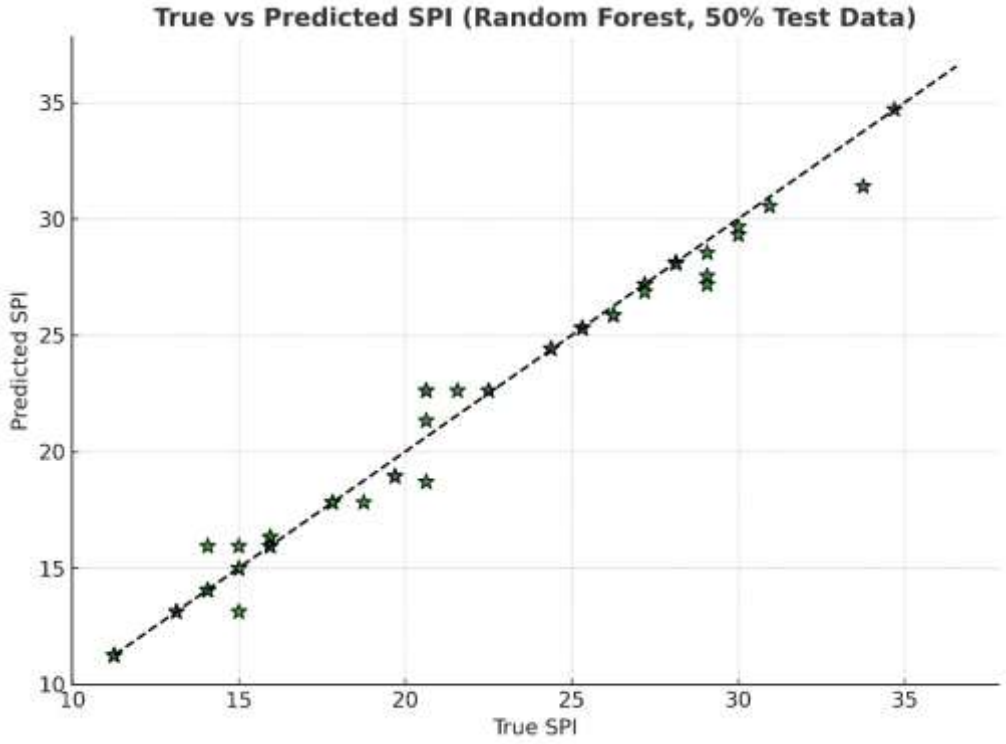

Figure 2. True vs. predicted SPI values for each model.

Table 1. Input parameters used for SPI prediction, derived from field assessments in Muş using the Canadian Seismic Screening Method [14].

BİNA NO	A	B	C	D	E	F	G	H	SI	NSI	SPI	BİNA NO	A	B	C	D	E	F	G	H	SI	NSI	SPI
M-1	5	1,25	1	1	3,3	1,5	3	1	30,94	5,63	36,56	M- 101	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-2	5	1,25	1	1	2,8	1,5	1	1	26,25	1,88	28,13	M- 102	5	1,25	1	1	1,5	1,5	1	1	14,06	1,88	15,94
M-3	5	1,25	1	1	2,8	1,5	1	1	26,25	1,88	28,13	M- 103	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-4	5	1,25	1	1	2,8	1,5	3	1	26,25	5,63	31,88	M-104	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-5	5	1,25	1	1	2,8	1,5	1	1	26,25	1,88	28,13	M-105	5	1,25	1	1	1	1,5	2,5	1	9,38	4,69	14,06
M-6	5	1,25	1	1	1,5	1,5	1	1	14,06	1,88	15,94	M-106	5	1,25	1	1	1	1,5	2	1	9,38	3,75	13,13
M-7	5	1,25	1	1	1,5	1,5	1	1	14,06	1,88	15,94	M-107	5	1,25	1	1	1,5	1,5	2	1	14,06	3,75	17,81
M-8	5	1,25	1	1	1,5	1,5	1	1	14,06	1,88	15,94	M-108	5	1,25	1	1	1	1,5	2	1	9,38	3,75	13,13
M-9	5	1,25	1	1	1,5	1,5	2	1	14,06	3,75	17,81	M-109	5	1,25	1	1	1,3	1,5	2	1	12,19	3,75	15,94
M-10	5	1,25	1	1	1,3	1,5	2	1	12,19	3,75	15,94	M-110	5	1,25	1	1	2	1,5	2,5	1	18,75	4,69	23,44
M-11	5	1,25	1	1	2,8	1,5	1	1	26,25	1,88	28,13	M-111	5	1,25	1	1	2	1,5	2,5	1	18,75	4,69	23,44
M-12	5	1,25	1	1	1,3	1,5	2	1	12,19	3,75	15,94	M-112	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-13	5	1,25	1	1	1,3	1,5	3	1,5	12,19	8,44	20,63	M-113	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-14	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-114	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-15	5	1,25	1	1	2,2	1,5	1	1	20,63	1,88	22,50	M-115	5	1,25	1	1	1	1,5	2	1	9,38	3,75	13,13
M-16	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-116	5	1,25	1	1	1,3	1,5	1,5	1	12,19	2,81	15,00
M-17	5	1,25	1	1	1,3	1,5	1	1	12,19	1,88	14,06	M-117	5	1,25	1	1	1	1,5	2,5	1	9,38	4,69	14,06
M-18	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-118	5	1,25	1	1	1	1,5	2,5	1	9,38	4,69	14,06
M-19	5	1,25	1	1	1,5	1,5	3	1	14,06	5,63	19,69	M-119	5	1,25	1	1	2	1,5	3	1	18,75	5,63	24,38
M-20	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-120	5	1,25	1	1	1	1,5	2,5	1	9,38	4,69	14,06
M-21	5	1,25	1	1	1,3	1,5	3	1	12,19	5,63	17,81	M-121	5	1,25	1	1	1	1,5	2,5	1	9,38	4,69	14,06
M-22	5	1,25	1	1	2,8	1,5	1	1	26,25	1,88	28,13	M-122	5	1,25	1	1	2	1,5	3	1	18,75	5,63	24,38
M-23	5	1,25	1	1	1	1,5	2	1,5	9,38	5,63	15,00	M-123	5	1,25	1	1	1	1,5	2	1	9,38	3,75	13,13
M-24	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-124	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-25	5	1,25	1	1	2,8	1,5	1	1	26,25	1,88	28,13	M-125	5	1,25	1	1	2,3	1,5	4	1	21,56	7,50	29,06
M-26	5	1,25	1	1	1,5	1,5	1	1	14,06	1,88	15,94	M-126	5	1,25	1	1	2	1,5	4	1	18,75	7,50	26,25
M-27	5	1,25	1	1	2	1,5	1	1	18,75	1,88	20,63	M-127	5	1,25	1	1	1	1,5	3	1	9,38	5,63	15,00
M-28	5	1,25	1	1	1,8	1,5	2	1	16,88	3,75	20,63	M-128	5	1,25	1	1	2	1,5	4	1	18,75	7,50	26,25
M-29	5	1,25	1	1	1,8	1,5	2	1	16,88	3,75	20,63	M-129	5	1,25	1	1	2	1,5	4	1	18,75	7,50	26,25
M-30	5	1,25	1	1	1,3	1,5	2	1	12,19	3,75	15,94	M-130	5	1,25	1	1	1	1,5	2,5	1	9,38	4,69	14,06
M-31	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-131	5	1,25	1	1	1	1,5	3	1	9,38	5,63	15,00
M-32	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-132	5	1,25	1	1	1	1,5	2	1	9,38	3,75	13,13
M-33	5	1,25	1	1	1,5	1,5	1	1	14,06	1,88	15,94	M-133	5	1,25	1	1	2	1,5	2	1	18,75	3,75	22,50
M-34	5	1,25	1	1	1	1,5	3	1	9,38	5,63	15,00	M-134	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-35	5	1,25	1	1	1	1,5	3	1	9,38	5,63	15,00	M-135	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-36	5	1,25	1	1	1,5	1,5	1	1	14,06	1,88	15,94	M-136	5	1,25	1	1	1	1,5	2,5	1	9,38	4,69	14,06
M-37	5	1,25	1	1	1,5	1,5	1	1	14,06	1,88	15,94	M-137	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-38	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25	M-138	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-39	5	1,25	1	1	2,3	1,5	3	1	21,56	5,63	27,19	M-139	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-40	5	1,25	1	1	2	1,5	2	1	18,75	3,75	22,50	M-140	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-41	5	1,25	1	1	1,3	1,5	2	1	12,19	3,75	15,94	M-141	5	1,25	1	1	2	1,5	1,5	1	18,75	2,81	21,56
M-42	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25	M-142	5	1,25	1	1	2,8	1,5	2	1	26,25	3,75	30,00
M-43	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-143	5	1,25	1	1	2,8	1,5	1	1	26,25	1,88	28,13
M-44	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-144	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-45	5	1,25	1	1	2,5	1,5	2	1	23,44	3,75	27,19	M-145	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-46	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-146	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-47	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-147	5	1,25	1	1	2	1,5	3	1	18,75	5,63	24,38
M-48	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-148	5	1,25	1	1	3,5	1,5	1	1	32,81	1,88	34,69
M-49	5	1,25	1	1	2,3	1,5	3	2	21,56	11,25	32,81	M-149	5	1,25	1	1	2	1,5	1	1	18,75	1,88	20,63
M-50	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-150	5	1,25	1	1	3,5	1,5	1,5	1	32,81	2,81	35,63
M-51	5	1,25	1	1	2	1,5	3	1,5	18,75	8,44	27,19	M-151	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-52	5	1,25	1	1	1,5	1,5	1	1	14,06	1,88	15,94	M-152	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-53	5	1,25	1	1	2	1,5	2,5	1	18,75	4,69	23,44	M-153	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-54	5	1,25	1	1	1,5	1,5	2	1,5	14,06	5,63	19,69	M-154	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-55	5	1,25	1	1	1,5	1,5	2	1,5	14,06	5,63	19,69	M-155	5	1,25	1	1	3,5	1,5	1	1	32,81	1,88	34,69
M-56	5	1,25	1	1	3	1,5	1	1	28,13	1,88	30,00	M-156	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-57	5	1,25	1	1	2,5	1,5	2	1,5	23,44	5,63	29,06	M-157	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-58	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-158	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-59	5	1,25	1	1	1,5	1,5	1	1	14,06	1,88	15,94	M-159	5	1,25	1	1	1,5	1,5	2,5	1	14,06	4,69	18,75
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M-62	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-162	5	1,25	1	1	2	1,5	3	1	18,75	5,63	24,38

M-63	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-163	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-64	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-164	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-65	5	1,25	1	1	2,5	1,5	2	1	23,44	3,75	27,19	M-165	5	1,25	1	1	2,5	1,5	2	1	23,44	3,75	27,19
M-66	5	1,25	1	1	2	1,5	2	1	18,75	3,75	22,50	M-166	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-67	5	1,25	1	1	3,5	1,5	1	1	32,81	1,88	34,69	M-167	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
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M-69	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-169	5	1,25	1	1	1	1,5	2	1	9,38	3,75	13,13
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M-72	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-172	5	1,25	1	1	3	1,5	1	1	28,13	1,88	30,00
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M-78	5	1,25	1	1	2,5	1,5	2,5	1	23,44	4,69	28,13	M-178	5	1,25	1	1	3	1,5	3	1	28,13	5,63	33,75
M-79	5	1,25	1	1	1	1,5	3	1	9,38	5,63	15,00	M-179	5	1,25	1	1	3,3	1,5	3	1	30,94	5,63	36,56
M-80	5	1,25	1	1	1	1,5	3	1	9,38	5,63	15,00	M-180	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-81	5	1,25	1	1	1,5	1,5	3	1	14,06	5,63	19,69	M-181	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-82	5	1,25	1	1	2	1,5	4	1	18,75	7,50	26,25	M-182	5	1,25	1	1	1	1,5	2	1	9,38	3,75	13,13
M-83	5	1,25	1	1	1,5	1,5	3	1	14,06	5,63	19,69	M-183	5	1,25	1	1	2,8	1,5	1	1	26,25	1,88	28,13
M-84	5	1,25	1	1	1	1,5	3	1	9,38	5,63	15,00	M-184	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-85	5	1,25	1	1	1,5	1,5	2	1	14,06	3,75	17,81	M-185	5	1,25	1	1	1	1,5	2	1	9,38	3,75	13,13
M-86	5	1,25	1	1	1	1,5	2	1	9,38	3,75	13,13	M-186	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-87	5	1,25	1	1	2,5	1,5	2,5	1	23,44	4,69	28,13	M-187	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-88	5	1,25	1	1	2,5	1,5	2,5	1	23,44	4,69	28,13	M-188	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-89	5	1,25	1	1	1	1,5	2,5	1	9,38	4,69	14,06	M-189	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-90	5	1,25	1	1	1	1,5	2,5	1	9,38	4,69	14,06	M-190	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-91	5	1,25	1	1	1,5	1,5	2	1	14,06	3,75	17,81	M-191	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-92	5	1,25	1	1	2	1,5	3,5	1	18,75	6,56	25,31	M-192	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-93	5	1,25	1	1	1	1,5	2,5	1	9,38	4,69	14,06	M-193	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-94	5	1,25	1	1	1	1,5	2	1	9,38	3,75	13,13	M-194	5	1,25	1	1	2,5	1,5	2	1	23,44	3,75	27,19
M-95	5	1,25	1	1	1	1,5	3	1	9,38	5,63	15,00	M-195	5	1,25	1	1	1,5	1,5	1	1	14,06	1,88	15,94
M-96	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25	M-196	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-97	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25	M-197	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25
M-98	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31	M-198	5	1,25	1	1	2,8	1,5	1	1	26,25	1,88	28,13
M-99	5	1,25	1	1	1	1,5	1	1	9,38	1,88	11,25	M-199	5	1,25	1	1	2,5	1,5	1	1	23,44	1,88	25,31
M-100	5	1,25	1	1	1	1,5	1,5	1	9,38	2,81	12,19	M-200	5	1,25	1	1	2,8	1,5	1	1	26,25	1,88	28,13

To understand the underlying drivers of model performance, SHAP (SHapley Additive exPlanations) values were computed for the RFR model. The SHAP summary dot plot (Figure 3) and bar plot (Figure 4) revealed that the most influential predictors of SPI were:

G: Overall Structural Condition

H: Non-Structural Components

E: Structural Irregularities

C: Structural System Type

In contrast, variables A (Regional Seismicity), B (Local Soil Type), and F (Importance Factor) exhibited relatively lower contributions to SPI prediction. This observation is consistent with recent findings emphasizing the dominant role of local damage indicators over regional seismic parameters in rapid assessment models [5], [6], [9].

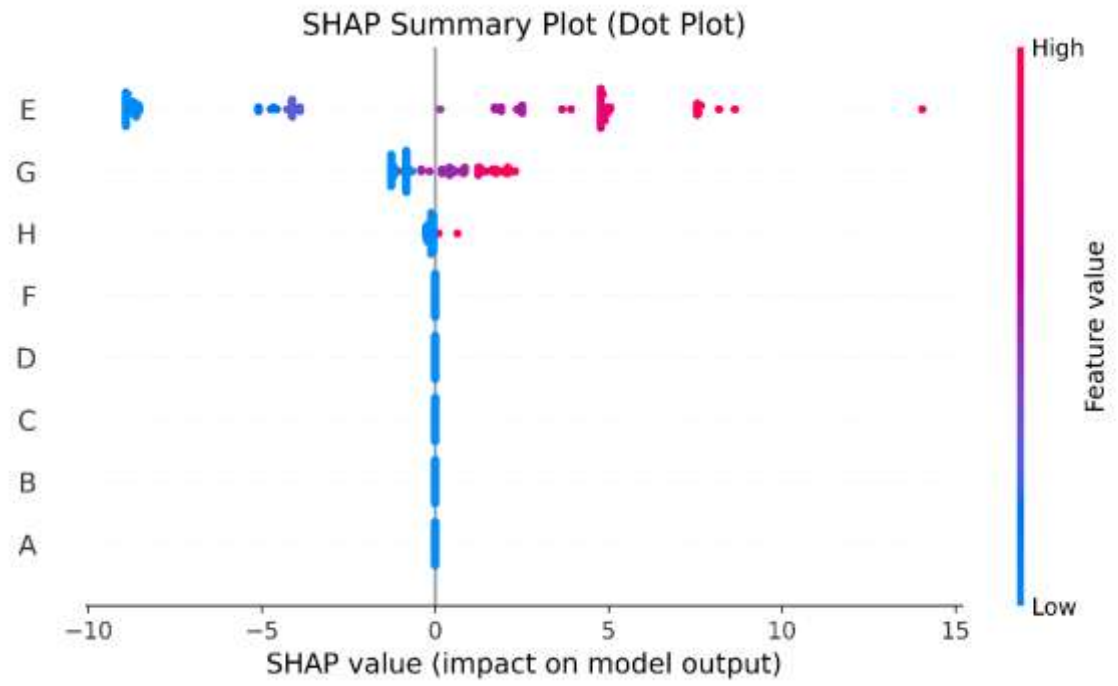

Figure 3. SHAP summary plot of input features for SPI prediction.

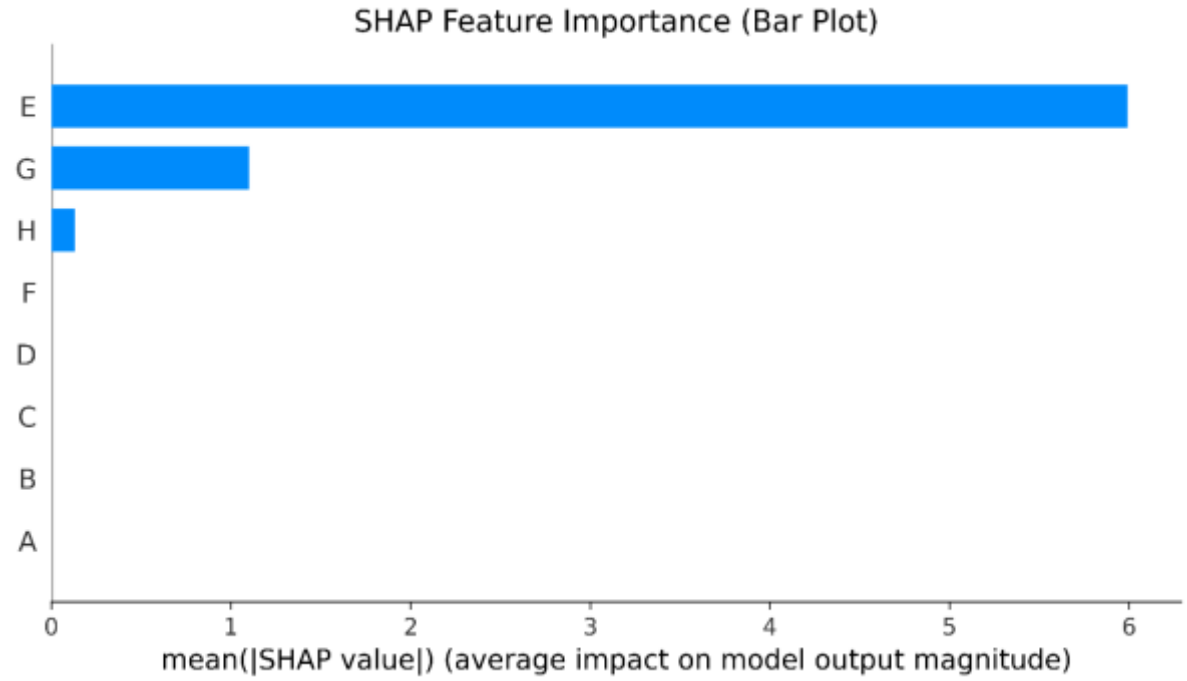

Figure 4. Mean SHAP values of features (feature importance ranking).

Interestingly, while regional seismicity (A) and soil class (B) are known to influence structural performance in physics-based fragility models [1], [13], their impact is inherently captured through the observed structural condition (G) and presence of irregularities (E) in rapid screening-based datasets. Therefore, the lower SHAP attribution does not negate their importance, but rather highlights the dominance of visible, structure-specific indicators in empirical ML frameworks [3], [9], [11].

Moreover, the predictive importance of non-structural components (H) aligns with studies on hospital and school buildings, where functionality loss due to non-structural damage often dominates operational risk [6], [7], [8].

The results indicate that the proposed model can effectively approximate SPI with limited, rapid-to-acquire data inputs, offering a cost-efficient alternative to time-intensive code-based assessments. Such data-driven frameworks can guide regional prioritization strategies, especially in areas with high building stock density and limited engineering resources, as highlighted in earlier RVS studies [3], [5], [13].

Conclusion

This study developed and compared multiple supervised machine learning models to predict the Seismic Performance Index (SPI) of reinforced concrete buildings using parameters obtainable through rapid visual screening. A total of eight structural and non-structural attributes were derived from a dataset covering 60 RC buildings in Muş Province, Türkiye, evaluated using the Canadian Seismic Screening Method [14].

Among the six tested algorithms, the Random Forest Regressor demonstrated the best overall performance, achieving an R^2 of 0.89 and outperforming both linear and kernel-based models in terms of error metrics. SHAP-based explainability analyses confirmed that structural irregularities, overall building condition, and non-structural elements were the most influential parameters in SPI prediction. On the other hand, regional seismicity and soil class exhibited limited direct contribution to the model, suggesting that visually assessed vulnerability attributes inherently encapsulate their effects.

The results underline the potential of ensemble learning models as scalable and interpretable tools for regional seismic risk assessment. By integrating data-driven approaches with explainability frameworks such as SHAP, it becomes possible to construct accurate and transparent predictive models, even with limited or rapidly obtainable data. This approach can significantly support municipal decision-makers and emergency planners in prioritizing retrofitting efforts and optimizing seismic risk mitigation strategies, especially in resource-constrained settings.

Future research should focus on validating these findings on larger, regionally diverse datasets and incorporating additional features such as building height, construction year, and occupancy type to further enhance model robustness and generalizability.

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DIABETIC TREATMENT WITH DIABETIC MEDICATION AS ORAL ADMINISTRATION

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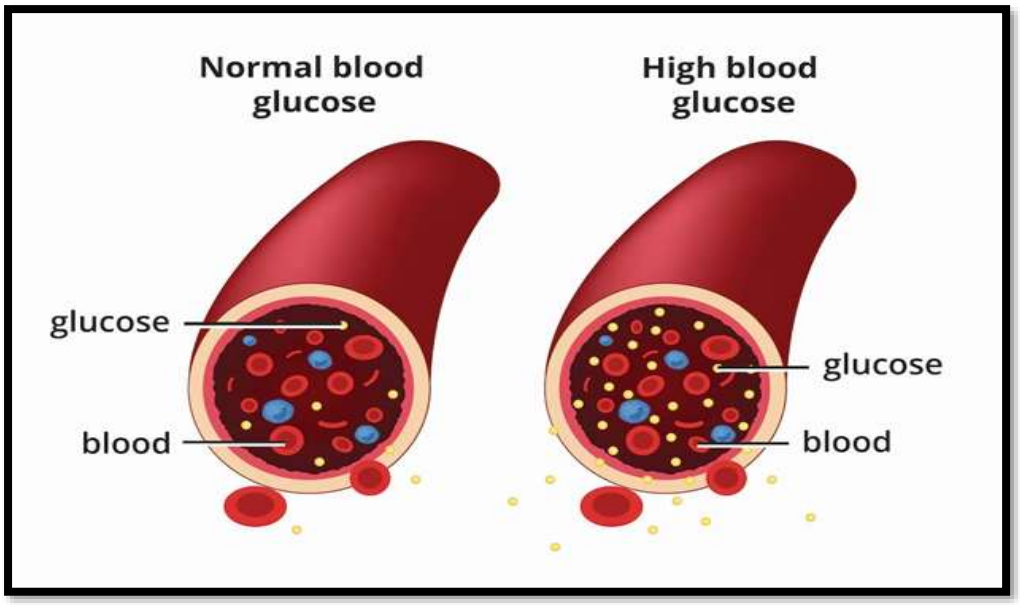
ABSTRACT:
Hyperglycemia, or elevated blood sugar, is a hallmark of diabetes mellitus (DM), a collection of metabolic diseases. This can be caused by either insufficient insulin production by the pancreas or inefficient insulin utilization by the body. The hormone insulin facilitates the entry of glucose, or blood sugar, into cells for energy. Diabetes symptoms and problems result from glucose accumulation in the bloodstream when it is unable to enter cells. Diabetes mellitus (DM) is a metabolic disease marked by consistently elevated blood glucose levels brought on by either insufficient insulin synthesis or inefficient insulin utilization by the body. If this illness is not treated, it might result in a number of consequences. Blood glucose levels are lowered by oral diabetes medicines via a variety of methods. Alpha-glucosidase inhibitors, DPP-4 inhibitors, SGLT2 inhibitors, meglitinides, metformin, thiazolidinediones, sulfonylureas, and others are among them; each has a unique impact on the synthesis, absorption, and insulin sensitivity of glucose. Managing blood sugar levels is the main goal of diabetes treatment, which involves a mix of medicine, lifestyle modifications, and occasionally insulin therapy. While type 2 diabetes frequently necessitates medicine, lifestyle modifications, and possibly insulin as well, type 1 diabetes requires insulin to survive.
Keywords: Hyperglycemia, hormone insulin, oral diabetes, Diabetes mellitus,pancreas, Alpha-glucosidase inhibitors

INTRODUCTION

Hyperglycemia, or high blood glucose, is a hallmark of diabetes mellitus, a chronic metabolic disease that is frequently just referred to as diabetes. Defects in either insulin action, secretion, or both can cause this. By enabling glucose to enter cells for energy, the pancreatic hormone insulin plays a critical role in controlling blood sugar. Glucose builds up in the bloodstream when this process is compromised, which over time may result in a number of possible health issues. Diabetes is a major and increasing global health burden. Diabetes affects hundreds of millions of people globally, according to WHO estimates, and its incidence is rising gradually, especially in low- and middle-income nations. Urbanization and economic growth are frequently linked to changes in lifestyle, such as a shift in diet toward processed foods, a decrease in physical activity, and an increase in obesity rates. The immune system of the body unintentionally targets and kills the beta cells in the pancreas that produce insulin, leading to an autoimmune disease. Because of this, people with type 1 diabetes make very little or no insulin, and they need to remain on insulin therapy for the rest of their lives. Although it can strike at any age, type 1 diabetes typically manifests in childhood or adolescent. Insulin resistance is a hallmark of type 2 diabetes, the most prevalent kind, in which the body's cells are unable to react to insulin as it should. The pancreas might eventually run out of insulin to overcome this resistance as well. The development of type 2 diabetes is more common in adults, however it is increasingly being diagnosed in younger people. It is closely linked to lifestyle factors like obesity, physical inactivity, and a poor diet.Other varieties of diabetes exist in addition to these main types, including gestational

diabetes, which occurs during pregnancy, and other particular types brought on by drugs, genetic flaws, or

other illnesses. Unmanaged diabetes has serious repercussions that can impact almost all of the body's organ systems. Damage to both large and small blood vessels can arise from chronic hyperglycemia, which can cause long-term problems like cardiovascular disease. elevated risk of hypertension, heart attack, and stroke. Neuropathy damages the nerves, resulting in pain, weakness, and numbness, especially in the hands and feet. renal failure may result from renal disease caused by nephropathy. Retinopathy can cause blindness and visual impairment by damaging the retina's blood vessels. An increased risk of infections, ulcers, and possibly amputation is another consequence of foot issues.To avoid or postpone these problems and preserve a high quality of life, people with diabetes must receive an early diagnosis and receive efficient treatment. Usually, care include of medicine, such as oral medications, insulin injections, or other injectable therapies, combined with lifestyle changes, such as dietary adjustments, consistent exercise, and weight control. A common and dangerous metabolic disease with major effects on world health is diabetes mellitus. To address this expanding issue and enhance the quality of life for individuals impacted, it is crucial to comprehend its various forms, the underlying causes, and the significance of early diagnosis and treatment. A range of disorders



collectively referred to as diabetes mellitus are typified by hyperglycemia, which is caused by deficiencies in either insulin action or secretion, or both. Even though Type 1 and Type 2 diabetes are the most well-known, precise diagnosis, effective treatment, and ultimately improved patient outcomes depend on an awareness of the subtle differences between the many forms of the disease. An autoimmune condition, type 1 diabetes (T1D) was once referred to as juvenile diabetes or insulin-dependent diabetes. of type 1 diabetes, the immune system of the body unintentionally targets and kills the beta cells of the pancreas, which are in charge of making insulin. Consequently, very little or no insulin is produced by those with T1D. Though it can start at any age, children and young people are most likely to have T1D. It's unclear exactly what causes an autoimmune attack, but environmental variables and genetic predisposition are thought to be involved. Previously known as adult-onset diabetes or non-insulin-dependent diabetes, type 2 diabetes (T2D) is the most common type of diabetes in the world. Insulin resistance, a condition in which the body's cells do not react to insulin as well, is what defines it. The pancreas may eventually become less capable of producing enough insulin to overcome this resistance, which could result in a relative insulin shortage. Obesity, sedentary lifestyles, and bad eating habits are

all closely associated with type 2 diabetes. T2D has historically developed in adults, but as these risk factors are more common, more children and adolescents are being diagnosed with the disease. Lifestyle changes are frequently the first line of treatment for type 2 diabetes. Oral drugs, injectable non-insulin therapy, and insulin, if necessary, may be added later. When a woman does not have diabetes before to becoming pregnant, she may develop gestational diabetes mellitus (GDM). It is typified by glucose intolerance, which is initially identified during pregnancy. Usually, pregnancy-related hormonal changes that impact insulin sensitivity cause GDM. Women with GDM are more likely to get type 2 diabetes later in life, and their children are also more likely to be obese and have type 2 diabetes, even though the condition often goes away after delivery. GDM is managed by dietary changes, physical activity, and occasionally insulin medication to keep the mother's and the unborn child's blood glucose levels within normal ranges. Monogenic diabetes syndromes, such as Maturity-Onset Diabetes of the Young (MODY) and neonatal diabetes, are genetically caused abnormalities of beta-cell activity or insulin action. For example, MODY includes a number of subtypes that are sometimes milder than T1D and may be treated without insulin at first. These subtypes are brought about by single gene changes that impact insulin action or production. Exocrine pancreatitis and cystic fibrosis are two conditions that can harm the pancreas and reduce its ability to produce insulin, which can result in diabetes. Diabetes caused by chemicals or drugs, Blood glucose levels can rise due to some drugs, such glucocorticoids, and diabetes can develop as a result. Endocrinopathies, as Acromegaly and Cushing's syndrome are two more hormonal conditions that might result in secondary diabetes. Diabetes is one of many different types of metabolic diseases. Even though Type 1 and Type 2 diabetes are the most prevalent, it's important to identify different kinds of gestational diabetes for individualized diagnosis and treatment. Comprehending the fundamental causes and traits of each kind enables medical practitioners to offer people with diabetes the best possible care and direction. As research continues, this sophisticated understanding keeps developing, resulting in more accurate diagnostic instruments and treatment approaches.

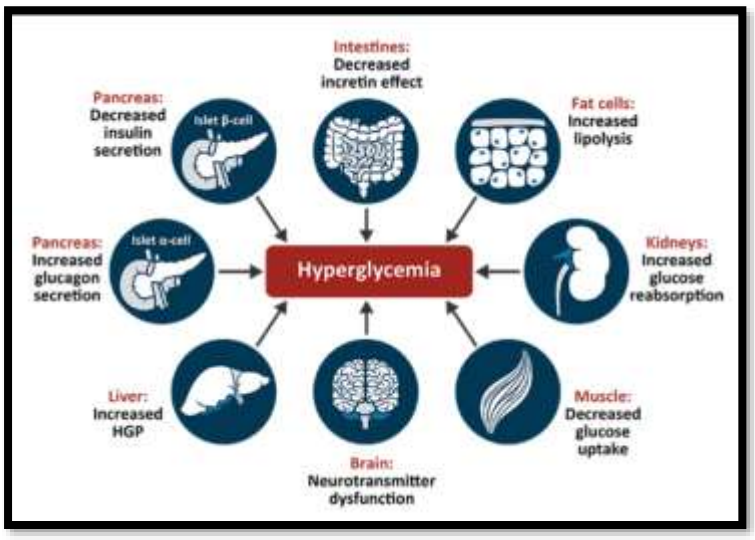
Causes and Symptoms:

Hyperglycemia, the result of the body's ineffective blood glucose regulation, is the cause of diabetes mellitus. The body's cells may become resistant to the insulin that is generated, or the pancreas may not produce enough insulin. Depending on the kind of diabetes, there may be differences in the root causes and symptoms. Type 1 Diabetes An autoimmune response is the main cause of type 1 diabetes. The immune system of the body unintentionally targets and kills the beta cells in the pancreas that produce insulin. Although the precise cause of this autoimmune reaction is unknown, environmental variables like viral infections and genetic predisposition are thought to be involved. As a result, people with type 1 diabetes have a complete lack of insulin. Multifactorial and more complex is type 2 diabetes. Relative insulin deficit, in which the pancreas is unable to produce enough insulin to overcome this resistance, and insulin resistance, in which the body's cells do not react appropriately to insulin, are the primary underlying problems. The risk of type 2 diabetes is considerably increased by a number of risk factors. Overweight and obesity as Insulin resistance is closely associated with excess body weight, especially of the abdomen. Being physically inactive can Insulin resistance might result from irregular activity. Ancestry The risk rises if you have a close family who has type 2 diabetes. Age is Generally speaking, the risk rises with age. Ethnicity may There is a larger propensity among some ethnic groups. An unhealthy diet rich in processed foods, sugar-filled beverages, and saturated fats may be a contributing factor. gestational One kind of diabetes occurs during pregnancy. During pregnancy, hormonal changes may result in insulin resistance. Women who have a family history of type 2 diabetes, obesity, or gestational diabetes are more vulnerable. Genetic flaws that impact the action or generation of insulin, pancreatic conditions (such as pancreatitis or cystic fibrosis), specific drugs, and other hormonal imbalances are less causes.Diabetes symptoms can range in severity and manifest either slowly (in type 2) or quickly (in type 1). In the early stages, some

persons may have minor symptoms or none at all, especially those with type 2 diabetes. Polyuria, or frequent urination, is a common symptom, particularly at night when the body is trying to get rid of extra glucose. Polydipsia (excessive thirst) is because of repeated urination, which causes fluid loss. Increased appetite, or polyphagia, is It's possible that cells aren't receiving enough glucose for energy even when they eat. Unexpected weight loss is more likely in people with type 1 diabetes because their bodies begin using fat and muscle as fuel since they are unable to use glucose. Fatigue may experiencing unusual fatigue as a result of the body's cells not getting enough energy. Vision loss can Elevated blood sugar levels can impact the eye's lens. Bruises and wounds that heal slowly could Elevated blood glucose levels can hinder the body's ability to mend itself. Oftentimes, diseases are The immune system might be weakened by high blood sugar. Neuropathy, or tingling, numbness, or pain in the hands or feet, is more common in people with diabetes who have had the disease for a long time. It's crucial to remember that while these symptoms definitely demand medical attention, they do not provide a clear diagnosis of diabetes. Early symptom detection can help prevent or postpone long-term problems by enabling prompt diagnosis and treatment, particularly in those with risk factors. It is advised that you get your blood glucose checked by a healthcare provider if you encounter any of these symptoms.

Pathology of diabetes

Diabetes mellitus is characterized by dysregulation of glucose metabolism, which is typically brought on by deficiencies in either insulin action or synthesis, or both. This results in long-term hyperglycemia and a variety of microvascular and macrovascular problems. There are differences in the precise pathogenic pathways among the primary forms of diabetes. The autoimmune loss of the insulin-producing beta cells in the pancreatic islets of Langerhans is the defining pathophysiology of type 1 diabetes. Immune cells like as T lymphocytes and macrophages infiltrate the islets during this process, which is called insulitis. These immune cells assault beta cell antigens because they see them as alien, which causes the beta cell mass to gradually decrease. There may be an initial "honeymoon phase" during which some beta cell function is retained. However, insulin production drastically decreases as the autoimmune damage progresses, ultimately resulting in a complete insulin shortage. Because there is insufficient insulin, glucose cannot enter cells to be used as fuel, which results in hyperglycemia, or an accumulation of glucose in the blood. In patients with chronic type 1 diabetes, the pancreas exhibits fibrosis, little to no detectable beta cells, and a marked decrease in the size and quantity of islets. Type 2 diabetes has a more complicated etiology that includes both beta cell failure and insulin resistance. The decreased ability of target tissues—mainly muscle, liver, and adipose tissue—to react to insulin is known as insulin resistance. Defects in insulin receptors, post-receptor signaling molecules, and glucose transporters (such as GLUT4 in muscle and fat) can all contribute to this resistance at the cellular level. Elevated amounts of free fatty acids, inflammation, and intracellular lipid buildup are some of the factors that lead to insulin resistance. The liver's ability to suppress the synthesis of glucose is compromised by insulin resistance. It causes a decrease in the absorption of glucose by muscle. The dysfunction of beta cells is People with type 2 diabetes frequently have a steady reduction in beta cell activity in addition to insulin resistance. First, hyperinsulinemia may result from the pancreas compensating for insulin resistance by secreting more insulin. The beta cells' ability to release enough insulin, however, gradually declines as they are unable to maintain this elevated output. Amyloid accumulation in the islets, lipotoxicity (the harmful effects of lipids), and glucotoxicity (long-term exposure to excessive glucose) are some possible causes of this. This eventually results in a relative insulin shortage, which makes hyperglycemia worse.Typical Pathological Repercussions of Prolonged Hyperglycemia Chronic hyperglycemia is the primary source of diabetes's long-term consequences, regardless of the disease's original cause. Damage to both major and tiny blood arteries is the cause of these problems. Diabetic Retinopathy: Possible blindness due to damage to the retina's tiny blood vessels. Kidney failure may result from diabetic nephropathy's damage to the kidneys' glomeruli, or filtering units.



Diabetic neuropathy can cause pain, numbness, and other neurological problems by damaging nerves as a result of metabolic abnormalities and an impeded blood supply. Concerning macro vascular complications, accelerated arterial hardening, or atherosclerosis, which raises the risk of coronary artery disease (heart attack, angina). Alzheimer's disease (stroke). Peripheral artery disease (foot ulcers, inadequate circulation). Chronic hyperglycemia is the hallmark of diabetes, which is characterized by either insulin resistance and beta cell dysfunction (Type 2) or autoimmune beta cell destruction (Type 1). This chronically high blood glucose subsequently triggers a cascade of degenerative changes in several organs, resulting in the disease's characteristic long-term effects. It is necessary to comprehend these pathogenic mechanisms in order to create effective diagnostic and therapy regimens.

Diagnosing Hyperglycemia:

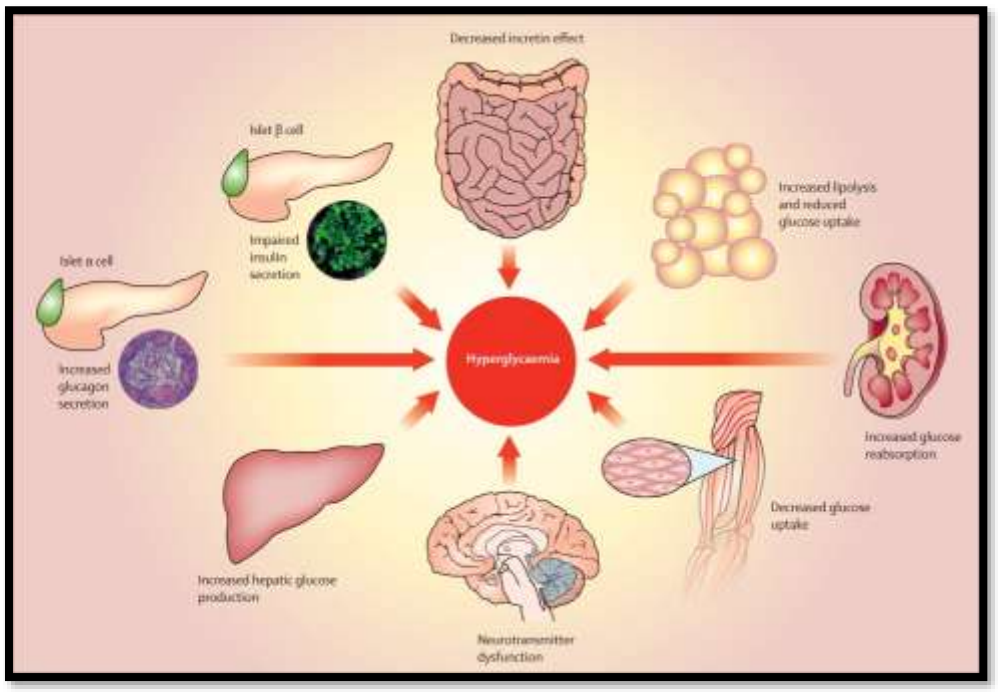
The primary method of diagnosing diabetes mellitus is blood glucose testing. Different test kinds are employed, and the diagnostic criteria differ slightly based on the test. Generally, unless the patient exhibits clear signs of hyperglycemia, a diagnosis of diabetes is verified when blood glucose levels reach or above specific criteria.Test for hemoglobin A1c (HbA1c), The average blood glucose levels over the previous two to three months are provided by this test. It calculates the proportion of glucose bound to hemoglobin, the protein in red blood cells that carries oxygen. More glucose binds to hemoglobin when blood glucose levels are greater. Typical Less than 5.7%,Pre-diabetes 5.7%–6.4%,Diabetes at least 6.5%.The HbA1c test has the benefit of not requiring fasting. Following an overnight fast of at least eight hours, blood glucose levels are measured using Fasting Plasma Glucose (FPG). In order to screen for diabetes, it is typically the first test performed. Less than 100 mg/dL (5.6 mmol/L) is normal. 100 to 125 mg/dL (5.6 to 6.9 mmol/L) is considered prediabetes. 126 mg/dL (7.0 mmol/L) or more is considered diabetes. The Oral Glucose Tolerance Test (OGTT) gauges the body's glucose metabolism. A fasting blood glucose level is measured after the person fasts for the entire night. They then consume a sweet beverage that contains 75 grams of glucose. Over the following two hours, blood glucose levels are periodically measured. At two hours, normal is less than 140 mg/dL (7.8 mmol/L). At two hours, prediabetes is 140–199 mg/dL (7.8–11.0 mmol/L). At two hours, diabetes is defined as 200 mg/dL (11.1 mmol/L) or above. The OGTT can be used to identify type 2 diabetes and is frequently used to diagnose gestational diabetes. Blood glucose is measured by the Random Plasma Glucose Test at any time of day, regardless of when the subject last had food. When diabetes symptoms are present, it is usually used. Diabetes is defined as blood sugar levels of 200 mg/dL (11.1 mmol/L) or greater, together with hyperglycemia symptoms such as frequent urination, increased thirst, and inexplicable weight loss. If symptoms are not obvious, additional test is usually required for confirmation. HbA1c > 6.5% and FPG ≥ 126 mg/dL or 2-hour plasma glucose ≥ 200 mg/dL during an OGTT are the criterion for a diagnosis of diabetes (apart from gestational diabetes), which is typically verified by a follow-up test on a subsequent day. A random plasma glucose level of 200 mg/dL or higher in a patient exhibiting the typical signs of hyperglycemia or hyperglycemic crisis. It may be possible to diagnose unequivocal

hyperglycemia with a single aberrant test result (e.g., very high random glucose with characteristic symptoms).Certain criteria are applied throughout pregnancy to detect gestational diabetes, usually using an OGTT with varying glucose load and time points. When blood glucose levels are higher than usual but do not yet match the criteria for diabetes, prediabetes is diagnosed. Because lifestyle changes can frequently stop or slow the growth of type 2 diabetes, identifying prediabetes is crucial. Analyzing blood glucose test findings in light of clinical presentation is essential to the diagnosis of diabetes. These tests are used by medical experts to precisely diagnose diabetics and direct the development of suitable management plans.

Preventive measures:

Type 2 diabetes, which makes up the great majority of cases globally, can be prevented or its onset postponed, although not all types of diabetes, like type 1, can be avoided. Prioritizing preventative measures is crucial in light of the rising frequency worldwide and the related health issues. The main focus of these tactics is on leading and sustaining a healthy lifestyle. A key component of prevention is changing one's lifestyle. Changing everyday routines in a way that is sustainable is one of the best ways to prevent type 2 diabetes. A balanced diet is essential for healthy eating. This comprises, Regulation of Portion Sizes is Controlling your portion sizes aids in weight and calorie consumption management. Selecting foods high in fiber, such as whole grains, fruits, and vegetables, can help control blood sugar levels and encourage fullness. Reduced consumption of processed foods and sugary drinks is linked to poor blood sugar regulation and weight increase. Choose water, whole, unprocessed foods, and beverages without added sugar. When choosing healthy fats, Select unsaturated fats from foods like avocados, almonds, seeds, and olive oil instead of trans and saturated fats. Frequent exercise can help Exercise helps control weight, increases insulin sensitivity, and enhances cardiovascular health in general. At least 150 minutes of moderate-intensity aerobic exercise (such as swimming or brisk walking) or 75 minutes of vigorous-intensity exercise (such as jogging) should be a weekly goal. Strength training activities should be included at least twice a week. To get the long-term advantages, consistency is essential. Keeping a Healthy Weight as a Being overweight and obese are major risk factors for type 2 diabetes. When those with prediabetes lose even a small amount of weight (5–7% of body weight), the risk is greatly decreased. The foundation of prevention is reaching and keeping a healthy weight by combining nutrition and exercise. Specific Interventions for People at High Risk. Those who have been classified as high-risk (such as those with prediabetes, a family history of type 2 diabetes, or a history of gestational diabetes) may benefit from more extensive therapy. It has been demonstrated that Diabetes Prevention Programs (DPPs), which are structured programs that frequently include food counseling, exercise regimens, and lifestyle coaching, are very successful in avoiding or postponing the onset of type 2 diabetes in people with prediabetes. Medication In certain situations, physicians may prescribe certain drugs, such metformin, to assist stop the progression from prediabetes to type 2 diabetes, especially for people who are at very high risk. However, rather than taking the place of lifestyle changes, medicine is usually used in conjunction with them. Keeping gestational diabetes at bay is Despite the fact that gestational diabetes occurs throughout pregnancy, some methods to lower the risk include Following a balanced diet during pregnancy, keeping a healthy weight before to becoming pregnant, and getting moderate exercise as advised by a doctor. Following pregnancy, women with a history of gestational diabetes should have routine screening for type 2 diabetes because their lifetime risk is elevated. The significance of early risk factor detection and management is To avoid or postpone the onset of type 2 diabetes and its complications, it is essential to recognize and control risk factors such as prediabetes, high blood pressure, and high cholesterol. Frequent screens and examinations can aid in early detection and prompt action, particularly for individuals with risk factors. While there is currently no way to prevent type 1 diabetes, proactive lifestyle changes that emphasize a balanced diet, frequent exercise, and keeping a healthy weight can greatly lower the chance of acquiring type 2 diabetes. For individuals who are more susceptible,

early risk factor management and focused interventions are essential for preventing diabetes and lessening its impact on both individuals and society.



Managing by treatment:

The goals of treating diabetes mellitus are to control blood sugar levels, reduce symptoms, and stop or postpone the emergence of long-term issues. The type of diabetes, the patient's general health, and their lifestyle all affect the treatment plan. Usually, a mix of medicine, lifestyle changes, and routine monitoring are used. Insulin therapy is a key component of type 1 diabetes care. Due to insufficient insulin production, the body has to supplement it with The injection of insulin is Rapid-acting, short-acting, intermediate-acting, and long-acting insulin are frequently injected several times a day. The body's demands are met throughout the day by customizing regimens. Insulin pumps are machines that continuously inject rapid-acting insulin under the skin, with the option of bolus dosages during meals. In addition to insulin, people with type 1 diabetes must regularly check their blood glucose levels: To monitor readings and modify insulin dosages appropriately, use a blood glucose meter or continuous glucose monitor (CGM). Eat a Balanced Diet: Maintaining a healthy diet and being aware of how various foods impact blood sugar levels Take Part in Regular Treatment for type 2 diabetes is often a step-by-step process. For example, lifestyle changes are typically the first line of treatment and are essential for the duration of the disease's care. Lean protein, fruits, vegetables, whole grains, and a reduction in processed and sugary meals are among the dietary changes they entail. Getting at least 150 minutes a week of moderate-intensity exercise is the goal of regular exercise. Because lifestyle modifications alone are insufficient to reach goal blood glucose levels, a variety of injectable and oral medicines, such as Metformin, are available. Frequently used as the first-line drug, it increases insulin sensitivity and decreases the liver's synthesis of glucose. Glutathiones and Sulfonylureas Encourage more insulin to be released by the pancreas. DPP-4 Inhibitors: Assist in reducing the synthesis of glucose and increasing insulin release. SGLT2 Inhibitors Urine glucose excretion should rise.

Agonists for GLP-1 Receptors Reduce glucose production and slow digestion. Insulin. may eventually be required if other drugs are insufficient to regulate blood sugar. Keeping an eye on blood sugar: Blood glucose levels should be regularly self-monitored so that patients and their healthcare team may evaluate the efficacy of the treatment plan and make any necessary modifications. CGMs are also being utilized more and more to manage type 2 diabetes. The overall management of diabetes is Comprehensive diabetes management, regardless of type, also include routine examinations. Among medical professionals include endocrinologists, primary care doctors, and other specialists (such as podiatrists and ophthalmologists). Diabetes education

and learning, including how to take medications, check blood sugar, identify and treat problems, and use good coping mechanisms. Handling additional risk factors such as elevated blood pressure and cholesterol is part of the management of associated conditions. The aim of diabetes treatment is to maintain blood glucose levels as near to the target range as is safe in order to avoid or postpone problems and enable people with diabetes to have active, healthy lifestyles. Each person's treatment plan is unique, and it may change over time in response to their needs.
Oral Drugs for Diabetes Type 2

Oral drugs are frequently an essential component of treatment plans for people with type 2 diabetes, particularly when dietary and activity changes are insufficient to reach desired blood glucose levels. These drugs help reduce blood sugar through a variety of methods. It is vital to remember that persons with type 1 diabetes need insulin, thus these drugs are usually not utilized for this condition.

Biguanides:

Metformin is the main example of a biguanide, which is a key component in the pharmaceutical treatment of type 2 diabetes mellitus. Reduction of hepatic glucose synthesis and improvement of peripheral insulin sensitivity are their main modes of action. Biguanides typically do not directly stimulate insulin secretion, which makes them less likely to cause hypoglycemia when taken as monotherapy than some other oral antidiabetic medications. Metformin is a first-line medication that is advised by major diabetic guidelines worldwide due to its effectiveness in lowering HbA1c, as well as its neutral or even positive effects on body weight and cardiovascular risk factors. While further research is needed for these applications, evidence indicates potential benefits beyond glycemic control in other illnesses, such as polycystic ovarian syndrome (PCOS) and even some types of cancer. Biguanides most frequently cause gastrointestinal adverse effects, including nausea, diarrhea, and abdominal pain, which usually go away with slow dose titration and taking the drug with meals. Lactic acidosis is an uncommon but dangerous side effect, especially in people with severe renal impairment. because of their ability to decrease blood sugar and their advantageous metabolic profile, biguanides—of which metformin is the archetypal medication—are essential for the treatment of type 2 diabetes. They are a key component of treatment plans meant to achieve ideal glycemic control and lessen the long-term problems linked to diabetes because of their proven safety and effectiveness.

Sulphonylures:
A class of oral hypoglycemic medications called sulfonylureas is frequently used to treat type 2 diabetes. Their main method of action is to increase the pancreatic beta cells' production of insulin, which lowers blood glucose levels. They depolarize these cells and release insulin by attaching to their sulfonylurea receptor, which blocks ATP-sensitive potassium channels. Clinically, sulfonylureas are useful in reducing HbA1c and are frequently regarded as an affordable choice. However, using them may result in adverse consequences, the most common of which is hypoglycemia, which can be minor to severe. Another known adverse effect that some people experience is weight gain. With somewhat distinct pharmacokinetic profiles and potencies, glibenclamide (glyburide), glipizide, and glimepiride are common examples of sulfonylureas. The patient's renal function, risk of hypoglycemia, and responsiveness are some of the criteria that influence the choice of sulfonylurea. Despite their ability to effectively reduce blood glucose, sulfonylureas do not treat the underlying insulin resistance that is frequently seen in type 2 diabetes. Since they target distinct facets of glucose dysregulation, they are commonly used in conjunction with other antihyperglycemic medications. The use of sulfonylureas in the treatment of diabetes nowadays must be carefully evaluated in light of emerging medication classes that

may have fewer risks of weight gain and hypoglycemia, as well as those situations where they have been shown to have cardiovascular advantages. They are still an important element of the treatment arsenal for type 2 diabetes, nevertheless, especially when cost is a major consideration and in individuals who don't have any serious risk factors for their primary adverse effects.

Meglitinides:

A class of oral antihyperglycemic medications called meglitinides is mostly used to treat type 2 diabetes. Their main method of action is to encourage the pancreatic beta cells to secrete more insulin. Meglitinides are especially good in reducing postprandial glucose excursions because they operate more quickly and have a shorter duration of action than sulfonylureas. such sulfonylureas, drugs in this class, such repaglinide and nateglinide, work by attaching to the ATP-sensitive potassium channels on beta cells, but at a different binding location. Insulin is subsequently released as a result of membrane depolarization and calcium influx. Unlike some other oral antidiabetic drugs, meglitinides are usually taken just before meals because of their quick action and short half-life, which allows for more flexibility in meal time. Meglitinides have been shown in clinical trials to be effective in reducing postprandial glucose levels and attaining overall glycemic control, either alone or in conjunction with other antidiabetic medications such as metformin. Although they are efficient at lowering blood glucose, they have a risk of hypoglycemia, which is generally seen as being lower than that of sulfonylureas because of their shorter action profile. Another possible side effect, however less severe, is weight gain.All things considered, meglitinides are a useful treatment choice for people with type 2 diabetes, especially when it comes to controlling post-meal glucose increases. In some therapeutic situations, their quick onset and brief duration of action provide a unique pharmacological profile that may be helpful; however, the danger of hypoglycemia must be carefully taken into account.

Thiazolidinediones:

Glitazones, another name for thiazolidinediones (TZDs), are a class of oral antidiabetic drugs used to treat type 2 diabetes. Their main way of working is by activating the nuclear receptor known as peroxisome proliferator-activated receptor-gamma (PPAR-γ), which increases insulin sensitivity in peripheral tissues like muscle, adipose tissue, and the liver. Better glucose absorption and utilization as well as a decrease in hepatic glucose synthesis are the results of this activation. As seen by decreases in HbA1c and fasting plasma glucose, TZDs like pioglitazone and rosiglitazone have proven effective in clinical settings in decreasing blood glucose levels. They can be taken either alone or in conjunction with other antidiabetic medications such as sulfonylureas or metformin. In addition to diabetic management, TZDs, especially pioglitazone, may also improve lipid profiles and provide some cardiovascular advantages. Edema, a higher risk of bone fractures, weight gain from fluid retention and increased adiposity, and other possible adverse effects are linked to the usage of TZDs. There have also been concerns expressed about the safety of rosiglitazone in particular for the cardiovascular system. As a result, the risk-benefit profile of each patient must be carefully considered before using TZDs.Because they target insulin resistance, TZDs are useful tools for controlling type 2 diabetes. Although they are useful in enhancing glucose control and may provide additional metabolic advantages, their use requires knowledge of their adverse effect profile and patient-specific factors.The person's blood glucose levels, other medical conditions, possible side effects, and cost are some of the variables that influence the choice of oral medication. For the best blood glucose control, a variety of oral drugs may frequently be prescribed. To choose the best course of therapy, people with type 2 diabetes must collaborate closely with their medical team.

CONCLUSION:

An extensive range of oral antidiabetic drugs has made great progress in the treatment of type 2 diabetes mellitus. In order to achieve glycemic control, reduce the risk of complications, and enhance the general quality of life for millions of people worldwide, these agents with its own distinct mechanisms of action are essential. Although lifestyle changes continue to be the mainstay of care, oral medications either alone or in combination frequently become required to reach and sustain desired blood glucose levels. There are many different classes of oral diabetes drugs, making the market diverse and lucrative. Metformin is an example of a biguanide, which is a basic medicine that focuses on insulin sensitivity and hepatic glucose production. They are frequently used as the first pharmaceutical intervention because to their proven effectiveness, relatively positive side effect profile, and possible cardiovascular advantages. Although sulfonylureas and meglitinides are good at encouraging the pancreatic beta cells to secrete insulin, they have a higher risk of hypoglycemia and weight gain, therefore patient selection and monitoring must be done carefully. Although thiazolidinediones provide an alternative method of decreasing blood sugar by improving peripheral insulin sensitivity, they are linked to weight gain, fluid retention, and possible cardiovascular issues, necessitating a careful evaluation of each patient's unique risk factors. The introduction of more recent classes, like SGLT2 and DPP-4 inhibitors, has opened up new therapy choices with clear benefits. DPP-4 inhibitors provide glucose-dependent insulin secretion, decreased hepatic glucose generation, and a decreased risk of hypoglycemia by altering incretin pathways. By encouraging renal glucose excretion, SGLT2 inhibitors not only lower blood glucose levels but also show promise in lowering blood pressure, helping patients lose weight, and most importantly protecting the kidneys and heart in some patient groups. Although they are less frequently employed as first-line treatments, alpha-glucosidase inhibitors can help regulate postprandial glucose excursions. Choosing the best oral drug, or combination of medications, is a complex procedure that calls for thorough evaluation of a number of variables. The patient's baseline HbA1c, comorbidities (such heart disease or chronic renal disease), hypoglycemia risk, possible adverse effects, influence on weight, patient preferences, and expense are some of these. Diabetes care has evolved to stress a customized approach, adjusting the treatment plan to each patient's unique requirements and situation. To attain the best glycemic control, combination therapy involving several oral medications, frequently with complementary modes of action, is commonly used. The complex pathophysiology of type 2 diabetes, which includes both insulin resistance and beta-cell dysfunction, can be addressed using this approach. Additionally, if the illness worsens or when oral drugs alone are unable to achieve target glucose levels, injectable therapies—such as insulin and GLP-1 receptor agonists—are frequently used in addition to oral medications. New insights into diabetes are being revealed by continuing research, which also opens the door for the creation of innovative treatment approaches. Although current oral drugs have been the focus of this discussion, even more precise and potent oral therapeutics may be developed in the future. To sum up, oral antidiabetic drugs are a vital component of the pharmacological treatment of type 2 diabetes. Because of their various modes of action, glycemic control may be customized, and the fact that there are several classes gives doctors a wide variety of tools to treat the intricate metabolic abnormalities that underlie the illness. Improving results and lessening the burden of this chronic condition depend on the best possible use of these drugs, directed by a patient-centered strategy that takes into account unique traits and preferences. Our approaches to treating diabetes will change as our knowledge of the disease does, and oral drugs will remain an important and developing part of this effort.

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TOWARDS A LOW-CARBON FUTURE: A COMPARATIVE TECHNO-ECONOMIC EVALUATION OF ENERGY SOURCES FOR SUSTAINABLE AND COST-EFFECTIVE TRANSITIONS

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Abstract
The transition to a low-carbon economy requires a thorough evaluation of various energy sources, including their efficiency, effectiveness, investment costs, and storage capacity. This article compares the major energy sources fossil fuels, nuclear, wind, solar, biomass, and hydrogen to identify the best options for integration into renewable energy systems. Recommendations are provided to optimize the use of renewable energy in a global context. Additionally, this article includes figures, interpretations, and key insights to enhance understanding of the energy transition.
Keywords: Energy transition, Renewable energy, Energy storage, Storage technologies, Hydrogen.

ERGENLERDE DİJİTAL BAĞIMLILIĞIN DEMOGRAFİK DEĞİŞKENLER AÇISINDAN İNCELENMESİ

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ÖZET
Dijital bağımlılık, dijital cihazların aşırı kullanımıyla oluşan bir bağımlılık türü olarak tanımlanmakta ve ergenler için hem olumlu ve hem de olumsuz birçok sonucun belirleyicisi olabilmektedir. Bu araştırmada; dijital bağımlılığın ergenler üzerinde oluşturabileceği olumsuz durumların araştırılması ve bu konuda geliştirilebilecek çözüm önerilerine katkı sağlaması amaçlanmaktadır. Bu amaç doğrultusunda, ergenlerin dijital bağımlılık düzeylerinin çeşitli demografik değişkenler açısından incelenmesi hedeflenmiştir. Bu araştırmada Samsun ilinde bulunan farklı liselerden toplam 297 öğrenciden veri toplanmıştır. Araştırmaya katılan katılımcıların %49.2'si kadın, %50.8'i erkek ve yaşları 14-18 aralığında olup ortalaması 16.03'tür (*SS* = 0.86). Araştırmada, Demografik Bilgi Formu ve Ergenler İçin Dijital Bağımlılık Ölçeği kullanılmıştır. Araştırmanın bulgularına göre, ergenlerin dijital bağımlılık düzeyinin sınıf düzeyine göre farklılaştığı; 11. sınıfta okuyan ergenlerin 9. sınıfta okuyan ergenlerden daha fazla dijital bağımlılık puanı bildirdikleri görülmüştür. Dijital bağımlılığın derslerde alınan notlarla ilişkisini incelemek için yapılan tek yönlü ANOVA analizi sonucunda ortalamanın altında not aldığını belirten ergenlerin ortalamanın üstünde not aldığını bildiren ergenlerden daha fazla dijital bağımlılık puanı bildirdiği görülmüştür. Ayrıca, dijital bağımlılığın algılanan gelir düzeyi ile ilişkisi incelendiğinde istatistiksel olarak anlamlı bir etkisinin olmadığı sonucuna ulaşılmıştır. Dijital bağımlılığı etkileyen değişkenler aşamalı regresyon ile incelendiğinde; dijital bağımlılık üzerinde en güçlü etkiye sahip değişkenin haftada kaç gün uyumadan önce ekran kullanıldığıdır. İkinci en güçlü etkiye sahip değişken ise haftada kaç gün uyandıktan sonra ekran kullanıldığı olarak belirlenmiştir. Hafta içi günlük ekran süresi ise üçüncü en güçlü yordayıcı olarak belirlenmiştir. Okul sonrası ekran kullanımı değişkeni dijital bağımlılık üzerinde istatiksel olarak anlamlı ve etkili bir faktör olarak belirlenmiştir. Bununla birlikte; televizyonun açık olma durumun ise zayıf ama anlamlı bir etkiye sahip olduğu ve aynı anda birden fazla ekran kullanma durumunun ise anlamlı, en zayıf etkiye sahip olan değişken olduğu sonucuna varılmıştır. Tüm bu sonuçlar birlikte değerlendirildiğinde ekran kullanımla ilgili özelliklerin dijital bağımlılık üzerinde önemli bir rol oynadığı söylenebilir.
Anahtar kelimeler: Dijital bağımlılık, ergenler, ekran kullanımı

AN INVESTIGATION OF DIGITAL ADDICTION IN ADOLESCENTS ACCORDING TO DEMOGRAPHIC VARIABLES

ABSTRACT

Digital addiction is defined as a type of addiction caused by the excessive use of digital devices and can be a determinant of both positive and negative outcomes for adolescents. This study aims to investigate the potential negative effects of digital addiction on adolescents and contribute to the development of possible solutions regarding this issue. In line with this aim, the study seeks to examine adolescents' levels of digital addiction in terms of various demographic variables. Data were collected from a total of 297 students from different high schools in the province of Samsun. Among the participants, 49.2% were female, 50.8% were male, and their ages ranged between 14 and 18, with a mean age of 16.03 (*SD* = 0.86). The study utilized a Demographic Information Form and the Digital Addiction Scale for Adolescents. According to the findings of the research, adolescents' levels of digital addiction differed by grade level; specifically, 11th-grade students reported higher digital addiction scores than 9th-grade students. One-way ANOVA analysis examining the relationship between digital addiction and academic performance revealed that adolescents who reported below-average grades had higher digital addiction scores than those who reported above-average grades. Moreover, when the relationship between digital addiction and perceived income level was examined, no statistically significant effect was found. Stepwise regression analysis revealed that the strongest predictor of digital addiction was the number of days per week digital devices were used before sleep. The second strongest predictor was the number of days per week devices were used immediately after waking up. Weekday screen time was identified as the third strongest predictor. Screen usage after school also had a statistically significant effect on digital addiction. Additionally, while having the television on had a weak but significant effect, the use of multiple screens simultaneously was found to have the weakest yet still statistically significant effect on digital addiction. Taken together, these results indicate that characteristics related to screen use play an important role in digital addiction.

Keywords: Digital addiction, adolescents, screen time

INTRODUCTION

The rapid emergence of various portable digital devices (such as smartphones, tablets, and laptops) has ushered individuals into a 'digital age' These digital devices have become a daily necessity for human life and learning, influencing work, entertainment, and social interaction (Ding & Li, 2023). The widespread integration of technology into all areas of life has enabled individuals from all age groups to benefit from it, and its ease of accessibility has significantly increased the amount of time people spend in front of screens each day (Gökçe et al., 2021). Due to the growing interaction with the virtual world, digital addiction has increasingly become a societal concern (Demirel et al., 2022). Digital addiction has been defined as an impulse control disorder characterized by the excessive use of digital devices (e.g., phones, computers, tablets) and digital platforms (e.g., social media, games, e-commerce, content platforms) (Kumar Sing & Kumar Singh, 2019). Digital addiction is considered a broad term that encompasses various forms of internet addiction, including gaming and social media addiction. Therefore, it involves not only addictions based on online use but also those related to offline digital engagement (Meng et al., 2022).

Compared to the early 2010s, the rate of smartphone use among adolescents has risen from 23.2% to 71.7%. Alongside this increase, the likelihood of adolescents spending 2 to 4 hours on screens has been observed to be nearly 4 times higher, and the likelihood of spending more than 4 hours has increased by 12 times (Mora-Monteros et al., 2023). During the COVID-19 pandemic, adolescents' screen time increased even further (Trott et al., 2022). According to

data from the Turkish Statistical Institute, in 2024, the rate of internet usage among individuals aged 16–74 was 88.8%. While the internet usage rate was 85.4% for women, it was 92.2% for men (TUIK, 2024). With this rising trend, using the internet every day of the week, spending four or more hours online daily, and being in the early stages of adolescence have emerged as significant risk factors associated with internet addiction (Bueno et al., 2024). Increased screen time during adolescence may negatively affect the cognitive control system and the brains reward system, which are still developing, and these effects may persist into adulthood, potentially leading to internet addiction in later life (Crone & Konijn, 2018; Marciano et al., 2021).

When examining the demographic factors influencing digital addiction in the literature, a study conducted in China with 50,000 students found that digital addiction was associated with demographic characteristics such as age, gender, and parental education level (Zhang et al., 2022). In a study conducted in Serbia (2023) with adolescents aged 11–19, a significant relationship was observed between gender and internet addiction, and individuals whose parents had lower education levels exhibited higher levels of internet addiction (Pjevac et al., 2023). A similar study conducted in Balıkesir in 2024 with 373 adolescents aged 12–18 revealed that female students had higher levels of digital addiction compared to male students. When examined by family income level, it was observed that higher income was positively correlated with higher levels of digital addiction (Paş & Çelik, 2024). In another study conducted in Bangladesh with students preparing for university entrance exams, males were found to have higher levels of digital addiction than females. Moreover, participants who were dissatisfied with their academic performance also showed higher levels of digital addiction (Al-Mamun et al., 2024).

The increasing duration of screen use, which has become a widespread phenomenon in the lives of adolescents, is known to be associated with physical, neurological, psychological, and behavioral problems (Guerrero et al., 2019; Qu et al., 2023; Lissak, 2018; Nakshine et al., 2022; Xu et al., 2024). Therefore, identifying the problems related to increased screen use is considered both urgent and significant. It is believed that determining the problems that may arise from screen use during adolescence and understanding whether these issues persist into adulthood will be crucial for developing effective strategies to address them.

In light of all this information, the present study aims to examine adolescents' levels of digital addiction in relation to their demographic characteristics. It is believed that the findings of this study will provide valuable insights for the development of public health policies targeting adolescence and for the formulation of strategies to address issues related to digital addiction.

MATERIAL AND METHODS

Participants

A total of 297 high school students from the Atakum and İlkadım districts of Samsun province participated in this study. Among the participants, 146 (49.2%) were female and 151 (50.8%) were male. Regarding grade level, 30.3% (n = 90) of the students were in 9th grade, 38% (n = 113) in 10th grade and 31.6% (n = 94) in 11th grade. Parental education levels were assessed using a 7-point scale (0 = primary school, 6 = doctoral degree). According to this scale, the mothers of the participants were reported to have the following education levels: 7.8% (n = 23) primary school, 12.2% (n = 36) middle school, 26.2% (n = 77) high school, 3.4% (n = 10) associate degree, 36.7% (n = 108) bachelor's degree, 10.9% (n = 32) master's degree, and 2.7% (n = 8) doctoral degree. The fathers' education levels were as follows: 5.1% (n = 15) primary school, 5.8% (n = 17) middle school, 25% (n = 73) high school, 3.8% (n = 11) associate degree, 42.8% (n = 125) bachelor's degree, 12.7% (n = 37) master's degree, and 4.8% (n = 5) doctoral degree. The parental relationship status was evaluated using a 4-point scale (0 = married and living together, 3 = one parent deceased). According to participants' responses, 88.1% (n = 260)

reported that their parents were married and living together, 2.7% (n = 8) married but living separately, 7.5% (n = 22) divorced and 1.7% (n = 5) had lost one parent.

Instruments

Demographic Information Form

This is a form prepared by the researchers that includes variables such as gender, age, and educational status, as well as questions evaluating screen time, based on the study by Semar and Bakshi (2022).

Digital Addiction Scale for Adolescents

The Digital Addiction Scale for Adolescents was developed by Seema et al. (2022) and later adapted into Turkish by Bağatarhan (2023), who also conducted the validity and reliability analyses. The scale is a 10-item instrument designed in a 7-point Likert format, aiming to assess adolescents' levels of digital addiction as well as where, for what purpose, and how frequently they use digital devices. The target population of the scale consists of adolescents aged 11 to 19. The scale addresses two interrelated aspects: adolescents' addiction to digital devices and their continuous use of these devices in various settings. Higher scores on the scale indicate higher levels of digital addiction (Bağatarhan, 2023). In the present study, the Cronbach's alpha internal consistency coefficient of the scale was found to be .80.

Procedures

Prior to data collection, an application was submitted to the Ethics Committee for Research and Publication in Social and Human Sciences at Ondokuz Mayıs University. With the committee's approval dated 31.01.2025 and numbered 2025-57, the study was deemed ethically appropriate. Data were collected from schools for which permission had been obtained from the Provincial and District Directorates of National Education. After obtaining the necessary permissions, data collection was conducted face-to-face. In order for participants to take part in the study, their parents were informed through a consent form, and parental permission was obtained. Participants were verbally informed about the purpose of the research, that participation was voluntary, and that their identities would remain confidential. After collecting the parental consent forms, the questionnaire forms were distributed and the administration was completed within approximately 40 minutes. The researchers' email addresses were included in the questionnaire form in case participants had any questions or concerns.

RESULTS AND DISCUSSION

An Examination of Digital Addiction in Adolescents by Gender and Grade Level

A 2×3 factorial ANOVA was conducted to examine whether digital addiction among adolescents differs according to gender and grade level. Preliminary analyses indicated that the assumptions of ANOVA were met. The results showed that the main effect of grade level on digital addiction was statistically significant ($F(2, 291) = 5.67$, $p < .001$, $\eta^2 = .024$). However, the main effect of gender ($F(1, 291) = 1.74$, $p < .05$, $\eta^2 = .01$) and the interaction effect between gender and grade level ($F(2, 291) = 2.02$, $p > .05$, $\eta^2 = .01$) were not statistically significant.

Follow-up analyses revealed that adolescents in 11th grade (M = 3.90, SD = 1.00) reported significantly higher digital addiction scores compared to those in 9th grade (M = 3.44, SD = 0.90).

The analysis results indicated that gender did not have a significant effect on digital addiction, whereas grade level did have a significant effect. In other words, as grade level increases, the level of digital addiction also increases. This finding is consistent with several studies in the literature. For instance, Seema et al. (2022) reported that digital addiction increases with higher grade levels. This may be explained by increased access to and autonomy in the use of digital devices as adolescents grow older.

An Examination of Digital Addiction in Adolescents Based on Academic Grades

A one-way ANOVA was conducted to determine whether digital addiction among adolescents differed according to their academic grades. Preliminary analyses confirmed that the assumptions of ANOVA were met. The results indicated that the main effect of academic grades on digital addiction scores was statistically significant ($F(1, 292) = 7.43$, $p < .001$, $\eta^2 = .03$). Follow-up analyses revealed that adolescents who reported receiving below-average grades ($M = 3.85$, $SD = .98$, n = 113) had significantly higher digital addiction scores compared to those who reported receiving above-average grades ($M = 3.54$, $SD = .91$, $n = 181$).

When examining the relationship between academic grades and digital addiction, it was found that students who reported lower academic performance had significantly higher digital addiction scores. Similarly, a study conducted in Bangladesh by Al-Mamun et al. (2024) found that students who were dissatisfied with their academic performance exhibited higher levels of digital addiction. This finding suggests that excessive use of digital devices, particularly for non-educational purposes, may negatively impact students' academic achievement.

An Examination of Digital Addiction in Adolescents Based on Perceived Economic Status

A one-way ANOVA was conducted to determine whether digital addiction among adolescents differed according to perceived income level. The analysis revealed that the main effect of perceived economic status on digital addiction was not statistically significant ($F(1, 291) = 0.58$, $p < .05$, $\eta^2 = .00$).

Table 1. Pearson correlation coefficients among the study variables

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1. Digital Addiction Scale	-											
2.Mother's Education Level	-.04	-										
3. Family Income Group	.03	.32	-									
4. Academic Grades	-.16**	.23	.21	-								
5. Frequency of Screen Use During School Activities	-.10	.01	.02	-.12*	-							
6. Frequency of Screen Use in After School Activities	-.29***	-.09	.01	.05	-.00	-						
7. Total Screen Time in the Past Month	.31***	.07	.05	-.07	-.02	-.18	-					
8. Whether the TV Remains On When No One Is Watching	-.20***	-.03	-.03	.08	.00	.06	-.09	-				
9. Number of Days per Week Screens Are Used After Waking Up	-.45***	.03	.04	.10	.04	.23	-.29	.19	-			
10. Number of Days per Week Screens Are Used Before Sleeping	-.46***	.09	.06	.09	.07	.30	-.42	.08	.44	-		
11. Average Daily Screen Time on Weekdays	.35***	-.04	-.07	-20	.09	-.17	.42	-.15	-.33	-.30	-	
12. Simultaneous Use of Multiple Screens	-.24***	-.00	-.02	-.04	-.00	.16	-.09	.18	.22	.15	-.13*	-

$p < .05 = ^{*}$, $p < .001 = ^{***}$

No significant difference was found between perceived economic status and digital addiction. Similarly, a study by Arslan et al. (2015) also concluded that economic status does not have a significant effect on digital addiction. This may be due to the fact that digital devices have become tools that are accessible and essential for everyone, regardless of socioeconomic level. In particular, the widespread use of digital devices for education and social interaction during the COVID-19 pandemic may have contributed to this outcome.

Analysis Results on Predicting Digital Addiction Among Adolescents

A stepwise regression analysis was conducted to examine the extent to which adolescents' digital addiction scores were predicted by several screen-related behavior variables. The results revealed that the most significant predictors were the number of days per week screens were used before sleeping ($\beta = .26$, $p < .001$), after waking up ($\beta = .21$, $p < .001$), and daily screen time on weekdays ($\beta = .15$, $p < .001$), all of which had a positive effect. Additionally, screen use after school ($\beta = .12$, $p < .05$), leaving the television on when no one is watching ($\beta = .10$, $p < .05$), and simultaneous use of multiple screens ($\beta = .10$, $p < .05$) also had significant but weaker positive effects. Together, these variables accounted for 29% of the variance in digital addiction scores.

The results of the regression analysis revealed that the strongest predictor of digital addiction among adolescents was screen use before sleep. This was followed by screen use after waking up, weekday screen time, and screen use after school, respectively. These findings suggest that excessive use of digital devices, particularly before sleeping and after waking up, may increase the likelihood of developing addiction. Furthermore, leaving the television on when no one is watching and the simultaneous use of multiple screens were also identified as factors influencing digital addiction levels. These results imply that using multiple digital devices at the same time may contribute to attention-related problems.

Conclusions

In this study, adolescents' levels of digital addiction were examined in relation to various demographic variables. The analyses revealed that while gender and perceived economic status did not have a significant effect on digital addiction, higher grade level and lower academic performance were found to have significant effects. The variables that predicted digital addiction included screen use before sleeping, screen use after waking up, weekday screen time, screen use after school, leaving the television on when no one is watching, and simultaneous use of multiple screens. The limitations of this study are as follows: the research was conducted in selected high schools in the province of Samsun; therefore, caution should be exercised when generalizing the findings. Future studies are recommended to employ longitudinal designs with larger samples from different regions. Additionally, future research could examine the relationship between digital addiction and family or peer relationships, as well as parental attitudes.

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DİJİTAL DETOKSUN AKILLI TELEFON BAĞIMLILIĞI VE AKILLI TELEFON AŞERMESİ ÜZERİNDEKİ ETKİSİ: DEMOGRAFİK ÖZELLİKLER AÇISINDAN BİR İNCELEME

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ÖZET

Teknolojik cihazlardaki gelişmelerle birlikte taşınabilir cihazlar aracılığıyla ekrana maruz kalma süresi artmaktadır. Ekrana sürekli maruz kalma teknoloji bağımlılığı gibi psikolojik sorunlarla birlikte fiziksel, sosyal ve nörolojik açıdan olumsuz sonuçlara neden olmaktadır. Bu gibi olumsuz sonuçlardan kaçınmak veya etkisini azaltmak için bilinçli teknoloji kullanımı, zaman yönetimi, düzenli dijital detoks uygulamak gibi stratejileri benimsemek önemlidir. Bu doğrultuda mevcut araştırmada akıllı telefon bağımlılığı ve akıllı telefon aşerme düzeyinin demografik özellikler açısından incelenmesi amaçlanmıştır. Bu amaçla, kartopu örnekleme yöntemi kullanılarak yaş ortalaması 20.56 olan ve tamamı lisans programına devam eden öğrencilerden oluşan 62 kişilik bir örneklemden veri toplanmıştır. Çalışmada veri toplama aracı olarak Demografik Bilgi Formu, Akıllı Telefon Bağımlılığı Ölçeği-Kısa Formu (ATBÖ-KF) ve Akıllı Telefon Aşerme Ölçeği (ATAÖ) kullanılmıştır. Ayrıca ekran süresinin kontrolü ve dijital detoks uygulaması için akıllı telefonlardaki 'Ekran Süresi' özellikleri kullanılmıştır. Değişkenlerin dijital detoks öncesi ve sonrası anlamlı bir farklılık gösterip göstermediğini incelemek için Mann-Whitney (Wilcoxon) testi ve t testi yapılmıştır. Dijital detoks kapsamında katılımcılardan Instagram, Twitter, Snapchat, TikTok ve Facebook gibi sosyal medya hesaplarını üç gün süreyle kullanmamaları istenmiştir. Katılımcıların neredeyse tamamının Instagram kullandığı ve Instagram kullanımında, detoks süreci boyunca anlamlı bir azalma olduğu görülmüştür (W = 1953.00, p = 0.00). Ancak katılımcıların sosyal medya kullanımı azalırken YouTube (W = 411.00, p = 0.00) ve WhatsApp kullanımının (t = 3.22, p = 0.00) da anlamlı düzeyde arttığı bulunmuştur. Toplam Ekran Süresi kullanımının ise uygulama sonrasında anlamlı biçimde azaldığı (t = -5.83, p = 0.00) gözlenmiştir. Akıllı Telefon Bağımlılığı Ölçeği-Kısa Formu (ATBÖ-KF) puanlarının dijital detoks sonrasında anlamlı düzeyde azaldığı (t = -4.34, p = 0.00) ama Akıllı Telefon Aşerme Ölçeği (ATAÖ) puanlarının ise dijital detoks sonrası anlamlı bir değişiklik göstermediği görülmektedir (t = -0.56, p = 0.57). Dijital detoks süresince katılımcıların YouTube ve WhatsApp kullanımını artırmaları nedeniyle akıllı telefona yönelik bir aşerme deneyimlemedikleri sonucuna varılmıştır.

Anahtar kelimeler: Dijital detoks, akıllı telefon bağımlılığı, akıllı telefon aşermesi

THE EFFECT OF DIGITAL DETOX ON SMARTPHONE ADDICTION AND SMARTPHONE CRAVING: AN INVESTIGATION IN TERMS OF DEMOGRAPHIC CHARACTERISTICS

ABSTRACT

Advancements in technological devices have led to an increase in the duration of exposure to screen through portable technologies. Constant exposure to screens leads to negative outcomes in physical, social, and neurological aspects, along with psychological problems such as technology addiction. To avoid or reduce these adverse effects, adopting strategies such as conscious technology use, time management, and regular digital detox practices is important. In this context, the present study aimed to examine smartphone addiction and smartphone craving levels in terms of demographic characteristics. For this purpose, data were collected from a sample of 62 university students (mean age = 20.56) recruited via snowball sampling. The Demographic Information Form, Smartphone Addiction Scale–Short Version (SAS-SV) and Smartphone Craving Scale (SCS) were used as data collection tools. Additionally, 'Screen Time' features of smartphones were used to monitor screen time and apply the digital detox intervention. Mann-Whitney (Wilcoxon) and t-tests were conducted to examine whether the variables showed significant differences before and after the digital detox. As part of the digital detox, participants were asked not to use social media accounts such as Instagram, Twitter, Snapchat, TikTok, and Facebook for three days. It was found that nearly all participants used Instagram, and a significant reduction in Instagram use was observed during the detox period (W = 1953.00, p = 0.00). However, while social media use decreased, there was a significant increase in YouTube (W = 411.00, p = 0.00) and WhatsApp use (t = 3.22, p = 0.00). Total screen time significantly decreased after the intervention (t = -5.83, p = 0.00). Smartphone Addiction Scale–Short Version (SAS-SV) scores significantly decreased after the digital detox (t = -4.34, p = 0.00), whereas Smartphone Craving Scale (SCS) scores did not show a significant change (t = -0.56, p = 0.57). It was concluded that participants did not experience significant smartphone craving during the digital detox process, likely due to the increased use of YouTube and WhatsApp.

Keywords: Digital detox, smartphone addiction, smartphone craving

INTRODUCTION

Technological advancements have led to increased screen exposure through portable devices. According to the Household Information Technologies Usage Survey Report (2024) published by the Turkish Statistical Institute (TUIK), 88.8% of individuals aged 16–74 use the internet, while 86.2% of people in Türkiye use WhatsApp, 71.3% use YouTube, and 65.4% use Instagram (TUIK, 2024). The excessive and addictive use of digital media-particularly through mobile devices-has been associated with physical, psychological, social, and neurological adverse outcomes, with factors such as duration of use and nighttime usage playing a significant role in these effects (Lissak, 2018). Pieh et al. (2025) reported that a three-week reduction in screen time had positive effects on depression, stress, sleep quality, and overall well-being, suggesting a potentially causal relationship. In contrast, Ramadhan et al. (2024) found that while digital detox was effective in reducing depressive symptoms, it had no significant impact on stress, life satisfaction, or overall well-being. In light of these findings, digital detox interventions and their psychological and behavioral outcomes have become a growing area of interest. Most studies on digital detox focus on temporarily restricting individuals' digital device use and examining the psychological, cognitive and behavioral effects of such interventions.

One of the primary issues targeted by digital detox interventions is the emergence of digital addiction behaviors resulting from excessive and uncontrolled use of digital technologies. In the literature, the term 'digital addiction' is used as an umbrella concept referring to the

prolonged and uncontrolled use of digital technologies. In this context, subtypes such as social media addiction, gaming addiction, internet addiction, smartphone addiction, and cyber-relationship addiction are included in the literature, and it is suggested that one-fourth of the general population may be affected by at least one of these subtypes (Meng et al., 2022). Social media addiction encompasses common features observed in many types of addiction, such as the development of tolerance, withdrawal symptoms, interpersonal or internal conflicts, mental preoccupation, tendencies to relapse, and mood changes (Andreassen, 2015). Individuals who use social media platforms intensively have been found to report higher levels of problematic use; in contrast, those who engage in digital detox practices report lower problematic use and higher levels of well-being (Schmuck, 2020). In a two-week social media detox study conducted by Coyne and Woodruff (2023), positive effects were reported among young adults not only in levels of social media and smartphone addiction, but also in sleep, life satisfaction, and stress-related domains. Similarly, a review study addressing digital detox interventions reported that although participants initially experienced some difficulties, they generally evaluated the process positively; in particular, positive changes in outcomes related to addiction and health were observed to persist even after the intervention (Anandpara et al., 2024).

When evaluating interventions targeting digital addiction, the concept of craving, a psychological symptom often accompanying addictive behaviors, also gains importance. Craving is defined as a strong desire or urge toward a specific object or action (Kemps, 2013). In a digital detox study conducted by Wilcockson et al. (2019), 45 adults were asked to refrain from using their smartphones for one day, and their craving levels for smartphone use were assessed. It was reported that participants with higher levels of problematic smartphone use exhibited higher craving levels, although no significant changes were observed in mood or anxiety levels. Similarly, in a one-week social media detox study conducted by Stieger and Lewetz (2018), increased levels of craving and boredom were observed following usage restriction, but only non-significant decreases were reported in positive and negative affect. In the study by Eide et al. (2018), participants in the smartphone restriction group reported higher levels of withdrawal symptoms compared to the control group, suggesting that such restrictions may trigger psychological withdrawal symptoms typically seen in behavioral addictions. In contrast, the study by Wadsley et al. (2023) found that a one-week social media restriction had no significant effect on either craving or implicit usage desire; therefore, classical withdrawal responses were not observed.

This study offers a unique contribution to the literature by jointly addressing the effects of digital detox on smartphone addiction and craving levels. Furthermore, examining the possible changes in these areas within an experimental design through a short-term intervention process is considered to provide more concrete evidence regarding the effectiveness of digital detox practices. The findings obtained are also expected to contribute to the development of applicable recommendations for individuals in similar age groups.

MATERIAL AND METHODS

Participants

The participants were selected using the snowball sampling method and consisted of 62 university students, all of whom were enrolled in undergraduate programs. Ethical approval was obtained at the outset of the study, and informed consent was secured from all participants. As shown in Table 1, the participants had a mean age of 20.56 and were all enrolled in undergraduate programs. Among them, 4.8% reported their socioeconomic status as low, 90.3% as medium and 4.8% as high.

Table 1. Summary statistics of demographic variables

Variable	Group	*n*	*%*
Gender	Male	29	46.77
	Female	33	53.23
Education Level	Undergraduate	62	100
Socioeconomic Status	Low	3	4.84
	Medium	56	90.32
	High	3	4.84
	M	*SS*	
Age	20.56	2.56	

Instruments

Demographic Information Form

This form, prepared by the researchers, aimed to collect participants' demographic characteristics such as age, gender, educational status, and screen time, as well as to assess potential confounding variables (e.g., whether the participant has received treatment for addiction, presence of any physical or psychological disorders, average daily screen time prior to the study, etc.).

Smartphone Addiction Scale–Short Version (SAS-SV)

The scale is a unidimensional, 10-item instrument developed to assess the risk of smartphone addiction in adolescents using a 6-point Likert-type format. The total score ranges from 10 to 60, with higher scores indicating a greater risk of addiction (Kwon et al., 2013). In the Turkish adaptation study, the Cronbach's alpha coefficient was reported as 0.867, and the test-retest reliability coefficient was 0.926, indicating that the scale is a valid and reliable tool with a single-factor structure (Noyan et al., 2015).

Smartphone Craving Scale (SCS)

This self-report measure was adapted based on the Penn Alcohol Craving Scale (PACS) (Flannery et al., 1999; Evren et al., 2008) and is designed to assess the frequency, intensity, duration of craving experienced over the past week, resistance to craving, and overall craving level. The scale consists of 5 items, each rated on a 0–6 Likert-type scale. The test–retest reliability coefficient of the scale is 0.79, while Cronbach's alpha internal consistency coefficients range from 0.77 to 0.78 across different samples. Validity analyses have demonstrated that the scale has a unidimensional structure and is a valid instrument in terms of both construct and criterion-related validity (Savcı, 2019).

Procedures

The study was conducted within a quasi-experimental design framework based on pre-test and post-test measurements. In the initial phase, participants' screen times for the past three days were recorded, followed by the administration of the Demographic Information Form, the Smartphone Addiction Scale–Short Version (SAS-SV) and the Smartphone Craving Scale (SCS). Participants underwent a digital detox intervention in which their access to Instagram, Twitter, TikTok, Snapchat, and Facebook applications on their phones was restricted for three days. During the digital detox period, screen times were monitored using the 'Digital Wellbeing' feature on Android devices and the 'Screen Time' feature on iOS devices, and access to social media applications was limited. Participants' total screen times during the detox period were recorded, and upon completion of the detox, the Smartphone Addiction Scale–Short Version (SAS-SV) and the Smartphone Craving Scale (SCS) were re-administered.

Statistical analyses were performed using the SPSS v26 software package. To examine the effects of categorical variables on quantitative variables, normality assumptions were first assessed; the Shapiro-Wilk test was used for groups with fewer than 30 participants, and the Kolmogorov-Smirnov test was used for larger groups. For non-normally distributed data, the

Mann–Whitney (Wilcoxon) test was applied, while for normally distributed data, the independent samples t-test was used. A significance level of 5% was adopted for all tests.

RESULTS AND DISCUSSION

As part of the digital detox intervention, participants were asked to refrain from using social media platforms such as Instagram, X (Twitter), Snapchat, TikTok, and Facebook for a period of three days. Examination of Table 2 reveals that nearly all participants primarily used Instagram and did not access it at all during the detox period. Additionally, a significant reduction in Instagram usage was observed by the end of the intervention (W = 1953.00, p = 0.00). As participants reduced their use of social media, a significant increase in YouTube (W = 411.00, p = 0.00) and WhatsApp usage (t = 3.22, p = 0.00) was found. Furthermore, total screen time was significantly reduced following the intervention (t = -5.83, p = 0.00) (see Table 2 and Table 3). These results highlight the impact of digital detox on limiting social media use and demonstrate that participants significantly reduced their engagement with various social media platforms-especially Instagram-while increasing their usage of YouTube and WhatsApp during the intervention.

Table 2. Comparisons before and after digital detox for non-normally distributed variables

Variable	Group	Median	Mean Rank	*W*	*p*
Instagram	Before	115.17	98.14	1,953.00	0.00
	After	0.00	57.96		
Twitter	Before	0.00	73.61	435.00	0.00
	After	0.00	61.09		
Snapchat	Before	1.00	89.21	703.00	0.00
	After	0.00	59.10		
TikTok	Before	0.00	73.79	210.00	0.00
	After	0.00	61.06		
Facebook	Before	0.00	64.29	15.00	0.06
	After	0.00	62.27		
YouTube	Before	19.50	61.11	411.00	0.00
	After	42.17	62.68		

Not. $^{*}p < 0.05$

One of the findings of the study is the significant decrease observed in the use of social media applications such as Instagram, Twitter, Snapchat, Facebook and TikTok. This indicates that the digital detox was effective in restricting the use of targeted social media platforms. These findings support those of Radtke et al. (2022), who reported the impact of digital detox on self-regulation and technology use habits. Despite the decrease in social media use, a significant increase was observed in the use of YouTube and WhatsApp. This suggests that during the detox period, individuals continued to satisfy their cravings for digital content through alternative applications. This result aligns with the concept of 'digital compensation behaviors' reported by Wilcockson et al. (2019) and Stieger and Lewetz (2018). Thus, while the short-term detox intervention successfully reduced the use of targeted applications, it also indicates the potential development of substitution behaviors, the effects of which should not be overlooked. On the other hand, the significant reduction in total screen time demonstrates that the digital detox had a positive impact on overall screen exposure. This finding is consistent with studies by Pieh et al. (2025) and Hager et al. (2023), which suggest that digital detox contributes positively to mental health.

According to the results of the t-test analysis (see Table 3), scores on the Smartphone Addiction Scale–Short Version (SAS-SV) significantly decreased following the digital detox intervention (t = -4.34, p = 0.00). However, no statistically significant change was observed in the scores of the Smartphone Craving Scale (SCS) after the intervention (t = -0.56, p = 0.57).

Table 3. Paired comparisons before and after digital detox for variables with normal distribution

Variable	Group	Mean (M)	SD	*t*	*p*
SAS-SV	Before	33.08	12.16	-4.34	0.00
	After	28.55	12.21		
SCS	Before	16.40	5.73	-0.56	0.57
	After	16.02	6.20		
WhatsApp	Before	72.67	65.66	3.22	0.00
	After	90.93	79.72		
Total Screen Time	Before	393.37	110.04	-5.83	0.00
	After	321.94	116.43		

Note. SAS-SV: Smartphone Addiction Scale–Short Version; SCS: Smartphone Craving Scale
Note. $^{*}p < 0.05$

The findings of the study indicated a statistically significant reduction in participants' scores on the Smartphone Addiction Scale-Short Version (SAS-SV) following the digital detox intervention. This outcome is consistent with previous research demonstrating the effectiveness of digital detox strategies in mitigating smartphone addiction (Schmuck, 2020; Lambert, 2022). However, no significant change was observed in the scores of the Smartphone Craving Scale (SCS) post-intervention. This result diverges from the findings reported by Wilcockson et al. (2019). In essence, while the intervention yielded measurable decreases in screen time and addiction levels, it did not elicit a significant difference in craving scores. This suggests that craving, as a more deeply rooted cognitive-emotional process, may not be readily modifiable through short-term interventions, highlighting the potential need for longer-term or more structured approaches in future research and practice.

In order to examine whether the changes observed in WhatsApp usage, YouTube usage, total screen time, Smartphone Addiction Scale-Short Version (SAS-SV) scores and Smartphone Craving Scale (SCS) scores following the digital detox intervention varied by gender, both the Mann-Whitney (Wilcoxon) test and independent samples t-test were conducted (see Table 4 and Table 5). The results revealed that gender did not have a statistically significant effect on the changes in WhatsApp usage ($W = 415.00$, $p = 0.38$), YouTube usage ($W = 469.00$, $p = 0.90$), total screen time ($t = -1.19$, $p = 0.24$), Smartphone Addiction Scale scores ($W = 441.00$, $p = 0.60$), or Smartphone Craving Scale scores ($W = 370.00$, $p = 0.13$). These findings indicate that the impact of the digital detox intervention was not moderated by gender.

Table 4. Gender-based comparison of changes associated with digital detox for non-normally distributed variables

Variable	Gender	Median	Mean Rank	*W*	*p*
WhatsApp	Male	-12.33	29.31	415.00	0.38
	Female	-6.33	33.42		
YouTube	Male	-14.67	31.17	469.00	0.90
	Female	-15.33	31.79		
SAS-SV	Male	2.00	30.21	441.00	0.60
	Female	3.00	32.64		
SCS	Male	-1.00	27.76	370.00	0.13
	Female	0.00	34.79		

Note. SAS-SV: Smartphone Addiction Scale–Short Version; SCS: Smartphone Craving Scale
Note. $^{*}p < 0.05$

Table 5. Gender-based comparison of digital detox-induced changes for normally distributed variables

Variable	Group	Mean	*SD*	*t*	*p*
Total Screen Time	Male	55.83	99.99	-1.19	0.24
	Female	85.14	92.72		

Note. $^{*}p < 0.05$

The analyses conducted based on gender revealed no significant differences in changes in WhatsApp, YouTube, total screen time, Smartphone Addiction Scale–Short Version (SAS-SV) and Smartphone Craving Scale (SCS) scores, suggesting that the digital detox intervention was equally effective for both male and female participants. Despite reducing their use of certain social media applications during the detox period, participants appeared to compensate for the digital void by increasing engagement with platforms such as YouTube and WhatsApp. This pattern implies that behavioral addictions may be driven not solely by specific applications, but by underlying internal needs. Furthermore, these findings align with the I-PACE model (Brand et al., 2016), which posits that digital addictions are maintained through the reciprocal interaction of cognitive and emotional factors.

Conclusions

The findings of the present study are largely consistent with the existing literature on the psychological and behavioral effects of digital detox interventions. In line with the study by Pieh et al. (2025), which reported positive effects of digital detox on well-being, the current study also revealed significant reductions in screen time and smartphone addiction levels. However, the lack of a significant change in craving scores aligns with the findings of Wilcockson et al. (2019), suggesting that short-term detox interventions may not directly influence more intrinsic experiences such as craving. Participants' tendency to shift from social media to other applications such as YouTube and WhatsApp during the detox process implies that digital detox may not only alter habitual behaviors but also activate compensatory strategies to fill the digital void. This observation highlights the necessity of developing more structured and guided detox programs to foster greater self-awareness and mindfulness in users. While short-term digital detox interventions may be effective in modifying behavioral patterns, cognitive and emotional dimensions such as craving may require longer or more intensive approaches.

Among the limitations of the current study are the homogeneity of the sample-limited to university students-and the short duration of the detox intervention. Nevertheless, the study provides valuable insights into the potential impact of short-term digital detox, offering an important contribution to the literature.

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UNDERSTANDING THE MECHANISMS OF ALZHEIMER'S DISEASE

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Abstract
Alzheimer's disease is a complex and progressive neurodegenerative disorder that represents the leading cause of dementia globally. It is characterized by a gradual decline in memory, cognitive abilities, and functional capacity, leading to significant personal and societal burden. The etiology of Alzheimer's disease is multifactorial, involving an intricate interplay between genetic predispositions and environmental risk factors. While specific genetic mutations such as those in *APP*, *PSEN1*, and *PSEN2* are known to cause early-onset familial Alzheimer's, the apolipoprotein E (APOE) ε4 allele remains the most significant genetic risk factor for the more common late-onset form. However, genetic predisposition alone does not determine disease onset. Environmental and lifestyle factors—including cardiovascular health, physical inactivity, poor diet, educational attainment, sleep quality, and exposure to neurotoxins—play crucial roles in modulating the risk and progression of the disease. These factors contribute to pathological processes such as amyloid-beta accumulation, tau protein hyperphosphorylation, neuroinflammation, and oxidative stress. Moreover, interactions between genetic susceptibility and environmental exposures can either exacerbate or mitigate disease risk, highlighting the importance of personalized approaches in prevention and treatment. Public health strategies focused on modifiable risk factors, combined with advances in genetic research and biomarker development, offer promising avenues for reducing the prevalence and impact of Alzheimer's disease. A comprehensive understanding of both genetic and environmental contributions is essential for the development of effective interventions aimed at delaying onset, slowing progression, and ultimately preventing Alzheimer's disease.
Keywords: Alzheimer's disease, genetics, environmental risk factors, APOE ε4, neurodegeneration, prevention strategies.

Introduction

Alzheimer's disease is a progressive neurodegenerative disorder and the most common cause of dementia worldwide, affecting millions of individuals and posing significant emotional, social, and economic challenges. Characterized by memory loss, cognitive impairment, and behavioral changes, Alzheimer's disease is marked by gradual deterioration in brain function, ultimately leading to loss of independence and death. Despite extensive research, the exact causes of the disease remain incompletely understood. What is increasingly clear, however, is that Alzheimer's does not arise from a single cause, but rather from a complex interplay of genetic predispositions and environmental influences accumulated over a person's lifetime.While certain genetic mutations and inherited risk factors—most notably the APOE ε4 allele—have been strongly linked to the disease, environmental and lifestyle factors such as cardiovascular health, education, diet, physical activity, sleep quality, and toxin exposure also play vital roles in shaping individual risk. These factors influence biological pathways involved

in amyloid-beta accumulation, tau pathology, inflammation, and oxidative stress—core mechanisms underlying neurodegeneration. By unraveling how genetic and environmental components interact, researchers hope to identify targeted strategies for prevention, early detection, and personalized treatment. Understanding this multifactorial etiology is crucial in the global effort to reduce the burden of Alzheimer's and improve quality of life for those affected.

Amyloid Plaques and Tau Tangles: Hallmarks of Alzheimer's Pathology

Amyloid plaques and tau tangles are the defining pathological hallmarks of Alzheimer's disease, a progressive neurodegenerative disorder that primarily affects memory, cognitive function, and behavior. These two abnormal protein aggregates play a central role in the onset and progression of the disease, and their presence in the brain is used diagnostically to confirm Alzheimer's during post-mortem analysis. The intricate interaction between amyloid plaques and tau tangles contributes to neuronal dysfunction, synaptic loss, and eventually, the widespread brain atrophy characteristic of advanced Alzheimer's disease.Amyloid plaques are extracellular deposits primarily composed of amyloid-beta (Aβ) peptides. These peptides are produced through the sequential cleavage of the amyloid precursor protein (APP) by enzymes called β-secretase and γ-secretase. Under normal circumstances, Aβ peptides are cleared from the brain, but in Alzheimer's disease, an imbalance between production and clearance leads to the accumulation of Aβ, especially the Aβ42 isoform, which is particularly prone to aggregation. Over time, these peptides accumulate and clump together to form insoluble plaques in the spaces between neurons. The plaques disrupt cell-to-cell communication and are thought to initiate a cascade of neurotoxic events that eventually lead to synaptic dysfunction and neuronal death.The presence of amyloid plaques alone, however, does not fully account for the cognitive symptoms seen in Alzheimer's disease. Many older individuals exhibit amyloid accumulation in the brain without significant cognitive impairment, suggesting that amyloid buildup may be necessary but not sufficient for the development of clinical Alzheimer's. This has led researchers to investigate other pathological features that may work in tandem with amyloid to cause neurodegeneration, most notably tau tangles.Tau tangles, or neurofibrillary tangles, are intracellular accumulations of hyperphosphorylated tau protein. Tau is a microtubule-associated protein that plays a critical role in stabilizing microtubules, which are part of the cell's cytoskeleton and important for intracellular transport. In Alzheimer's disease, tau becomes abnormally hyperphosphorylated, which diminishes its ability to bind to microtubules. The result is the formation of twisted filaments that aggregate into tangles inside neurons. These tangles disrupt the structural integrity of the neuron, impair axonal transport, and contribute to cell death.Unlike amyloid plaques, the distribution of tau tangles in the brain correlates more closely with the severity of cognitive impairment in Alzheimer's disease. Tau pathology begins in the entorhinal cortex and hippocampus, regions essential for memory formation, and then spreads in a stereotypical pattern throughout the brain as the disease progresses. This progression is described by Braak staging, a classification system that outlines the topographical spread of tau pathology and is commonly used in neuropathological assessment.The relationship between amyloid plaques and tau tangles is complex and not yet fully understood. One widely accepted hypothesis, known as the amyloid cascade hypothesis, proposes that the accumulation of amyloid-beta is the initiating event in Alzheimer's pathology, which then triggers a series of downstream effects, including tau hyperphosphorylation and tangle formation. This model suggests that while amyloid-beta initiates the disease process, it is the spread of tau pathology that directly correlates with neuronal dysfunction and cognitive decline. Recent research supports the idea that amyloid deposition may create a permissive environment that facilitates the misfolding and spread of tau proteins across neurons in a prion-like fashion.Neuroinflammation and the role of glial cells also play an important intermediary role between amyloid and tau pathologies. Microglia, the brain's resident immune cells, become

activated in response to amyloid plaques, releasing inflammatory cytokines and reactive oxygen species. While this inflammatory response may initially aim to clear amyloid, chronic activation of microglia can lead to sustained inflammation that exacerbates neuronal damage and promotes tau pathology. Astrocytes, another type of glial cell, also undergo changes that contribute to the inflammatory milieu and impair metabolic support to neurons. Thus, inflammation acts as a bridge that links amyloid and tau pathology, amplifying neurodegeneration.Another significant consequence of amyloid and tau pathology is synaptic dysfunction, which is strongly associated with the cognitive symptoms of Alzheimer's disease. Amyloid-beta oligomers, the soluble precursors to plaques, are particularly neurotoxic and have been shown to interfere with synaptic signaling, long-term potentiation, and memory formation. Similarly, tau tangles disrupt axonal transport mechanisms essential for maintaining synaptic health. As synapses deteriorate, communication between neurons becomes impaired, leading to the breakdown of neural networks critical for cognition and memory.Therapeutic efforts have traditionally focused on reducing amyloid burden, given its central role in the amyloid cascade hypothesis. Numerous anti-amyloid therapies, including monoclonal antibodies such as aducanumab and lecanemab, have been developed to target and clear amyloid plaques from the brain. While some of these treatments have shown promise in reducing amyloid levels and slowing cognitive decline in early-stage Alzheimer's patients, they have also raised concerns regarding side effects such as amyloid-related imaging abnormalities (ARIA). More recent therapeutic strategies are beginning to target tau pathology directly, using anti-tau antibodies and small molecule inhibitors of tau phosphorylation and aggregation, although these are still largely in experimental stages.In addition to targeted therapies, researchers are exploring combination treatments that address both amyloid and tau, as well as the inflammatory processes that connect them. This multifaceted approach reflects a growing consensus that Alzheimer's disease is a complex disorder involving multiple pathological mechanisms that interact synergistically. By targeting multiple aspects of the disease simultaneously, it may be possible to achieve more substantial and sustained therapeutic benefits.In conclusion, amyloid plaques and tau tangles are the primary pathological features of Alzheimer's disease, each contributing to the progressive neurodegeneration in distinct but interconnected ways. Amyloid-beta accumulation initiates the pathological cascade, while tau tangles drive the clinical progression and cognitive decline. The interplay between these two pathologies, mediated by neuroinflammation and synaptic dysfunction, underpins the devastating effects of Alzheimer's on the brain. Despite decades of research, the precise mechanisms through which these proteins cause disease remain only partially understood, highlighting the need for continued investigation. Advances in imaging, biomarkers, and therapeutics offer hope for earlier diagnosis and more effective treatments, but a cure remains elusive. Nevertheless, understanding the role of amyloid plaques and tau tangles is essential for unraveling the mysteries of Alzheimer's disease and developing strategies to prevent, slow, or halt its progression.

Neuroinflammation and Oxidative Stress: Contributing Factors to Disease Progression

Neuroinflammation and oxidative stress are critical contributing factors to the progression of neurodegenerative diseases, particularly Alzheimer's disease, Parkinson's disease, and other forms of dementia. These pathological processes, while distinct in their mechanisms, often operate in tandem and amplify each other, creating a vicious cycle that exacerbates neuronal damage, synaptic dysfunction, and cognitive decline. Understanding how neuroinflammation and oxidative stress interplay with genetic and environmental factors offers deeper insight into the multifactorial nature of neurodegeneration and highlights potential therapeutic targets for disease intervention.Neuroinflammation refers to the activation of the brain's innate immune system in response to injury, infection, or disease. This process is primarily mediated by microglia, the resident immune cells of the central nervous system, and astrocytes, which support and maintain the neuronal environment. In the early stages, neuroinflammation serves

a protective role: activated microglia clear cellular debris, secrete growth factors, and help maintain homeostasis. However, in chronic neurodegenerative conditions, this beneficial response becomes maladaptive. Prolonged microglial activation leads to the sustained release of pro-inflammatory cytokines, chemokines, and reactive oxygen species (ROS), which not only fail to resolve the underlying pathology but actively contribute to neuronal injury.In Alzheimer's disease, for example, the accumulation of amyloid-beta plaques and tau tangles acts as a persistent stimulus that triggers microglial activation. These misfolded protein aggregates are recognized as danger-associated molecular patterns (DAMPs), eliciting an immune response intended to clear them. However, microglia often fail to effectively degrade amyloid and tau, especially as the disease progresses and their phagocytic capacity diminishes with age and cellular stress. This ineffectiveness leads to a state of chronic inflammation characterized by elevated levels of interleukin-1β (IL-1β), tumor necrosis factor-alpha (TNF-α), and other pro-inflammatory mediators. Astrocytes, which are normally involved in maintaining the blood-brain barrier and providing metabolic support to neurons, also become reactive in this environment, releasing inflammatory molecules and further disrupting neuronal function. This chronic inflammatory state not only damages neurons directly but also impairs neurogenesis and synaptic plasticity, processes critical for learning and memory.Oxidative stress, another key factor in neurodegeneration, results from an imbalance between the production of reactive oxygen species and the brain's ability to detoxify these reactive intermediates or repair the resulting damage. The brain is particularly susceptible to oxidative damage due to its high oxygen consumption, abundant lipid content, and relatively low antioxidant defenses. ROS and reactive nitrogen species (RNS), which include superoxide anions, hydrogen peroxide, and nitric oxide, can damage cellular components such as lipids, proteins, and DNA. This damage impairs essential cellular functions, leading to mitochondrial dysfunction, energy failure, and eventually, cell death.In neurodegenerative diseases, oxidative stress is both a cause and a consequence of pathological changes. Mitochondrial dysfunction, a common feature in these conditions, leads to excessive ROS production, which further damages mitochondrial DNA and respiratory chain proteins, exacerbating the oxidative burden. This self-reinforcing loop leads to energy deficits and promotes neuronal apoptosis. Additionally, oxidative stress modifies key proteins involved in disease pathogenesis. In Alzheimer's disease, for instance, oxidative damage alters the structure of amyloid-beta and tau, promoting their aggregation and toxicity. Lipid peroxidation, another outcome of oxidative stress, leads to the formation of toxic aldehydes like 4-hydroxynonenal (4-HNE), which interfere with cellular signaling and induce apoptosis.Importantly, neuroinflammation and oxidative stress are not isolated phenomena; they are deeply interconnected. Inflammatory cells such as microglia produce large amounts of ROS and RNS as part of the immune response. In turn, oxidative stress can activate transcription factors such as nuclear factor kappa-light-chain-enhancer of activated B cells (NF-κB), which drive the expression of inflammatory genes. This bidirectional relationship creates a feedback loop that amplifies neuronal damage. Moreover, both oxidative stress and inflammation disrupt the blood-brain barrier (BBB), allowing peripheral immune cells and toxins to enter the brain and further exacerbate inflammation and oxidative injury.The aging process intensifies the vulnerability of the brain to both inflammation and oxidative stress. Aging is associated with a gradual decline in mitochondrial efficiency and antioxidant defenses, as well as a state of low-grade systemic inflammation known as "inflammaging." This predisposes the elderly brain to a more pronounced and prolonged inflammatory response to stress or injury. Genetic factors also modulate an individual's susceptibility to these processes. For instance, individuals with the APOE4 allele, a major genetic risk factor for Alzheimer's disease, exhibit increased oxidative stress and a heightened inflammatory response, potentially accelerating disease progression.Environmental factors such as exposure to toxins, poor diet, lack of physical activity, and chronic stress also contribute to neuroinflammation and oxidative

stress. Diets high in saturated fats and sugars promote inflammation and reduce levels of brain-derived neurotrophic factor (BDNF), a protein crucial for neuronal survival and plasticity. Conversely, diets rich in antioxidants and anti-inflammatory compounds, such as those found in fruits, vegetables, and omega-3 fatty acids, can mitigate these harmful processes. Physical activity has been shown to reduce inflammation and oxidative stress while enhancing mitochondrial function and neurogenesis, underscoring the importance of lifestyle interventions in disease prevention and management.From a therapeutic standpoint, targeting neuroinflammation and oxidative stress offers promising avenues for slowing or halting disease progression. Anti-inflammatory drugs, both non-steroidal and more specific immunomodulators, have been explored with mixed results. While some have shown efficacy in preclinical models, translating these findings into clinical success has been challenging due to issues of timing, drug delivery, and off-target effects. Similarly, antioxidant therapies such as vitamin E, coenzyme Q10, and N-acetylcysteine have demonstrated neuroprotective effects in animal models, but human trials have yielded inconsistent outcomes. This inconsistency may be due to the difficulty in achieving effective concentrations in the brain, the advanced stage at which treatments are typically administered, or the complexity of the disease mechanisms themselves.Recent advances in precision medicine and biomarker discovery offer hope for more targeted interventions. For example, neuroimaging techniques and cerebrospinal fluid analyses now allow for the early detection of inflammation and oxidative damage, potentially enabling earlier and more personalized treatment. Furthermore, novel drug candidates are being developed to specifically modulate microglial activation states, enhance endogenous antioxidant responses, and protect mitochondrial function. These next-generation therapies, especially when combined with lifestyle modifications and cognitive interventions, may hold the key to mitigating the devastating impact of neurodegenerative diseases.In summary, neuroinflammation and oxidative stress are central contributors to the progression of neurodegenerative diseases, including Alzheimer's disease. They are driven by a complex interplay of genetic, environmental, and age-related factors that ultimately lead to chronic cellular damage, synaptic dysfunction, and neuronal loss. While both processes initially arise as protective responses, their chronic activation transforms them into potent drivers of neurodegeneration. The interconnection between inflammation and oxidative damage creates a self-perpetuating cycle that accelerates disease pathology. A comprehensive understanding of these mechanisms is essential for developing effective prevention and treatment strategies. Continued research into their roles and regulation, coupled with advances in diagnostics and therapeutics, may pave the way for interventions that can slow or even prevent the progression of these debilitating disorders.

Disrupted Neurotransmission: The Role of Acetylcholine and Other Neurotransmitters

Disrupted neurotransmission is a fundamental pathological feature of many neurodegenerative diseases, particularly Alzheimer's disease, and it plays a central role in the cognitive and behavioral symptoms that characterize these conditions. Among the various neurotransmitters involved, acetylcholine holds a particularly crucial position due to its central function in learning, memory, and attention. However, other neurotransmitters such as glutamate, dopamine, serotonin, and norepinephrine are also significantly affected, contributing to a wide array of symptoms beyond memory loss, including mood disturbances, psychosis, and motor dysfunction. The disruption in the balance and function of these neurotransmitters stems from the complex neurodegenerative processes that damage or destroy neurons, alter synaptic plasticity, and impair the intricate signaling networks required for normal brain function.Acetylcholine, the primary neurotransmitter of the cholinergic system, is essential for cognitive processing. It is synthesized in cholinergic neurons by the enzyme choline acetyltransferase (ChAT) and plays a pivotal role in modulating arousal, attention, learning, and memory by acting on both muscarinic and nicotinic receptors. In Alzheimer's disease, there

is a marked loss of cholinergic neurons, particularly in the basal forebrain region, including the nucleus basalis of Meynert. This loss leads to a significant reduction in acetylcholine levels throughout the cortex and hippocampus—areas heavily involved in memory and cognition. The cholinergic hypothesis of Alzheimer's disease, one of the earliest and most enduring theories of the disease, posits that this depletion of acetylcholine is directly responsible for the cognitive deficits observed in patients. Although this hypothesis has been partially supplanted by the amyloid and tau hypotheses, it remains a cornerstone for symptomatic treatment strategies. Drugs such as donepezil, rivastigmine, and galantamine—acetylcholinesterase inhibitors—are commonly prescribed to delay the breakdown of acetylcholine in the synaptic cleft, thereby enhancing cholinergic transmission and providing modest improvements in cognitive function.Despite the therapeutic emphasis on acetylcholine, it is increasingly clear that Alzheimer's disease and other neurodegenerative disorders involve widespread neurotransmitter disruption. Glutamate, the brain's main excitatory neurotransmitter, is vital for synaptic plasticity and memory formation through its action on NMDA (N-methyl-D-aspartate) and AMPA receptors. However, in the context of neurodegeneration, excessive glutamate activity—known as excitotoxicity—can become damaging. Overactivation of NMDA receptors leads to an influx of calcium ions into neurons, triggering pathways that result in oxidative stress, mitochondrial dysfunction, and ultimately cell death. This pathological process is particularly relevant in Alzheimer's disease, where amyloid-beta peptides have been shown to interfere with glutamate uptake by astrocytes, resulting in an accumulation of extracellular glutamate. Memantine, an NMDA receptor antagonist, is one of the few drugs approved for moderate to severe Alzheimer's disease. It acts by blocking excessive NMDA receptor activity while preserving normal neurotransmission, offering symptomatic relief and potentially slowing neuronal damage.Dopaminergic transmission, though more commonly associated with Parkinson's disease, is also impaired in some types of dementia, such as Lewy body dementia and Parkinson's disease dementia. Dopamine is critical for regulating movement, motivation, and reward pathways. In Parkinsonian syndromes, the degeneration of dopaminergic neurons in the substantia nigra leads to motor symptoms such as tremors, rigidity, and bradykinesia. However, in dementias involving Lewy bodies, there is additional cortical involvement that affects cognition and behavior. These patients often experience hallucinations, delusions, and significant fluctuations in attention, which may be linked to altered dopamine signaling. Moreover, dopaminergic dysregulation has been implicated in the apathy and lack of motivation observed in some Alzheimer's disease patients, indicating that dopamine's influence extends beyond movement control into the realm of cognitive and emotional processing.Serotonin, a neurotransmitter involved in mood regulation, sleep, and appetite, is also disrupted in neurodegenerative diseases. Reduced serotonergic function has been observed in the brains of Alzheimer's disease patients, particularly in areas like the raphe nuclei and the prefrontal cortex. This deficit is believed to contribute to neuropsychiatric symptoms such as depression, anxiety, aggression, and sleep disturbances, which are common in Alzheimer's and other dementias. The degeneration of serotonergic neurons, coupled with changes in receptor sensitivity and serotonin transporter function, leads to an overall decline in serotonergic tone. Selective serotonin reuptake inhibitors (SSRIs) are often prescribed to manage these symptoms, although their efficacy varies. Moreover, serotonin plays a role in neuroplasticity and neurogenesis, and its reduction may exacerbate the progression of neurodegeneration by impairing the brain's ability to adapt and repair.Norepinephrine, primarily produced in the locus coeruleus, is another neurotransmitter significantly impacted in Alzheimer's disease. It modulates arousal, attention, and the stress response. The locus coeruleus is one of the first regions to show tau pathology, even in the early stages of Alzheimer's, leading to a substantial loss of noradrenergic neurons. This decline correlates with attentional deficits and may also contribute to the heightened inflammatory response observed in Alzheimer's disease, as

norepinephrine has anti-inflammatory properties. Thus, the loss of noradrenergic tone not only affects cognitive and emotional regulation but may also exacerbate the inflammatory processes that drive neurodegeneration.The disruption of neurotransmission in neurodegenerative diseases is not limited to a simple depletion of neurotransmitters but involves a complex interplay of altered synthesis, release, receptor binding, reuptake, and degradation. Synaptic dysfunction, a hallmark of early Alzheimer's disease, reflects this intricate dysregulation. Amyloid-beta oligomers and hyperphosphorylated tau proteins interfere with synaptic vesicle release, receptor trafficking, and postsynaptic signaling pathways. These disruptions compromise long-term potentiation (LTP), a cellular correlate of learning and memory, and enhance long-term depression (LTD), leading to synaptic weakening. Moreover, oxidative stress and neuroinflammation further impair neurotransmission by damaging synaptic membranes and altering receptor function.The cumulative effect of disrupted neurotransmitter systems is a progressive breakdown in the brain's communication networks, leading to the characteristic symptoms of neurodegenerative diseases. Memory loss, confusion, changes in mood and behavior, sleep disturbances, and motor impairments all reflect the breakdown of specific neurotransmitter pathways. Therapeutic strategies have thus aimed to restore neurotransmitter balance, either by enhancing deficient systems (as in the case of acetylcholine and dopamine) or by inhibiting overactive ones (as with glutamate). However, these treatments are primarily symptomatic and offer only temporary relief, underscoring the need for disease-modifying therapies that address the underlying neurodegenerative processes.In conclusion, disrupted neurotransmission is a central mechanism in the pathophysiology of Alzheimer's disease and related disorders. While the cholinergic deficit has been a major focus due to its direct link to cognitive impairment, the roles of glutamate, dopamine, serotonin, and norepinephrine are equally important in shaping the broad spectrum of symptoms experienced by patients. The intricate interplay between these neurotransmitter systems, in conjunction with synaptic pathology, oxidative stress, and inflammation, creates a complex neurochemical environment that drives disease progression. Future therapeutic approaches must therefore adopt a multifaceted strategy, targeting multiple neurotransmitter systems and their regulatory mechanisms to achieve meaningful improvements in both symptoms and disease course.

Genetic and Environmental Risk Factors: Unraveling the Complex Etiology of Alzheimer's Disease

Alzheimer's disease, the most common cause of dementia worldwide, is a multifactorial neurodegenerative disorder with a complex etiology involving a dynamic interplay between genetic and environmental risk factors. While the clinical manifestations—primarily memory loss, cognitive decline, and behavioral changes—are well characterized, the precise mechanisms that lead to the onset and progression of the disease remain elusive. This complexity arises from the fact that no single cause can account for all cases of Alzheimer's disease. Instead, a wide array of genetic predispositions and environmental exposures interact over decades to influence an individual's risk. Understanding these factors and how they converge on common pathological pathways such as amyloid-beta deposition, tau hyperphosphorylation, neuroinflammation, and synaptic dysfunction is crucial for developing effective strategies for prevention, early detection, and treatment.On the genetic front, the most well-established risk factor for late-onset Alzheimer's disease (LOAD), which accounts for the vast majority of cases, is the apolipoprotein E (APOE) gene. This gene encodes a protein involved in lipid metabolism and neuronal repair. The APOE gene has three common alleles—ε2, ε3, and ε4—with the ε4 variant significantly increasing the risk of Alzheimer's disease. Individuals who inherit one copy of the ε4 allele have approximately a two- to three-fold increased risk, while those with two copies may have up to a 12-fold higher risk. APOE ε4 is thought to contribute to disease by impairing amyloid-beta clearance from the brain, promoting its aggregation into toxic plaques, and enhancing tau pathology and neuroinflammation. In

contrast, the ε2 allele appears to have a protective effect, though the mechanisms remain unclear. Importantly, the presence of APOE ε4 is neither necessary nor sufficient for developing Alzheimer's, as many carriers never develop the disease and many patients do not carry the allele, underscoring the multifactorial nature of its pathogenesis.In addition to APOE, several other genes have been implicated in Alzheimer's risk, particularly through genome-wide association studies (GWAS). These studies have identified numerous loci associated with disease susceptibility, including genes involved in immune response (such as TREM2 and CD33), lipid metabolism (ABCA7), synaptic function (BIN1), and endosomal trafficking (SORL1). Mutations in these genes typically confer smaller individual risks compared to APOE ε4, but their cumulative effects, especially in the context of gene-gene and gene-environment interactions, can be substantial. Moreover, in rare cases of early-onset familial Alzheimer's disease (EOFAD), which occurs before the age of 65, highly penetrant mutations in genes such as APP (amyloid precursor protein), PSEN1 (presenilin 1), and PSEN2 (presenilin 2) have been identified. These mutations lead to abnormal processing of APP, resulting in the overproduction of the amyloid-beta 42 peptide, which is prone to aggregation. Although these mutations account for a very small percentage of cases, they have provided critical insights into the molecular underpinnings of Alzheimer's disease.

Despite the significance of genetic factors, they cannot fully explain the variability in disease onset and progression, which points to the crucial role of environmental and lifestyle influences. Numerous studies have identified modifiable risk factors that contribute to Alzheimer's disease, many of which overlap with risk factors for cardiovascular disease. These include hypertension, diabetes, obesity, smoking, physical inactivity, poor diet, and hypercholesterolemia. These conditions can lead to cerebrovascular damage, reduced cerebral blood flow, and increased oxidative stress and inflammation—all of which may exacerbate the neurodegenerative processes associated with Alzheimer's. Additionally, chronic systemic inflammation and metabolic dysregulation have been shown to affect brain function and structure, potentially accelerating the progression of pathology.Education and cognitive engagement have also emerged as powerful modifiers of Alzheimer's risk. Higher levels of education and lifelong mental stimulation are associated with increased cognitive reserve, a concept referring to the brain's ability to compensate for pathology through more efficient or flexible use of neural networks. Individuals with greater cognitive reserve may tolerate more neuropathology before clinical symptoms emerge, thereby delaying the onset of cognitive decline. This has led to the growing recognition of social and intellectual enrichment as protective factors, highlighting the importance of sustained mental activity through reading, problem-solving, and social interaction.Another important environmental factor is traumatic brain injury (TBI), particularly when it involves loss of consciousness or occurs repeatedly, as seen in contact sports or military service. TBI is associated with a significantly increased risk of Alzheimer's disease and other dementias. The mechanisms linking TBI to Alzheimer's include direct neuronal damage, disruption of the blood-brain barrier, increased amyloid-beta deposition, and chronic neuroinflammation. Some studies suggest that TBI may trigger or accelerate the accumulation of tau pathology, leading to conditions such as chronic traumatic encephalopathy (CTE), which shares overlapping features with Alzheimer's.Sleep disturbances have also been implicated in the development of Alzheimer's disease. Poor sleep quality, sleep apnea, and disrupted circadian rhythms are associated with impaired amyloid-beta clearance, possibly due to reduced function of the glymphatic system, a recently discovered waste clearance system in the brain that operates predominantly during sleep. Chronic sleep deprivation may therefore contribute to the accumulation of neurotoxic proteins and exacerbate oxidative stress and inflammation, further increasing disease risk.Environmental toxins, such as heavy metals (lead, mercury, and aluminum), pesticides, and air pollution, have also been investigated for their potential neurotoxic effects. Exposure to these substances has been associated with increased oxidative

stress, mitochondrial dysfunction, and inflammation, which may promote the development or progression of Alzheimer's disease. Although the evidence is still emerging and often observational, these findings suggest that environmental pollutants could act as subtle but chronic contributors to neurodegeneration, especially when combined with genetic susceptibility.The interaction between genetic and environmental factors is perhaps the most critical aspect of understanding Alzheimer's disease etiology. It is now evident that certain environmental exposures may have a more pronounced effect in individuals with specific genetic backgrounds. For example, the detrimental impact of high cholesterol or head trauma appears to be amplified in carriers of the APOE ε4 allele. Similarly, lifestyle modifications such as exercise, healthy diet, and cognitive stimulation may offer greater protective benefits in genetically at-risk populations. This has led to the development of precision medicine approaches, which aim to tailor prevention and treatment strategies based on an individual's genetic profile, lifestyle, and environmental exposures.The complexity of Alzheimer's disease etiology underscores the importance of a multifaceted approach to prevention and management. While we cannot change our genes, understanding our genetic risk can help inform decisions about lifestyle and medical interventions. Public health strategies aimed at promoting cardiovascular health, reducing obesity and diabetes, encouraging lifelong learning, and minimizing exposure to environmental toxins may significantly reduce the global burden of Alzheimer's disease. Simultaneously, continued research into the genetic architecture of the disease, including the identification of new risk loci and the exploration of gene-environment interactions, will deepen our understanding and facilitate the development of targeted therapies.In conclusion, Alzheimer's disease arises from a highly complex interplay of genetic predispositions and environmental factors. The identification of key genetic markers such as APOE ε4 and mutations in APP, PSEN1, and PSEN2 has illuminated critical pathways in disease pathogenesis, particularly those involving amyloid and tau metabolism. At the same time, modifiable lifestyle and environmental factors—including cardiovascular health, cognitive engagement, sleep quality, and toxin exposure—significantly influence disease risk and progression. The convergence of these diverse elements into a shared set of neurobiological pathways illustrates the multifactorial nature of Alzheimer's and the necessity for comprehensive, individualized approaches to its prevention and treatment.

Conclusion

In conclusion, Alzheimer's disease is a multifactorial neurodegenerative disorder shaped by a complex interplay of genetic and environmental factors. While genetic components like the APOE ε4 allele and mutations in APP, PSEN1, and PSEN2 significantly increase susceptibility, they do not act in isolation. Environmental influences—including cardiovascular health, education, diet, physical activity, sleep quality, and exposure to toxins—play a crucial role in modulating risk and disease progression. The interaction between these factors influences key pathological processes such as amyloid deposition, tau aggregation, oxidative stress, and neuroinflammation. Understanding this intricate etiology is essential for developing effective prevention strategies and personalized treatments. Public health initiatives promoting healthy lifestyles, along with advances in genetic screening and biomarker research, offer promising avenues for reducing the burden of Alzheimer's disease. Ultimately, a holistic approach that integrates genetic risk assessment with environmental and lifestyle modifications holds the greatest potential to delay or prevent the onset of this devastating condition.

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THE IMPACT OF DIABETES ON GLOBAL HEALTH

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Abstract
Diabetes mellitus, a chronic metabolic disorder characterized by elevated blood glucose levels, has become a significant global health challenge. The increasing prevalence of diabetes, particularly type 2 diabetes, is largely driven by factors such as urbanization, sedentary lifestyles, poor dietary habits, and rising obesity rates. This condition leads to a range of complications including cardiovascular disease, kidney failure, neuropathy, and retinopathy, which impose substantial economic burdens on individuals, healthcare systems, and societies at large. The global response to diabetes involves a multi-faceted approach that includes prevention, early diagnosis, and effective management. Prevention strategies focus on promoting healthy eating, physical activity, and weight management to reduce the risk of developing type 2 diabetes. Early screening programs are essential for detecting the disease in its early stages, allowing for timely interventions. Management of diabetes typically involves a combination of lifestyle modifications, medication, and regular monitoring of blood glucose levels. Advances in treatment options, including new drug classes and insulin therapies, have improved outcomes for many patients. However, disparities in access to care remain a significant challenge, particularly in low- and middle-income countries. The involvement of global organizations, governments, and the private sector is critical to improving access to diabetes care and fostering research to develop better treatments. A concerted effort across all sectors is required to mitigate the growing burden of diabetes and improve the quality of life for affected individuals.
Keywords: Diabetes, Prevention, Early Diagnosis, Management, Complications, Global Response.

Introduction

Diabetes mellitus is a chronic, metabolic disorder that has become one of the most significant global health challenges of the 21st century. It is characterized by persistent high blood glucose levels due to the body's inability to produce or effectively use insulin, a hormone essential for regulating glucose metabolism. The disease primarily presents in two forms: type 1 diabetes (T1D) and type 2 diabetes (T2D). Type 1 diabetes is an autoimmune condition where the body's immune system attacks and destroys insulin-producing beta cells in the pancreas, while type 2 diabetes is characterized by insulin resistance, where the body's cells do not respond properly to insulin, often accompanied by a gradual decline in insulin production. Type 2 diabetes accounts for approximately 90-95% of all diabetes cases worldwide, and its rapid increase in prevalence is of particular concern to public health authorities.The global burden of diabetes has been growing steadily, driven by various factors such as urbanization, aging populations, unhealthy dietary habits, physical inactivity, and rising rates of obesity. According to the

International Diabetes Federation (IDF), over 537 million adults worldwide were living with diabetes in 2021, and this number is expected to rise significantly over the coming decades. The rise of diabetes has profound implications not only for individual health but also for public health systems, economies, and society at large. The disease is associated with numerous complications, including cardiovascular diseases, kidney failure, neuropathy, and retinopathy, all of which contribute to high mortality rates and reduced quality of life for affected individuals. Additionally, diabetes is a leading cause of disability, blindness, and amputations, further highlighting the need for effective prevention and management strategies.Preventing and managing diabetes has become a priority in healthcare globally. The impact of diabetes is not limited to its physical effects, as it also poses a significant economic burden due to medical costs for treatment, hospitalizations, and management of complications. This economic strain affects both individuals and healthcare systems, particularly in low- and middle-income countries where access to quality care is often limited. In high-income countries, while access to treatment may be more readily available, the rising cost of medications and technologies, along with the increasing demand for care, continues to present a challenge. The need for a sustainable approach to managing diabetes, including both prevention and treatment, is critical to mitigate the growing economic burden.The global response to diabetes involves a multi-faceted approach that includes prevention, early detection, education, and improved access to medical care. Prevention is largely centered around lifestyle changes, as type 2 diabetes is largely preventable through maintaining a healthy diet, regular physical activity, and weight management. Public health initiatives that aim to reduce obesity and encourage healthier lifestyles are vital to addressing the root causes of the diabetes epidemic. In addition, early diagnosis through regular screening allows for timely interventions that can delay the onset of the disease and prevent or minimize complications.Effective management of diabetes requires a comprehensive approach, combining lifestyle interventions, medications, and regular monitoring. Patients are encouraged to adopt a healthy lifestyle, including maintaining an optimal body weight, engaging in physical activity, and following a balanced diet, while simultaneously managing their blood glucose levels. Medication, including insulin for type 1 diabetes and oral medications for type 2 diabetes, is necessary for many patients to achieve good glycemic control and prevent complications. Advances in diabetes technologies, such as continuous glucose monitoring and insulin pumps, have improved disease management, particularly for patients with type 1 diabetes, but access to these innovations remains a significant issue in many parts of the world.A critical aspect of managing diabetes is addressing its complications, which can range from mild symptoms to life-threatening conditions. Cardiovascular disease, kidney disease, blindness, and amputations are among the most common complications of poorly controlled diabetes. As a result, integrated care that involves a team of healthcare professionals—including endocrinologists, cardiologists, nephrologists, and nutritionists—is essential for managing the disease and preventing complications. Diabetes education and self-management support are also important components of diabetes care, as they empower individuals to take control of their condition and make informed decisions about their health.As the diabetes epidemic continues to grow, there is an increasing recognition of the need for coordinated global efforts to address the disease. International organizations such as the World Health Organization (WHO) and the International Diabetes Federation (IDF) have been at the forefront of advocating for better diabetes care, prevention, and research. Governments, healthcare systems, and the private sector must collaborate to reduce the burden of diabetes through policies that promote healthy lifestyles, improve access to affordable treatments, and support research into new therapies and potential cures.In conclusion, diabetes is a global health crisis with profound impacts on individuals, communities, and healthcare systems. The rising prevalence of diabetes, particularly type 2 diabetes, is driven by lifestyle factors such as poor diet, lack of physical activity, and obesity. The disease is associated with

severe complications that contribute to high mortality and disability rates, as well as significant economic costs. The global response to diabetes requires a multifaceted approach that includes prevention, early detection, effective management, and addressing the underlying social and environmental determinants of health. By prioritizing diabetes prevention and improving access to care and treatments, it is possible to reduce the burden of diabetes and improve health outcomes for millions of people worldwide.

Epidemiology of Diabetes: Prevalence and Trends

Diabetes mellitus is a chronic metabolic disorder that has reached epidemic proportions globally, posing a major public health challenge due to its increasing prevalence, economic burden, and impact on quality of life. Characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both, diabetes is broadly classified into type 1 diabetes (T1D), type 2 diabetes (T2D), gestational diabetes mellitus (GDM), and other specific types. Among these, type 2 diabetes accounts for approximately 90–95% of all cases and is largely influenced by lifestyle and environmental factors, making it a preventable disease to a significant extent. Over the past few decades, the global prevalence of diabetes has risen dramatically. According to the International Diabetes Federation (IDF), in 2021, over 537 million adults (aged 20–79 years) were living with diabetes worldwide, and this number is projected to rise to 643 million by 2030 and to 783 million by 2045 if current trends continue. The rapid rise in prevalence is driven by aging populations, urbanization, sedentary lifestyles, unhealthy diets, and increasing rates of obesity, all of which are closely linked to the development of insulin resistance and beta-cell dysfunction characteristic of T2D.Epidemiological trends show significant geographic variation in diabetes prevalence, with the highest rates observed in low- and middle-income countries (LMICs), where nearly 80% of people with diabetes currently reside. This shift reflects a global transition in disease burden, traditionally associated with affluence, now increasingly affecting developing nations. Countries such as India and China have some of the highest numbers of individuals living with diabetes due to large populations and rapid socioeconomic changes that influence diet and physical activity patterns. In high-income countries, diabetes prevalence has stabilized or increased at a slower pace, partly due to improved awareness, screening programs, and public health initiatives targeting risk factors. However, disparities still exist within countries, where diabetes disproportionately affects minority and low-income populations, underscoring the influence of social determinants of health on disease risk and outcomes.Age is a critical factor in the epidemiology of diabetes. The prevalence of both type 1 and type 2 diabetes increases with age, although T1D typically presents in childhood or adolescence and is considered an autoimmune condition with genetic and environmental triggers. T2D, on the other hand, commonly manifests in adulthood, although increasing rates are now being observed in younger age groups, including adolescents and even children. This alarming trend in youth-onset T2D is particularly concerning, as early-onset diabetes is associated with a more aggressive disease course, higher risk of complications, and greater lifetime healthcare needs. Contributing factors include rising childhood obesity, poor dietary habits, physical inactivity, and genetic predispositions. Gender also plays a role in diabetes prevalence, with slight differences in rates between men and women that vary by region and diabetes type. For example, globally, T2D prevalence is slightly higher in men, while women may face higher risks of diabetes-related complications due to biological and social factors.Another important dimension of diabetes epidemiology is the burden of undiagnosed cases. A significant proportion of individuals living with diabetes are unaware of their condition, especially in countries lacking widespread screening and access to healthcare. The IDF estimates that nearly one in two adults with diabetes globally remains undiagnosed. Undiagnosed diabetes increases the risk of severe complications, such as cardiovascular disease, kidney failure, neuropathy, retinopathy, and lower limb amputations, which often develop insidiously over years of

unmanaged hyperglycemia. These complications not only reduce life expectancy but also impose substantial economic costs on individuals and healthcare systems. Consequently, early detection and timely intervention are critical components of diabetes control strategies.In addition to prevalence, the incidence of diabetes—the rate of new cases occurring in a population over time—is another important epidemiological measure. While global incidence trends are difficult to monitor uniformly due to variations in data quality, studies suggest that T2D incidence has risen in tandem with increasing obesity rates and aging populations. In contrast, the incidence of T1D has also shown an upward trend globally, though it remains much less common than T2D. The reasons for rising T1D incidence are not fully understood but may involve environmental factors such as viral infections, early-life diet, microbiome alterations, and vitamin D deficiency, all potentially influencing immune system development and beta-cell autoimmunity.Gestational diabetes mellitus (GDM) is another form of diabetes with important epidemiological implications. GDM is characterized by glucose intolerance first recognized during pregnancy and is associated with increased risks for both mother and child. Women with GDM have a higher likelihood of developing T2D later in life, and their offspring are more prone to obesity and metabolic disorders. The prevalence of GDM varies widely depending on diagnostic criteria, population demographics, and screening practices, but it is generally increasing in parallel with global obesity and diabetes trends. Addressing GDM is particularly important as it provides a unique opportunity for early intervention in high-risk populations.The global diabetes burden is not confined to clinical outcomes alone—it also includes significant economic costs. Diabetes-related healthcare expenditures are substantial and growing, particularly in countries with aging populations and limited healthcare resources. The IDF reported that global health spending on diabetes reached an estimated USD 966 billion in 2021, a figure that is expected to increase in coming years. These costs are driven by direct medical expenses (e.g., medications, hospitalizations, diagnostics) and indirect costs (e.g., productivity losses, disability, premature mortality). The economic impact is especially pronounced in LMICs, where out-of-pocket spending can be catastrophic for individuals and families, further entrenching cycles of poverty and ill health.Despite the daunting statistics, progress has been made in addressing diabetes at the global and national levels. Public health campaigns promoting healthy lifestyles, sugar consumption reduction, and physical activity have gained traction in many countries. Screening and early diagnosis efforts are being strengthened, and management guidelines are becoming more widely disseminated. The emergence of new pharmacological treatments and technologies—such as continuous glucose monitoring, insulin pumps, and SGLT2 inhibitors—has improved glycemic control and reduced the risk of complications for many patients. However, gaps in access to care, particularly in resource-limited settings, remain a major barrier to equitable diabetes management. Moreover, the COVID-19 pandemic has highlighted the vulnerability of individuals with diabetes to severe illness and disrupted healthcare services worldwide, potentially worsening outcomes and delaying diagnosis in many regions.In conclusion, the epidemiology of diabetes reflects a rapidly evolving global health challenge marked by rising prevalence, changing demographic patterns, and significant health and economic consequences. Type 2 diabetes, driven by lifestyle and environmental changes, accounts for the majority of the burden and is increasingly affecting younger populations, especially in developing countries undergoing rapid urbanization. Undiagnosed diabetes and its complications represent a hidden epidemic with far-reaching implications. Although public health efforts and medical advances have improved diabetes management in some regions, much work remains to be done to curb the disease’s spread and mitigate its impact. A coordinated, global response that emphasizes prevention, early detection, equitable access to care, and social determinants of health is essential to reverse current trends and reduce the future burden of diabetes.

Complications of Diabetes: Cardiovascular, Renal, and Neurological Impacts

Diabetes mellitus is a chronic metabolic condition that, if not properly managed, leads to a wide array of severe complications that affect multiple organ systems. Among the most significant and life-threatening of these are cardiovascular, renal, and neurological complications, which together account for much of the morbidity and mortality associated with the disease. The prolonged elevation of blood glucose levels, or hyperglycemia, that characterizes diabetes plays a central role in the pathogenesis of these complications by promoting oxidative stress, inflammation, endothelial dysfunction, and the formation of advanced glycation end-products (AGEs). These biological changes progressively damage the blood vessels, nerves, and organs, thereby impairing their function and triggering a cascade of disease processes that significantly reduce both the quality and expectancy of life for individuals living with diabetes.Cardiovascular complications are the leading cause of death in people with diabetes, making cardiovascular disease (CVD) one of the most critical concerns in diabetes management. Individuals with diabetes have a two- to four-fold increased risk of developing various forms of CVD, including coronary artery disease, myocardial infarction (heart attack), stroke, peripheral artery disease, and heart failure. This heightened risk is largely attributed to the detrimental effects of chronic hyperglycemia on blood vessel walls, which leads to endothelial dysfunction, a key early event in the development of atherosclerosis. Hyperglycemia contributes to the accumulation of AGEs, which stiffen and thicken the vascular endothelium, reduce nitric oxide availability, and promote inflammation. Additionally, diabetes often coexists with other major cardiovascular risk factors such as hypertension, dyslipidemia, and obesity, forming a metabolic syndrome that synergistically exacerbates cardiovascular risk. Diabetic dyslipidemia, characterized by elevated triglycerides, low high-density lipoprotein (HDL) cholesterol, and small, dense low-density lipoprotein (LDL) particles, is particularly atherogenic and accelerates plaque formation in the arteries. Furthermore, diabetes impairs the heart's ability to pump effectively, even in the absence of overt coronary artery disease, leading to a condition known as diabetic cardiomyopathy, which increases the risk of heart failure. Despite advances in cardiovascular treatment and preventive measures, diabetes remains a potent and independent risk factor for CVD, necessitating aggressive and multifaceted management strategies to mitigate its impact.Renal complications of diabetes, collectively termed diabetic kidney disease (DKD), are another major cause of morbidity and mortality. Diabetes is the leading cause of chronic kidney disease (CKD) and end-stage renal disease (ESRD) worldwide. The pathophysiology of DKD involves hyperglycemia-induced damage to the glomeruli—the filtering units of the kidney—leading to increased permeability of the glomerular basement membrane and subsequent albuminuria, an early marker of kidney damage. Over time, persistent hyperglycemia and hypertension accelerate the decline in glomerular filtration rate (GFR), eventually progressing to kidney failure if left untreated. Structural changes such as glomerular sclerosis, mesangial expansion, and tubulointerstitial fibrosis contribute to the irreversible loss of renal function. The presence of albuminuria is not only a predictor of renal decline but also an independent risk factor for cardiovascular events, linking renal and cardiovascular health in a bidirectional relationship. Management of diabetic kidney disease requires tight glycemic control, blood pressure management—particularly through the use of renin-angiotensin system inhibitors like ACE inhibitors or ARBs—and control of proteinuria. In advanced stages, patients may require dialysis or kidney transplantation, both of which carry significant burdens in terms of quality of life and healthcare costs. Given the asymptomatic nature of early kidney damage, regular screening for microalbuminuria and estimated GFR is essential in people with diabetes to allow for early detection and intervention.Neurological complications of diabetes, known as diabetic neuropathies, represent another major group of chronic complications that significantly impair patient well-being. These disorders result from prolonged exposure to hyperglycemia, which

leads to nerve ischemia and damage through mechanisms such as polyol pathway activation, oxidative stress, and the accumulation of AGEs. Diabetic neuropathy can affect any part of the nervous system but is most commonly observed as peripheral neuropathy, particularly distal symmetric polyneuropathy, which presents with symptoms such as pain, burning, tingling, numbness, and loss of sensation in the extremities, especially the feet and legs. This sensory loss predisposes individuals to unnoticed injuries, infections, and foot ulcers, which can lead to serious consequences such as gangrene and lower-limb amputations. Diabetic foot complications, often caused by a combination of neuropathy, peripheral arterial disease, and poor wound healing, are among the most debilitating and costly outcomes of diabetes and require comprehensive foot care and regular monitoring.Autonomic neuropathy is another serious form of diabetic nerve damage that affects the autonomic nervous system, which controls involuntary bodily functions. It can involve multiple organ systems, leading to a wide range of symptoms and complications. Cardiovascular autonomic neuropathy, for example, can result in resting tachycardia, exercise intolerance, orthostatic hypotension, and an increased risk of silent myocardial infarction due to impaired pain perception. Gastrointestinal manifestations of autonomic neuropathy include gastroparesis (delayed stomach emptying), constipation, diarrhea, and fecal incontinence, which significantly affect nutritional status and quality of life. Genitourinary complications include bladder dysfunction, which increases the risk of urinary tract infections, and sexual dysfunction, such as erectile dysfunction in men and decreased libido or arousal difficulties in women. These autonomic complications not only reduce the quality of life but can also complicate diabetes management, as erratic gastric emptying and poor bladder function can interfere with nutrient absorption and glycemic control.In addition to these major organ systems, diabetes also affects the eyes and can lead to diabetic retinopathy, which is a leading cause of blindness in working-age adults. Retinopathy develops due to damage to the retinal microvasculature, resulting in hemorrhages, exudates, microaneurysms, and neovascularization. In its advanced form, it can lead to retinal detachment, macular edema, and vision loss. Like other complications, diabetic retinopathy progresses silently and can only be detected through regular eye examinations. Effective management of blood glucose, blood pressure, and lipid levels, as well as timely ophthalmologic interventions such as laser therapy or intravitreal injections, are essential to prevent vision loss.The complications of diabetes are not only clinical concerns but also major public health issues, given their widespread impact on disability, productivity, and healthcare costs. People with diabetes are more likely to be hospitalized, suffer from comorbid conditions, and require long-term care. Furthermore, the psychosocial burden of living with complications—ranging from chronic pain and mobility limitations to depression and social isolation—adds another dimension to the disease's impact. Preventing these complications requires a comprehensive approach that includes early diagnosis, continuous monitoring, patient education, lifestyle modification, and pharmacological treatment to maintain optimal glycemic control and address associated risk factors. Multidisciplinary care teams, including endocrinologists, nephrologists, cardiologists, neurologists, dietitians, and diabetes educators, play a vital role in delivering holistic care that addresses the full spectrum of diabetes-related complications.In conclusion, the complications of diabetes—particularly those affecting the cardiovascular, renal, and nervous systems—represent the most serious and life-altering consequences of the disease. They arise from a shared pathophysiological foundation rooted in chronic hyperglycemia and are exacerbated by associated metabolic and vascular abnormalities. These complications not only contribute to the high rates of morbidity and mortality among individuals with diabetes but also place a substantial burden on healthcare systems worldwide. Effective management and prevention of these complications rely on early detection, patient-centered care, and a sustained commitment to lifestyle and medical interventions that reduce the long-term risks associated with this pervasive chronic disease.

Economic Burden of Diabetes: Healthcare Costs and Lost Productivity

Diabetes mellitus represents not only a significant medical challenge but also a profound economic burden on individuals, healthcare systems, and national economies worldwide. As the global prevalence of diabetes continues to rise, the associated costs—both direct and indirect—have escalated dramatically, placing increasing pressure on public health infrastructure and economic stability, especially in low- and middle-income countries. The economic impact of diabetes is multifaceted, encompassing direct healthcare expenditures such as medical consultations, hospitalizations, medications, diagnostic tests, and treatment of complications, as well as indirect costs related to lost productivity, absenteeism, disability, early retirement, and premature mortality. These costs are compounded by the chronic nature of the disease, which typically requires lifelong management, ongoing monitoring, and multidisciplinary care to prevent and treat a wide range of acute and chronic complications. The International Diabetes Federation (IDF) estimated that in 2021 alone, global health spending on diabetes reached USD 966 billion—a staggering figure that reflects both the rising number of people affected and the complexity of managing the condition and its consequences.The direct medical costs of diabetes include expenses related to physician visits, laboratory testing, glucose monitoring, medications such as insulin and oral hypoglycemics, and specialized care for complications such as cardiovascular disease, kidney failure, neuropathy, retinopathy, and amputations. These complications significantly increase the cost of care. For instance, a person with diabetes and one or more complications may incur healthcare costs several times higher than someone without complications. Hospitalizations, often necessitated by acute events like diabetic ketoacidosis, hypoglycemia, myocardial infarction, or stroke, are among the most expensive components of direct costs. Moreover, managing chronic complications like dialysis for end-stage renal disease or surgical interventions for diabetic foot ulcers adds to the long-term financial burden. Technological advancements in diabetes care, including continuous glucose monitors (CGMs), insulin pumps, and smart insulin pens, while beneficial in improving disease control and quality of life, can further escalate healthcare expenses due to their high costs and the need for ongoing supplies and maintenance.In many high-income countries, a significant portion of diabetes-related healthcare costs is absorbed by national health systems or insurance providers, but in many low- and middle-income countries, patients bear much of the financial burden themselves. Out-of-pocket spending can be catastrophic, particularly in households with limited income, leading to treatment non-adherence, delayed medical care, and poor health outcomes. The economic strain on families can extend beyond the affected individual, as caregivers often reduce working hours or leave employment to provide necessary support, thereby exacerbating the cycle of poverty and health disparity. The economic burden of diabetes at the household level is thus not limited to medical expenses but includes the broader financial implications of caregiving, transportation to health facilities, dietary modifications, and the psychological toll associated with managing a chronic, demanding illness.Beyond direct costs, diabetes imposes substantial indirect costs that are often even more significant in economic evaluations. One of the most pressing indirect costs is lost productivity due to illness-related absenteeism, reduced work capacity (presenteeism), disability, and premature death. Individuals with poorly managed diabetes often experience complications that limit their ability to work or maintain regular employment, leading to decreased earning potential and early withdrawal from the workforce. In high-income countries, productivity losses can be particularly large given the higher average wages and longer life expectancy. For example, diabetes-related vision loss or amputation can severely restrict a person’s capacity to engage in skilled labor, while cognitive impairment associated with long-term diabetes can affect decision-making and job performance. Moreover, frequent medical appointments and hospital stays further disrupt employment and productivity, particularly in jobs that lack flexible scheduling or sick leave

policies.The impact of diabetes on national economies is profound, especially when considering the cumulative effects of lost tax revenue, increased social security payouts, and reduced economic output. Countries with rapidly aging populations and increasing diabetes prevalence face the dual challenge of rising healthcare expenditures and shrinking workforces, both of which threaten long-term economic sustainability. In developing countries, where health systems are often under-resourced, the growing burden of diabetes diverts scarce resources from other pressing health priorities, undermining efforts to achieve broader public health goals. Additionally, the economic burden is not confined to adult populations; the rising incidence of type 2 diabetes in children and adolescents presents a long-term economic threat, as these individuals will require lifelong care and may face early-onset complications that limit their economic productivity well before traditional retirement age.Diabetes-related disability also contributes significantly to indirect costs. Individuals with advanced diabetic complications may be unable to perform daily tasks or participate fully in society, necessitating long-term care, rehabilitation, and social support services. These needs translate into increased spending by both public welfare systems and families. In many cases, the psychological burden of living with diabetes—particularly when complicated by depression or anxiety—further reduces an individual's ability to function effectively in work and social environments. Mental health issues in diabetes are often underdiagnosed and undertreated, yet they contribute to poorer disease management, higher healthcare use, and greater economic cost.Preventive strategies and early interventions have the potential to significantly reduce the economic burden of diabetes by delaying or preventing the onset of complications and improving overall health outcomes. Investment in lifestyle modification programs, early screening, public education, and community-based interventions has been shown to be cost-effective in many settings. For example, programs that promote physical activity, healthy eating, weight management, and smoking cessation can reduce the incidence of type 2 diabetes and its complications, leading to long-term healthcare savings and increased productivity. Furthermore, improved access to affordable medications, diabetes education, and regular monitoring can prevent costly complications and reduce hospital admissions. The economic case for prevention is compelling, yet many health systems struggle to allocate sufficient resources to these initiatives, often due to the political and budgetary challenges associated with shifting from treatment-focused models to prevention-oriented care.

Employers also play a critical role in managing the economic burden of diabetes through workplace wellness programs, health insurance benefits, and support for employees with chronic illnesses. Programs that provide diabetes screening, health coaching, flexible scheduling for medical appointments, and accommodations for employees with disabilities can enhance worker well-being and productivity while reducing absenteeism and turnover. In the long run, a healthy workforce is a more economically productive one, and investment in employee health yields substantial returns for businesses and economies alike.In conclusion, the economic burden of diabetes is vast and multifaceted, encompassing direct medical costs, indirect productivity losses, and broader societal impacts. As the global prevalence of diabetes continues to rise, particularly in economically vulnerable populations, the financial strain on individuals, families, health systems, and economies will intensify. Addressing this burden requires a comprehensive, multisectoral approach that includes investing in prevention, expanding access to effective care, supporting workplace health initiatives, and strengthening health system capacity to manage chronic diseases. By prioritizing early intervention and sustained disease management, societies can reduce the economic toll of diabetes and improve outcomes for millions of people worldwide.

Global Response to Diabetes: Prevention, Management, and Treatment Strategies

The global response to diabetes has evolved significantly over the past few decades as the prevalence of the disease continues to rise, with an estimated 537 million adults living with

diabetes worldwide, a number that is expected to increase substantially in the coming years. This global rise in diabetes is largely driven by lifestyle factors such as poor diet, physical inactivity, and obesity, as well as aging populations and urbanization. In response to this escalating health crisis, there has been a concerted effort at both national and international levels to address the prevention, management, and treatment of diabetes. The World Health Organization (WHO), national health agencies, and various non-governmental organizations have all recognized the need for comprehensive, multifaceted strategies to reduce the burden of diabetes and its associated complications. Effective responses require a combination of primary prevention efforts, early diagnosis, integrated care models, and improved access to treatment and medications.Prevention is a cornerstone of the global response to diabetes, particularly type 2 diabetes, which is largely preventable through lifestyle interventions. A key strategy for prevention is promoting healthy eating, regular physical activity, and weight management. Public health campaigns that raise awareness about the importance of a balanced diet, reducing sugar intake, and engaging in physical exercise have been implemented in numerous countries. These campaigns aim to reduce the prevalence of obesity, a major risk factor for type 2 diabetes. In many countries, these programs are targeted at children and adolescents to prevent the onset of obesity and diabetes at a younger age, which is increasingly recognized as a major issue as the incidence of type 2 diabetes in younger populations rises. Schools, workplaces, and community centers have become key sites for intervention, where nutrition education, exercise programs, and health screenings are incorporated into everyday activities.In addition to individual lifestyle changes, several countries have introduced policies to reduce diabetes risk at the population level. These include measures such as imposing taxes on sugary drinks, restricting the marketing of unhealthy foods to children, and improving food labeling to help consumers make healthier choices. The implementation of urban planning strategies that promote physical activity, such as the creation of pedestrian-friendly spaces, bike lanes, and public parks, has been another important development in diabetes prevention. These structural changes aim to encourage more active lifestyles and reduce the prevalence of obesity, thereby lowering the risk of diabetes. While these preventive strategies are still in their early stages in some regions, they represent a promising approach to tackling the root causes of diabetes at a systemic level.Screening and early diagnosis are also central to the global response to diabetes. Identifying individuals at risk of diabetes before they develop full-blown symptoms allows for earlier intervention and better management of the disease. In many countries, there has been a push to implement widespread screening programs to identify people with undiagnosed diabetes or prediabetes. The introduction of simple and cost-effective screening tests, such as the fasting blood glucose test or the hemoglobin A1c test, has made it easier for healthcare providers to detect the condition early. For people with prediabetes, interventions such as lifestyle changes—specifically weight loss, improved diet, and increased physical activity—can significantly reduce the risk of progression to type 2 diabetes. Screening programs, however, require adequate infrastructure, trained healthcare personnel, and public awareness, which can be a challenge in low-resource settings.Once diabetes is diagnosed, effective management and treatment become essential to prevent complications and improve quality of life. Diabetes management typically involves a combination of lifestyle modifications, blood sugar monitoring, and pharmacological interventions. Self-management is a key element in diabetes care, and patients are encouraged to monitor their blood glucose levels regularly, adhere to prescribed medications, and adopt a healthy diet and exercise regimen. Diabetes education programs are critical in empowering individuals to take charge of their health and understand the importance of lifestyle changes, medication adherence, and regular monitoring. Health professionals, including diabetes educators, nutritionists, and counselors, play an important role in guiding patients through their treatment plans and helping them set achievable goals.Medications are central to the management of diabetes, particularly

for those who cannot achieve adequate blood sugar control through lifestyle changes alone. The treatment of type 1 diabetes, which involves an absolute lack of insulin production, requires lifelong insulin therapy. Insulin therapy can be administered through injections or insulin pumps, and advances in insulin formulations and delivery methods have made it easier for patients to achieve better glycemic control with fewer side effects. In type 2 diabetes, medications are used to address insulin resistance and improve insulin secretion. The treatment landscape for type 2 diabetes has expanded in recent years with the introduction of new classes of drugs, such as sodium-glucose cotransporter-2 (SGLT2) inhibitors, glucagon-like peptide-1 (GLP-1) receptor agonists, and DPP-4 inhibitors. These medications not only help control blood sugar levels but also provide additional benefits such as weight loss and reduced cardiovascular risk, which are particularly important for individuals with type 2 diabetes, who often face cardiovascular complications. Despite the advances in medication, access to these drugs remains a challenge in low-income settings, where many people cannot afford the cost of modern treatments, thereby exacerbating health disparities.Another key aspect of diabetes management is addressing complications that arise from the disease. People with diabetes are at higher risk for a range of complications, including cardiovascular disease, kidney disease, neuropathy, and retinopathy. Effective management requires integrated care that addresses not only blood glucose control but also the prevention and treatment of these complications. For example, managing blood pressure and cholesterol levels is essential for reducing the risk of heart disease and stroke in people with diabetes. Regular eye exams and screening for kidney damage are also critical to prevent blindness and renal failure, both of which are common complications of poorly controlled diabetes. Multidisciplinary care teams, including endocrinologists, cardiologists, nephrologists, ophthalmologists, and other specialists, are essential to provide comprehensive care and improve long-term outcomes for people with diabetes.Global organizations such as the WHO, the International Diabetes Federation (IDF), and various national diabetes associations play a pivotal role in shaping global diabetes policies and strategies. These organizations advocate for greater investment in diabetes care, research, and prevention programs, particularly in low- and middle-income countries where diabetes prevalence is rising rapidly. The WHO has included diabetes as a target in its global strategy for non-communicable diseases, and the IDF runs numerous initiatives to raise awareness, improve access to care, and promote research into new treatments and cures. The United Nations has also recognized the growing diabetes epidemic as a public health priority, emphasizing the need for governments to take a more proactive role in addressing the disease.In addition to international efforts, the private sector also plays an important role in the global response to diabetes. Pharmaceutical companies, medical device manufacturers, and technology firms are constantly working to develop new drugs, medical devices, and digital health tools that can improve diabetes management. Innovations such as continuous glucose monitors, insulin pumps, and telemedicine services are improving patient care, particularly for those with type 1 diabetes and complex cases of type 2 diabetes. Moreover, partnerships between public and private sectors have been instrumental in scaling up diabetes prevention and management programs in many countries.In conclusion, the global response to diabetes is multifaceted, encompassing prevention, early diagnosis, integrated management, and treatment strategies. Prevention efforts focus on lifestyle changes and public health policies aimed at reducing risk factors such as obesity, physical inactivity, and poor diet. Early diagnosis through screening allows for timely intervention, while effective management through medication, education, and regular monitoring can significantly reduce the risk of complications. Multidisciplinary care and global partnerships are essential for addressing the growing diabetes epidemic, especially in low- and middle-income countries. With continued investment in research, policy development, and public health infrastructure, it is possible to reduce the

impact of diabetes and improve the lives of millions of individuals living with this chronic condition.

conclusion

In conclusion, the global response to diabetes requires a comprehensive, multi-pronged approach to effectively address both the growing prevalence of the disease and its associated complications. Prevention strategies focusing on lifestyle changes, including healthy eating, regular physical activity, and weight management, are vital in reducing the incidence of type 2 diabetes, particularly in high-risk populations. Early diagnosis through widespread screening programs plays a crucial role in identifying individuals at risk and implementing timely interventions that can delay or prevent the onset of full-blown diabetes. In terms of management, ongoing advancements in medications, insulin therapies, and continuous glucose monitoring have significantly improved the quality of care, although access to these innovations remains a challenge in lower-resource settings. The importance of integrated care teams to manage not only blood sugar levels but also diabetes-related complications cannot be overstated, as cardiovascular disease, kidney failure, and neuropathy are common in individuals with poorly controlled diabetes. Global organizations, governments, and the private sector must continue to work together to promote prevention, improve access to care, and invest in research to develop better treatments and, ultimately, a cure. A collective effort across sectors and countries is essential to reduce the burden of diabetes and improve outcomes for millions affected worldwide.

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DİVAN ŞİİRİNDE SES-ANLAM İLİŞKİSİ: YANSIMA SÖZCÜKLER

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ÖZET
Klasik Türk edebiyatında edebî eserler, nazım ve nesir şeklinde kalme alınır. Mensur metinler, daha serbest bir şekilde yazılırken manzum metinler belli bir ölçü ve düzen içinde oluşturulur. Şiirde asonans, aliterasyon, sözcük-ses tekrarları, paralellikler, vezin ve ritim gibi unsurlar ile bir ahenk sağlanır ve bu unsurlar arasındaki ses-anlam ilişkisi, şiirin estetik ve duygusal etkisini artırır. Yansıma sözcükler de sesin anlamı pekiştirmedeki rolü ile dikkat çeker. Yansıma sözcükler, doğadaki seslerin taklit edilmesiyle oluşturularak imgelerin daha canlı gösterilmesini ve duyguyu yoğun hâle gelmesini sağlar. Mesela dilimizde en çok kullanılan "tak, çat, tık, gürül, şırıl, şıp" gibi yansıma sözcükler, tabiattaki seslerin taklididir ve bu sesler sayesinde imgeler daha canlı gösterilir. Böylece duygusal ve zihinsel algı daha derin bir hâl alır. Yansıma sözcükler doğa tasviri, bireyin duygusal tepkileri gibi birçok yaratımda etkilidir. Örneğin "tak" sesi ile bir kapının vurulma sesini daha etkili bir şekilde gösterilmesini sağlar. Coşkulu bir akarsuyun akışını ifade etmek için "şırıl şırıl" ifadesi kullanılır ve bu sesler ile doğanın canlılığı/hareketine vurguda bulunulur. Bu şekilde şiirin işitsel gücü artar. Yansıma sözcüklerdeki seslerin kullanımı ile okuyucu uyarılır ve şiirin tekdüzeliği ortadan kaldırılır. Yansıma sözcükler, mazmunlar ile birlikte kullanıldığında anlamı katmanlı hâle getirir ve şiirin müzikalitesini olumlu yönden etkiler. Bu çalışma divanlarda tespit ettiğimiz yansıma sözcüklerin anlam üzerindeki etkisini, duyguyu güçlendirmedeki rolünü ortaya koymayı amaçlamaktadır.
Anahtar Kelimeler: Yansıma Sözcükler, Divan Şiiri, Ses-Anlam İlişkisi, Estetik Ahenk

THE SOUND-MEANING RELATIONSHIP IN DIVAN POETRY: ONOMATOPOEIC WORDS

ABSTRACT
In classical Turkish literature, literary compositions are categorized into verse and prose forms. Prose texts are characterized by a relatively unrestricted style, whereas poetic texts adhere to specific metrical and structural conventions. In poetry, elements such as assonance, alliteration, phonetic repetitions, parallelisms, meter, and rhythm collectively establish a harmonious aesthetic, with the interplay of sound and meaning significantly enhancing the poem's emotive and artistic resonance. Onomatopoeic words are particularly noteworthy for their capacity to reinforce semantic content through auditory imitation. These words, derived from the mimicry of natural sounds, vividly animate imagery and intensify emotional expression. Common Turkish onomatopoeic terms, such as "tak," "çat," "tık," "gürül," "şırıl," and "şıp," emulate environmental sounds, thereby rendering imagery more dynamic and evocative. This linguistic device fosters a deeper emotional and cognitive engagement. Onomatopoeic words prove effective in various poetic contexts, including depictions of nature and expressions of individual emotional responses. For example, the sound "tak" vividly conveys the auditory impression of a door being struck, while "şırıl şırıl" captures the vibrant flow of a rushing stream, accentuating the vitality of natural phenomena. Such sonic elements amplify the auditory potency of the

poem, stimulating reader engagement and mitigating any sense of monotony. When integrated with metaphorical constructs (mazmun), onomatopoeic words generate multilayered meanings, further enriching the poem's musicality. This study seeks to elucidate the semantic influence of onomatopoeic words identified within divan poetry and their role in amplifying emotional depth.
Keywords: Onomatopoeia, Divan Poetry, Sound-Semantics Interrelation, Aesthetic Harmony

EVAPORATİF SOĞUTMA İŞLEMİNDE HAVA HIZI VE SU SICAKLIĞININ ÜFLEME HAVASINA ETKİSİNİN İNCELENMESİ ÜZERİNE BİR ÇALIŞMA

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ÖZET
Bu çalışma, evaporatif soğutma sistemlerinde hava hızı ve su sıcaklığının çıkış havası sıcaklığı ile bağıl nem üzerindeki etkilerini deneysel olarak incelemeyi amaçlamaktadır. Deneylerde UFO marka bir evaporatif soğutucu kullanılmıştır. Çalışma kapsamında üç farklı hava hızı (5 m/s, 7 m/s, 9 m/s) ve üç farklı su sıcaklığı (14,5 °C, 22,5 °C ve 7 °C) kullanılarak dokuz farklı deney seti oluşturulmuştur. Her deneyde giriş havasının sıcaklığı ve bağıl nemi ölçülmüş; çıkışta ise hava sıcaklığı ve bağıl nem değerleri kaydedilmiştir.
Elde edilen sonuçlara göre; su sıcaklığının düşmesiyle çıkış havası sıcaklığında belirgin bir azalma gözlemlenmiştir. Örneğin; 5 m/s hava hızı ve 14,5 °C su sıcaklığında çıkış havası sıcaklığı ortalama 22,0 °C'ye kadar düşerken, aynı hava hızında ve 22,5 °C su sıcaklığında bu değer ortalama 23,5 °C olmuştur. Ayrıca, çıkış havasının bağıl nemi düşük su sıcaklıklarında ortalama %58,5'e kadar ulaşırken, yüksek su sıcaklığında bu oran %55,5 civarındadır.
Hava hızının etkisine bakıldığında; 5 m/s hızda 23,5 °C olan ortalama çıkış sıcaklığı, 9 m/s'ye çıkarıldığında 24,0–24,4 °C aralığına yükselmiş ve bağıl nemde de benzer şekilde düşüş gözlemlenmiştir. Bu durum, hava hızındaki artışın hava-su etkileşim süresini azaltarak soğutma etkinliğini sınırladığını göstermektedir.
Sonuç olarak, evaporatif soğutma sistemlerinde düşük su sıcaklığı ve düşük hava hızı koşulları, daha etkili bir soğutma performansı sağlamaktadır. Bu bulgular, enerji verimli ve çevre dostu iklimlendirme çözümlerinin geliştirilmesi açısından önemli katkılar sunmaktadır.
Anahtar Kelimeler: Evaporatif soğutma, hava hızı, su sıcaklığı, bağıl nem, çıkış havası sıcaklığı

A STUDY ON THE EFFECT OF AIR VELOCITY AND WATER TEMPERATURE ON SUPPLY AIR IN EVAPORATIVE COOLING PROCESS

ABSTRACT
This study experimentally investigates the effects of air velocity and water temperature on the outlet air temperature and relative humidity in an evaporative cooling system. A UFO-brand direct evaporative cooler was used in the experiments. Nine different test conditions were created using three air velocities (5 m/s, 7 m/s, and 9 m/s) and three water temperatures (14.5 °C, 22.5 °C, and 7 °C). In each test, the inlet air temperature and relative humidity were recorded, and the outlet air temperature and humidity were measured.
The results reveal that decreasing water temperature significantly reduces outlet air temperature. For instance, at 5 m/s air velocity and 14.5 °C water temperature, the outlet air temperature dropped to an average of 22.0 °C, whereas it remained around 23.5 °C at 22.5 °C

water temperature. Similarly, relative humidity increased from 55.5% to 58.5% when cooler water was used.
Regarding air velocity, increasing from 5 m/s to 9 m/s resulted in a higher outlet temperature ranging from 24.0 to 24.4 °C on average, with a slight decrease in relative humidity. This indicates that higher air velocity shortens the contact time between air and water, reducing the system's cooling effectiveness.
In conclusion, the most efficient evaporative cooling performance is achieved under low air velocity and low water temperature conditions. These findings contribute to the optimization of energy-efficient and environmentally sustainable HVAC systems, particularly in hot and dry climate regions.
Keywords: Evaporative cooling, air velocity, water temperature, relative humidity, outlet air temperature

ENZYMES AND POULTRY FEED INDUSTRY

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Abstract
Poultry sector is one of the major established industries of Pakistan that is committed to provide valuable meat to our community. Phytases, cellulases, xylanases and proteases are the main enzymes being added in the poultry feed. The addition of these enzymes is important because their addition in feed put a positive impact on the growth of poultry bird. Phytases are responsible for the availability of free phosphorus while the xylanases and cellulases are responsible for the availability of monomeric absorbable sugars for the growth of bird whereas proteases also involve for the improvement of digestion of proteins. In the absence of these enzymes the phytate, cellulose and xylan are not being digested by the poultry bird and these components of feed simply pass through the digestive track and are removed from the body with manure and contribute in environmental pollution.

In the current study the phytase, cellulase and xylanase genes from hyper-thermophilic bacterium were amplified by using the PCR and ligated into the cloning vector pTZ57R/T. These vectors were transferred in the *E.coli* DH5α cells. The expression of phytase, cellulase and xylanase genes were analyzed in *E.coli* BL21CodonPlus cells with the help of pET expression system. Recombinant proteins were purified through different chromatographic techniques and their molecular masses were determined through SDS-PAGE. Recombinant proteins were characterized. The locally produced recombinant enzymes were utilized for supplementation of poultry feed to examine their effect on the growth of poultry birds. The supplementation of poultry feed with locally produced enzymes showed significant growth enhancing effect on poultry birds and improved the feed uptake and feed conversion ratio.

Key Words: Poultry enzymes, Recombinant proteins, hyper-thermophilic bacterium

TRİMETAZİDİN DİHİDROKLORİD'İN HeLa KANSER HÜCRELERİ ÜZERİNE SİTOTOKSİK ETKİSİNİN ARAŞTIRILMASI

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ÖZET
Trimetazidin dihidroklorid (TMD), ağızdan alınan VASTAREL MR®35 mg ve VASTAREL MR® 60 mg modifiye salım tabletin etkin maddesidir. Çalışmamızda VASTAREL MR' ın etkin maddesi olan TMD'nin, HeLa kanser hücreleri ve T0063 sağlıklı karaciğer hücreleri üzerine sitotoksik etkisi ilk kez araştırılmıştır. Sitotoksik etkinin belirlenmesinde MTT (3- (4,5-dimetiltiyazol 2-il) -2,5-difeniltetrazolyum bromür) kolorimetrik test yöntemi kullanılmıştır. Bu amaçla; HeLa ve T0063 hücreleri uygun besi yerinde kültür edilerek, TMD ve sisplatinin farklı (0-200 µM) derişimlerinin 24, 48 ve 72 saat uygulama sürelerinde sitotoksik etkinlikleri değerlendirilmiştir. TMD'nin hem HeLa hem de T0063 için IC_{50} değerleri >200 µM olarak belirlenmiştir. Sisplatinin; HeLa ve T0063 hücrelerinde 24, 48 ve 72 saat için IC_{50} değerleri sırasıyla; 21,81 ± 0,022 µM, 9,66 ± 0,018 µM, 5,57 ± 0,028 µM ve 58,15 ± 0,048 µM, 41,93 ± 0,034 µM, 38,17 ± 0,025 µM olarak belirlenmiştir. Sisplatinin HeLa ve T0063 hücrelerinin %50'sinin ölümüne neden olan derişimi (IC_{50}) ile farklı derişimlerde (0-200 µM) TMD, HeLa ve T0063 hücrelerine uygulanarak TMD + sisplatinin HeLa ve T0063 hücreleri üzerine olası sitotoksik etkisi ile ilgili ilkin veriler elde edilmiştir. Sisplatin + TMD uygulanması sonucunda HeLa ve T0063 hücrelerinde 24, 48 ve 72 saat için IC_{50} değerleri sırasıyla; 14,87 ± 0,113 µM, 8,93 ± 0,11 µM, 25,91 ± 0,093 µM ve 147,4 ± 0,116 µM, 86,28 ± 0,096 µM, 35,98 ± 0,102 µM olarak belirlenmiştir. Sisplatin + TMD uygulamasının; sisplatinin tek başına uygulanmasına göre HeLa hücrelerinde daha yüksek sitotoksik etki gösterirken, sağlıklı hücrelerde sitotoksisiteyi düşürdüğü gözlenmiştir. Ayrıca sisplatin + TMD uygulamasının sisplatinin tek başına uygulanmasına göre HeLa hücrelerine karşı seçicilik indeksini arttığı belirlenmiştir.
Anahtar Kelimeler: Antikanser aktivite, HeLa, MTT, Trimetazidin dihidroklorid

INVESTIGATION OF CYTOTOXIC EFFECT OF TRIMETAZIDINE DIHYDROCHLORIDE on HeLa CANCER CELLS

ABSTRACT
Trimetazidine dihydrochloride (TMD) is the active pharmaceutical ingredient of VASTAREL MR® 35 mg and VASTAREL MR® 60 mg modified-release tablets, which are administered orally. In our study, the cytotoxic effect of TMD, the active ingredient of VASTAREL MR, on HeLa cancer cells and T0063 human healthy liver cells were investigated for the first time. The cytotoxic effect was evaluated using the MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) colorimetric assay. For this purpose, HeLa and T0063 cells were cultured in appropriate growth media, and the cytotoxicity of TMD and cisplatin at various concentrations (0–200 µM) was assessed after 24, 48, and 72 hours of exposure. The IC_{50} values of TMD for both HeLa and T0063 were determined as >200 µM. The IC_{50} values of cisplatin against HeLa and T0063 cells were found to be; 21.81 ± 0.022 µM, 9.66 ± 0.018 µM, 5.57 ±

0.028 μM and 58.15 ± 0.048 μM, 41.93 ± 0.034 μM, 38.17 ± 0.025 μM for 24, 48 and 72 hours were respectively. The concentration of cisplatin that caused 50% death of HeLa and T0063 cells (IC_{50}) and different concentrations of TMD (0-200 μM) were applied to HeLa and T0063 cells to obtain preliminary data on the possible cytotoxic effect of TMD + cisplatin on HeLa and T0063 cells. As a result of cisplatin + TMD application, the IC_{50} values against HeLa and T0063 cells were determined as; 14.87 ± 0.113 μM, 8.93 ± 0.11 μM, 25.91 ± 0.093 μM and 147.4 ± 0.116 μM, 86.28 ± 0.096 μM, 35.98 ± 0.102 μM for 24, 48 and 72 hours, respectively. The combined application of cisplatin + TMD exhibited higher cytotoxic effects on HeLa cells compared to cisplatin alone, while reducing cytotoxicity in healthy cells. Furthermore, it was determined that the selectivity index of cisplatin towards HeLa cells increased when used in combination with TMD, indicating a more targeted cytotoxic effect.
Keywords: Anticancer activity, HeLa, MTT, Trimetazidine dihydrochloride

ENVIRONMENTAL STRESS AND PLANT BIOCHEMISTY

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Abstract :
Environmental stress significantly impacts plant biochemistry, influencing growth, development, productivity, and survival. Various abiotic stress factors such as drought, salinity, extreme temperatures, heavy metals, and ultraviolet radiation induce profound biochemical and physiological changes in plants. In response to these stressors, plants activate a complex network of signaling pathways and defense mechanisms that involve alterations in primary and secondary metabolism. One of the key biochemical responses includes the accumulation of osmolytes like proline, glycine betaine, and sugars, which help maintain cellular osmotic balance. Antioxidant enzymes such as superoxide dismutase (SOD), catalase (CAT), and peroxidases are also upregulated to mitigate oxidative damage caused by reactive oxygen species (ROS). Additionally, stress conditions trigger the biosynthesis of secondary metabolites such as phenolics, flavonoids, and alkaloids, which play roles in stress tolerance and signaling. Plant hormones like abscisic acid (ABA), salicylic acid, and jasmonic acid are crucial regulators in modulating stress-responsive gene expression and biochemical pathways. Advances in molecular biology and omics technologies have further enhanced our understanding of stress-induced biochemical reprogramming and the identification of stress-responsive genes and proteins. These insights are essential for developing stress-resilient crop varieties through genetic engineering and sustainable agricultural practices. Understanding plant biochemical responses to environmental stress not only reveals fundamental mechanisms of plant adaptation but also has practical applications in improving crop tolerance and productivity under changing climatic conditions. This article reviews the key biochemical strategies plants use to combat environmental stress and their implications for agriculture and ecosystem stability.

Keywords:
Environmental stress, Plant biochemistry, Abiotic stress, Antioxidant enzymes, Osmolytes, Secondary metabolites, Stress tolerance, ROS, Phytohormones, Climate resilience

EPILEPSY

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Abstract
Epilepsy is a chronic neurological disorder characterized by recurrent, unprovoked seizures resulting from abnormal electrical activity in the brain. It affects approximately 50 million people worldwide, making it one of the most common neurological conditions. Seizures can vary in type and severity, ranging from brief lapses in attention or muscle jerks to severe and prolonged convulsions. The etiology of epilepsy is diverse, including genetic predispositions, structural brain abnormalities, infections, head trauma, and stroke. Diagnosis typically involves clinical evaluation, electroencephalography (EEG), and neuroimaging. While antiepileptic drugs (AEDs) are the primary treatment, about one-third of patients are drug-resistant and may require alternative therapies such as surgery, vagus nerve stimulation, or dietary interventions. Epilepsy not only imposes medical challenges but also significant psychosocial burdens, including stigma and reduced quality of life. Continued research is essential to improve treatment outcomes, understand the underlying mechanisms, and develop preventive strategies

Keywords
- Epilepsy
- Seizures
- Neurological disorder
- Antiepileptic drugs (AEDs)
- Refractory epilepsy
- Seizure classification
- Electroencephalogram (EEG)
- Temporal lobe epilepsy
- Generalized seizures

Introduction

Epilepsy is a chronic neurological disorder characterized by recurrent, unprovoked seizures resulting from excessive electrical discharges in the brain. Affecting over 50 million people worldwide, it represents a major public health issue with significant medical, psychological, and social implications. Epilepsy is not a single disease but a spectrum of brain disorders with varying seizure types, causes, and outcomes. While advances in diagnosis and treatment have improved the quality of life for many individuals, a substantial number remain resistant to conventional therapies, highlighting the need for continued research and innovation.

Causes and Classification

The etiology of epilepsy is diverse and can be classified as genetic, structural, metabolic, infectious, immune-related, or of unknown origin. In children, genetic syndromes and developmental disorders are common causes, whereas in adults, head trauma, stroke, and brain tumors are more prevalent. In many low- and middle-income countries, infectious diseases such as neurocysticercosis and meningitis are major contributors.

The International League Against Epilepsy (ILAE) classifies seizures into focal (originating in one hemisphere), generalized (involving both hemispheres), and unknown onset. This classification aids in diagnosis, treatment planning, and prognosis.

Pathophysiology

Epileptic seizures occur due to an imbalance between excitatory and inhibitory neurotransmitters in the brain, primarily glutamate and gamma-aminobutyric acid (GABA).

This imbalance leads to sudden, synchronous firing of neurons. In focal epilepsy, the abnormal activity begins in a localized brain region, whereas generalized seizures involve widespread brain networks from the onset.

Clinical Features

Seizures vary widely depending on the type and affected brain region. Common manifestations include:

- **Focal seizures**: Twitching, sensory disturbances, or altered consciousness.
- **Generalized seizures**: Loss of consciousness, stiffening, and jerking of limbs (tonic-clonic seizures), or brief lapses in awareness (absence seizures).

Seizures may be triggered by factors such as sleep deprivation, stress, flashing lights, or alcohol.

Diagnosis

A thorough clinical history is essential in diagnosing epilepsy, often supplemented by eyewitness accounts. Diagnostic tools include:

- **Electroencephalography (EEG)**: Records electrical activity in the brain and may detect epileptiform discharges.
- **Magnetic Resonance Imaging (MRI)**: Helps identify structural causes such as tumors, malformations, or scarring.
- **Genetic testing**: Useful in certain pediatric epilepsy syndromes.

Proper diagnosis is critical to differentiate epilepsy from other conditions like syncope, migraines, or psychogenic nonepileptic seizures.

Management and Treatment

Medications

Antiepileptic drugs (AEDs) are the first line of treatment and can control seizures in about 70% of patients. Commonly used AEDs include:

- Levetiracetam
- Valproic acid
- Carbamazepine
- Lamotrigine

Drug choice depends on seizure type, patient age, comorbidities, and potential side effects. Some patients may require a combination of drugs (polytherapy).

Surgical Options

For patients with drug-resistant epilepsy, surgery may offer the best chance of seizure control. Types of epilepsy surgery include:

- **Lobectomy**: Removal of the seizure focus (e.g., temporal lobe).
- **Corpus callosotomy**: Disconnection of hemispheres to prevent spread.
- **Laser ablation** and **stereotactic radiosurgery** are less invasive alternatives.

Dietary Therapies

The ketogenic diet (high-fat, low-carbohydrate) has shown effectiveness, especially in children with difficult-to-control epilepsy. Modified versions like the low glycemic index diet are also used.

Neuromodulation

Techniques such as **vagus nerve stimulation (VNS)** and **deep brain stimulation (DBS)** are used in refractory cases to reduce seizure frequency.

Psychosocial Impact

Beyond physical health, epilepsy significantly affects mental and social well-being. Many individuals experience depression, anxiety, memory problems, and social stigma. Children with epilepsy may face learning difficulties and reduced educational opportunities. Support groups, psychological counseling, and public education are important components of holistic care

Prevention and Global Health

Infectious causes of epilepsy are largely preventable through improved sanitation, vaccination, and early treatment. In many low-income regions, lack of access to diagnosis and treatment—termed the **epilepsy treatment gap**—results in high morbidity and mortality. Strengthening healthcare systems and raising awareness are vital to address these challenges.

Conclusion

Epilepsy is a complex and multifaceted neurological disorder that affects millions of people globally. Although significant advances have been made in understanding and treating the condition, challenges remain, particularly for those with drug-resistant forms or those living in underserved areas. A multidisciplinary approach—including medication, surgery, dietary therapy, psychosocial support, and public health interventions—is essential for optimal management. Continued research, innovation, and global collaboration are necessary to improve outcomes and reduce the burden of epilepsy on individuals and society.

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DEPREM SONRASINDA ÖN ÜRETİMLİ EĞİTİM YAPILARI KURULUŞU: HATAY ANAOKULU PROJESİ ÜZERİNDEN BİR OKUMA

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ÖZET
Türkiye'nin aktif deprem kuşağında yer alması, yapılaşma süreçlerinde dayanıklılık ve hız kriterlerini zorunlu kılmaktadır. Özellikle eğitim yapıları, afet sonrası toplumsal iyileşme sürecinde kritik rol oynar. Bu çalışmada, 6 Şubat 2023 depremlerinden etkilenen Hatay ilinde, afet sonrası hızlı müdahale kapsamında inşa edilen ön üretimli bir anaokulu projesi ele alınmıştır. Çalışma kapsamında ön üretimli yapı sistemlerinin depreme dayanıklılık, kurulum hızı ve sürdürülebilirlik açısından avantajları literatür destekli olarak değerlendirilmiş; uygulanan proje ise tasarım ilkeleri, malzeme seçimi ve kurulum süreci yönüyle detaylandırılmıştır. Sonuç olarak, afet sonrası yeniden yapılanma sürecinde ön üretimli yapıların eğitsel mekânlar için etkin bir çözüm sunduğu, benzer risk altındaki bölgeler için örnek teşkil ettiği vurgulanmıştır.
Anahtar Kelimeler: Deprem, Ön üretimli yapım teknikleri, Anaokulu, Afet sonrası mimarlık.

POST-EARTHQUAKE DEPLOYMENT OF PREFABRICATED EDUCATIONAL BUILDINGS: ANALYSIS THROUGH THE HATAY KINDERGARTEN PROJECT

ABSTRACT
Turkey's location in an active earthquake zone necessitates durability and speed criteria in construction processes. Especially educational buildings play a critical role in the post-disaster social recovery process. In this study, a prefabricated kindergarten project constructed within the scope of rapid post-disaster response in Hatay province, which was affected by the February 6, 2023 earthquakes, is discussed. Within the scope of the study, the advantages of prefabricated building systems in terms of earthquake resistance, installation speed and sustainability are evaluated with the support of the literature, and the applied project is detailed in terms of design principles, material selection and installation process. As a result, it is emphasized that prefabricated structures offer an effective solution for educational spaces in the post-disaster reconstruction process and set an example for similarly at-risk regions.
Keywords: Earthquake, Prefabricated building, Kindergarten, Post-disaster architecture.

GİRİŞ

Türkiye, aktif fay hatlarının yoğun olarak bulunduğu bir deprem ülkesidir. Kandilli Rasathanesi (2023) verilerine göre, Türkiye topraklarının yaklaşık %92'si deprem riski altındadır ve nüfusun %95'i aktif fay hatları üzerinde yaşamaktadır. Bu durum, barınma kadar kamusal hizmet yapılarının da depreme dayanıklı olacak şekilde planlanmasını zorunlu kılmaktadır. Özellikle 6 Şubat 2023 tarihinde Kahramanmaraş merkezli olarak yaşanan ve Hatay da dâhil olmak üzere 11 ili etkileyen depremler, yapı stoğundaki zafiyetleri gözler önüne sermiştir. Bu kapsamda, eğitim yapılarının dayanıklı, hızlı şekilde inşaa edilebilir ve sürekliliği sağlayacak sistemlerle inşaa edilmesi hayati bir konudur. Anaokulu gibi erken çocukluk eğitimi verilen yapılar, sadece fiziksel değil aynı zamanda psikolojik güvenlik de sunmalıdır.

Gerek dünyada gerekse Türkiye'de, afet sonrası kullanılan ön üretimli yapıların çeşitli tasarım parametreleri üzerinden değerlendirilmesi, giderek artan bir önem kazanmaktadır. Afet sonrası inşa edilen eğitim yapıları yalnızca fiziksel ve yapısal güvenlik sağlamakla sınırlı kalmayıp, aynı zamanda öğrencilerin psikolojik iyilik hâlini, sosyal etkileşimini ve eğitsel sürekliliğini destekleyecek şekilde bütüncül bir anlayışla ele alınması gerekmektedir. Bu bağlamda UNESCO ve UNICEF (2015), afet sonrası okul yapılarının toplumların yeniden toparlanmasında temel rol üstlenen güvenli ve kapsayıcı öğrenme ortamları olarak tasarlanması gerektiğini belirtmektedir.

Güncel uygulamalr üzerinden, afet sonrası ön üretimli yapılar yalnızca barınma ihtiyacı gözetilerek değil, kaliteli eğitim, temiz enerji ve sürdürülebilir kentleşme gibi hedefler üzerinden değerlendirildiğinde daha kapsamlı bir performans analizi yapılabilmektedir (Qin et al., 2023). Geçici okul tasarımlarının sürdürülebilir bir eğitim altyapısına dönüşebilmesi için proje aşamasında tasarımda etkin performans kriterlerinin belirlenmesi gerekmektedir. Bu yaklaşım, sadece hızlı kurulum amaçlı yapıları, bağlam içinde uzun ömürlü yapılar olarak yer edinmesini sağlamaktadır.

Bu yapıların planlama süreçleri, yalnızca hızlı kurulum değil, aynı zamanda mekânsal kalite, kullanıcı konforu ve sürdürülebilirlik ölçütleri doğrultusunda şekillendirilmelidir. Nitelikli uygulamalara bakıldığında, Endonezya'da bir deprem sonrası inşa edilen modüler okul prototipi "plug-and-play" ilkesine dayanan birleştirilebilir modül sistemlerinin, kalıcı kullanım niteliğine sahip kaliteli öğrenme ortamları oluşturduğunu doğrulamaktadır (Yatmo vd. 2020). Bu prototipte, yerel malzeme kullanımı, iklime uygun tasarım ve modüler üretim stratejileri başarıyla bütünleştirilmiştir. Sürdürülebilirlik açısından, endüstriyel üretim süreçleri ile şekillenen bu yapılar, yaşam döngüsü boyunca daha düşük enerji tüketimi, daha az atık üretimi ve malzeme geri kazanımı gibi avantajlar sunmaktadır. Pons ve Wadel (2011), Katalonya'daki 200'den fazla okulun prefabrik sistemlerle inşa edildiğini ve bu yapıların hem kaynak kullanımını azalttığını hem de geri dönüştürülebilirliğe olanak sağladığını vurgulamaktadır

Ergun, Kutlu ve Bekar (2024), 6 Şubat 2023 depremlerinin ardından Diyarbakır'da örneklenen bir prefabrik okul yapısı üzerinden gerçekleştirilen değerlendirmeleri ile eğitim amaçlı kullanılan prefabrik yapıların yalnızca kısa vadeli acil müdahale çözümleri olarak değil, aynı zamanda uzun vadeli sürdürülebilirlik hedefleri doğrultusunda da ele alınması gerektiğini vurgulamaktadır. Bu yapıların malzeme seçimi, enerji verimliliği, iç mekân kalitesi ve çevresel etkiler bakımından çok boyutlu analizlerle irdelenmesi gerektiğini ortaya koymaktadır. Bu durum, afet sonrası yeniden yapılanma süreçlerinde eğitim yapılarının yalnızca hızlı üretim süreci ile değil, aynı zamanda sürdürülebilir performans kriterleriyle bütüncül bir şekilde tasarlanmasının önemine işaret etmektedir.

Çalışma kapsamında Hatay'da gerçekleştirilen ön üretimli anaokulu projesi, yukarıda belirtilen ilkesel çerçeveler doğrultusunda ele alınmış, afet sonrası hızlı müdahale gerekliliği ile uzun vadeli sürdürülebilirlik hedefleri arasında bir denge kurma potansiyeli üzerinden değerlendirilmiştir. Proje, yalnızca yapım süreci ve taşıyıcı sistem açısından değil; aynı zamanda kullanıcı konforu, mekânsal süreklilik, çevresel uyum ve sosyal bütünleşme gibi çok

boyutlu parametreler temelinde incelenerek, afet sonrası eğitim yapılarının tasarımında yeni açılımlar sunmayı amaçlamaktadır.

YÖNTEM

Bu çalışma, afet sonrası eğitim yapılarında kullanılan ön üretimli sistemleri yapım tekniği, malzeme kullanımı ve mekânsal organizasyon açısından değerlendiren nitel bir araştırmadır. Yöntemde, vaka analizi yaklaşımı benimsenmiş; Türkiye'de 2023 Kahramanmaraş depremleri sonrasında Hatay'da uygulanan ön üretimli anaokulu yapısı örneklem olarak seçilmiştir.

Çalışma iki temel aşamadan oluşmaktadır. İlk aşamada, uluslararası literatür taraması yapılarak dünya genelinde afet sonrası inşa edilen modüler okul yapıları incelenmiş; özellikle Endonezya, İspanya ve Japonya gibi afet riski yüksek ülkelerdeki uygulamalardan elde edilen bulgular doğrultusunda değerlendirme kriterleri oluşturulmuştur. Böylece, dünyadaki eşdeğer örnekler ışığında vaka analizi yöntemiyle örnek ön üretimli yapı uygulaması bütüncül olarak irdelenmiştir.

İkinci aşamada ise, Hatay'daki yapıya ilişkin proje dokümantasyonları, saha gözlemleri ve teknik veriler üzerinden detaylı analiz yapılmıştır. Bu kapsamda yapının taşıyıcı sistemi, üretim ve montaj süreci, kullanılan yapı malzemeleri ve mekânsal kurgusu değerlendirilmiş; elde edilen bulgular literatürde tanımlanan kriterlerle karşılaştırılmıştır.

Çalışmanın genel amacı, afet sonrası süreçlerde hız, dayanıklılık ve sürdürülebilirlik dengesi kurabilen ön üretimli yapı sistemlerinin mekânsal ve teknik düzeyde nasıl işlediğini örnek bir uygulama üzerinden ortaya koymak ve benzer projeler için yol gösterici değerlendirmeler sunmaktır.

Ön Üretimli Yapım Teknikleri ve Afet Sonrası Uygulamalarda Kullanımı

Afet sonrası yapılaşma süreçlerinde ön üretimli yapım sistemleri, zaman, maliyet ve kaynak etkinliği gibi avantajları sayesinde öncelikli tercihler arasında yer almaktadır. Bu yapım teknikleri, yapı elemanlarının fabrika ortamında standartlara uygun şekilde üretilip sahada birleştirilmesini esas alır. Eğitim yapıları gibi kamusal kullanım amaçlı binalarda bu sistemlerin kullanımı, hem yapım sürecini hızlandırmakta hem de geçici çözümlerle konvansiyonel yapılardaki işleyişin işlevsel sürekliliğini sağlamaktadır.

Uğurlu (2020), ön üretimli yapıların deprem sonrası krizlerde barınma, eğitim ve sağlık yapıları için en uygun çözümlerden biri olduğuna dikkat çekmektedir. Özellikle eğitim gibi sürekliliği önemli olan alanlarda bu sistemler, hem zaman hem de kaynak tasarrufu sağlar.

Erken çocukluk eğitimi verilen anaokulu gibi yapılarda, mekânsal esneklik, doğal aydınlatma ve havalandırma, akustik konfor ve güvenli tahliye gibi tasarım parametreleri öncelik kazanır. Modüler okul yapı birimlerinin iç mekân standardizasyonu ve genişletilebilirliği sayesinde farklı büyüklükteki arsalara kolayca uyarlanabildiğini ve pedagojik standartlara uygun bir eğitim ortamı sunmaktadır (Ahmed, 2024).

Ön üretimli yapım sistemleri genel olarak panel sistemleri, modüler birimler, hafif çelik karkas sistemler ve konteyner tabanlı yapılar olmak üzere çeşitlenmektedir. Panel sistemlerinde duvar, döşeme ve çatı elemanları ayrı ayrı üretilerek sahada birleştirilirken, modüler sistemlerde tam donanımlı hacimler blok hâlinde taşınarak yerinde birleştirilir. Hafif çelik sistemler ise hem taşıyıcı hem de kaplama malzemeleri açısından hızlı montajı destekler. Konteyner sistemleri, özellikle afet sonrası ilk müdahale dönemlerinde geçici okul ya da sağlık birimleri için esnek kullanım olanağı oluşturur (Pons & Wadel, 2011). Ön üretimli yapılar farklı uygulama teknikleri ve farklı malzeme türleri ile oluşturulabilmektedir (Şekil 1).



Fig. 1. Farklı malzeme seçenekleri ve farklı yapı bileşenleri ile oluşturulmuş ön üretimli okul uygulamaları (Carissa vd., 2025)

Karkas konstrüksiyon, betopan panel gibi sistemlerle bütünleşen ön üretimli yapılar, ayrıca enerji verimliliği ve taşıyıcılık açısından da avantaj sağlamaktadır (Demir ve Yıldız, 2019). Ön üretimli yapım sistemlerinde kullanılan malzeme türleri, yapının işlevine, taşıyıcı sistem gereksinimlerine, iklim koşullarına ve yeniden kullanılabilirlik hedeflerine göre çeşitlilik göstermektedir. Ahşap, çelik ve beton (özellikle prekast biçiminde) en yaygın kullanılan temel malzeme türleridir. Bu malzemeler, hem yapım süreci hem de kullanım performansı açısından çeşitli avantajlar sunmaktadır.

Afet sonrası eğitim yapılarında ön üretimli sistemlerin kullanımı yalnızca hızlı müdahale açısından değil, pedagojik, çevresel ve sosyo-kültürel sürdürülebilirlik açısından da stratejik bir fırsat sunmaktadır. Bu nedenle tasarım süreci, sadece yapı teknolojisine değil, aynı zamanda eğitsel içerik, çocuk güvenliği, toplumsal psikoloji ve çevresel koşullar gibi çok boyutlu etkenlere bağlıdır. Ön üretimli yapıların sahada konvansiyonel inşa yöntemlerine göre avantajları bulunmaktadır (Tablo 1).

Tablo 1. Konvansiyonel yapım teknikleri ile ön üretimli yapım teknikleri karşılaştırması

Özellik	**Konvansiyonel Yapım Teknikleri**	**Ön Üretimli Yapım Teknikleri**
İnşaat Süresi	Uzun	Kısa
Maliyet	Yüksek	Orta / Düşük
Depreme Dayanıklılık	Değişken (eski yapı zayıf)	Yüksek
Kalite Kontrolü	Sahada, sınırlı	Fabrikada, yüksek denetim
Kurulum Hızı	Yavaş	Çok hızlı
Geri Dönüşüm / Modülerlik	Düşük	Yüksek
Malzeme İsrafı	Fazla	Az
Taşınabilirlik	Yok / Zor	Kolay / Modüler
Hızlı Eğitim Devamlılığı	Zor	Mümkün
Enerji Verimliliği	Orta / Düşük	Yüksek
Afet Sonrası Psikolojik Etki	Belirsiz	Güven hissi sağlar
Yaygınlaştırılabilirlik	Zor	Kolay

Hatay Anaokulu Projesi

2023 Kahramanmaraş merkezli depremlerin ardından bölgede ortaya çıkan eğitim ihtiyacını karşılamak amacıyla hayata geçirilen Hatay Anaokulu Projesi,İnce Prefabrik ve Alp Prefabrik

yürütücülüğünde tasarlanmış ve uygulanmıştır. Hatay/Samandağ/Tomruksuyu Mahallesinde uygulanan bu proje, 2023 depremlerinin ardından bölgede ortaya çıkan eğitim ihtiyacına hızlı ve güvenli bir çözüm sunmak amacıyla tasarlanmıştır. Projede, çocukların fiziksel ve psikolojik güvenliği ön planda tutulmuş; doğal aydınlatma, acil tahliye senaryoları, oyun alanları ve eğitim birimleri gibi unsurlar modüler sistemle entegre edilmiştir.



Fig. 2. Montajı Tamamlanmış Kullanıma Hazır Hali (Gamzenur Cüre arşivi)

Yapı yaklaşık 345 metrekare kapalı alana sahiptir. Mekânsal organizasyon çocukların pedagojik ve güvenlik ihtiyaçlarına yanıt verecek şekilde şekillendirilmiştir. Planda 6 derslik, 1 çok amaçlı salon, öğretmenler odası, idari birim, mutfak, lavabo alanları ve oyun bahçesine açılan dolaşım alanları yer almaktadır (Fig. 2).

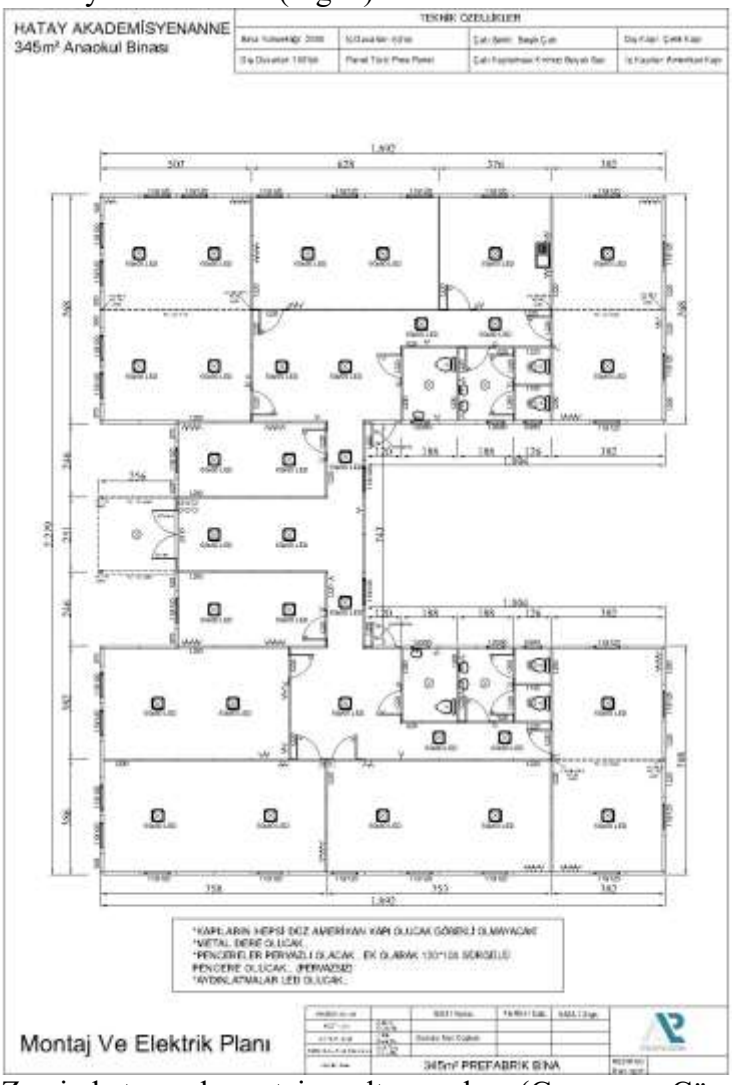

Fig. 3. Zemin kat panel montaj ve altyapı planı (Gamzenur Cüre arşivi)

Yapı sistemi olarak hafif çelik konstrüksiyon tercih edilmiştir. Taşıyıcı aks sistemi 120 cm modül aralığına göre düzenlenmiş ve bu modüler kurguya uygun şekilde duvar panelleri,

döşeme ve çatı elemanları önceden üretilmiştir (Fig. 3). Dış cephede ısı yalıtımı sağlayan betopan paneller kullanılırken; iç mekânda alçıpan bölücü duvarlar tercih edilmiştir. Elektrik ve mekanik altyapı bileşenleri ile birlikte üretimi fabrikada tamamlanan yapı, sahaya taşınarak yalnızca 21 gün içinde kurulmuş ve kullanıma açılmıştır. Bu proje, afet sonrası dönemde çocuklar için güvenli, sağlıklı ve hızlı erişilebilir eğitim ortamı oluşturma hedefini taşıyan nitelikli bir uygulama örneği olarak değerlendirilmektedir.

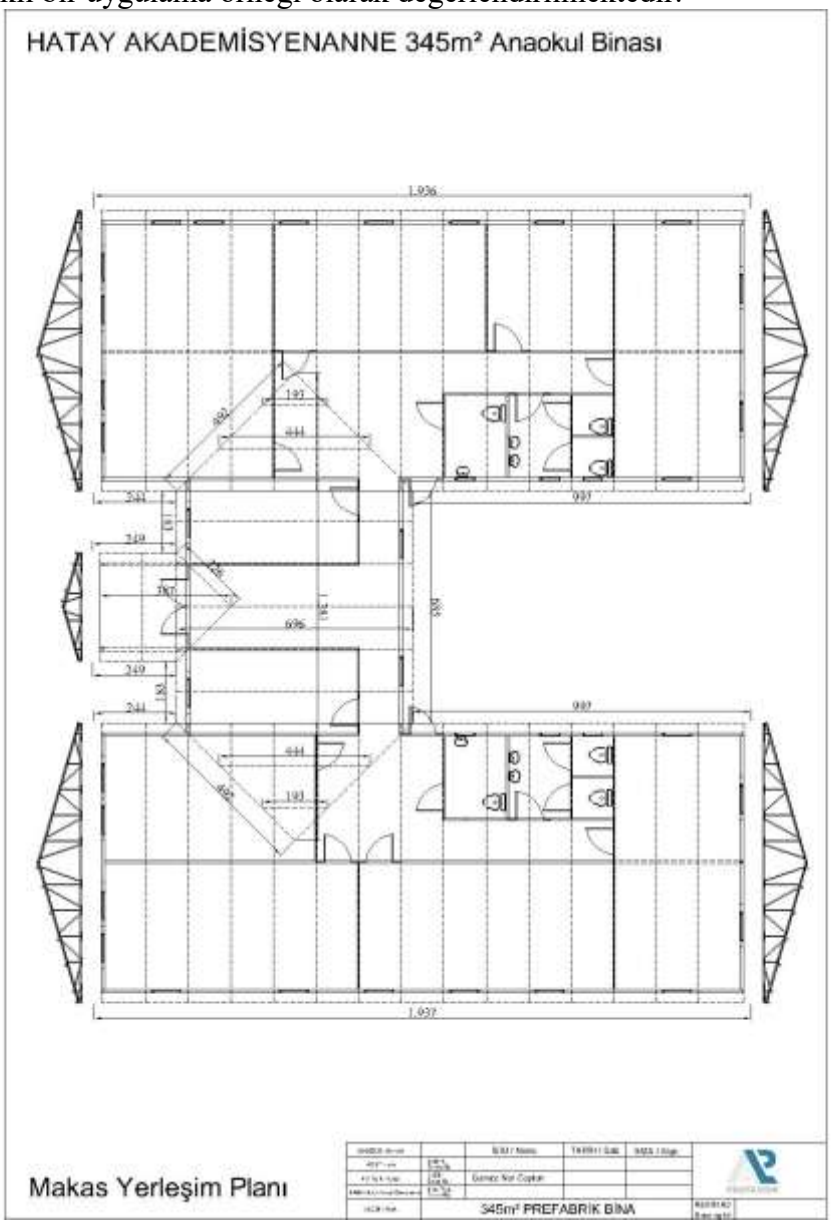

Fig. 4. Modül dağılımı ve çatı makası yerleşim planı (Gamzenur Cüre arşivi)

BULGULAR

Hatay'da gerçekleştirilen ön üretimli anaokulu projesi kapsamında elde edilen bulgular, yapı sisteminin afet sonrası müdahaleye uygunluğu, kullanıcı deneyimi, enerji verimliliği ve kurulum hızı başlıkları altında değerlendirilmiştir.

İlk olarak, projenin **kurulum süreci** incelenmiştir. Hafif çelik taşıyıcı sistem ve karkaslı panel dış cephe malzemeleri sayesinde yapı, saha hazırlığından tam faaliyete geçişine kadar olan tüm süreçte toplam **21 gün içerisinde** tamamlanmıştır. Arazi hazırlığı 3 gün, modüllerin sevkiyatı ve yerleştirilmesi 2 gün, ana konstrüksiyon montajı 8 gün, elektrik ve su tesisatı 4 gün ve iç mekân donatımı 4 gün sürmüştür. Bu süre, geleneksel betonarme bir eğitim yapısıyla

kıyaslandığında en az **%60 oranında zaman kazancı** anlamına gelmektedir. Özellikle afet sonrası acil müdahale gereken bir ortamda bu süre, projenin en önemli avantajlarından biri olarak değerlendirilmiştir.
Yapı sisteminin **mühendislik değerlendirmesi** sonucunda da yüksek performans gösterdiği görülmüştür. Bağımsız mühendislik denetimleri, taşıyıcı sistemlerin mevcut deprem yönetmeliğine %100 uyumlu olduğunu raporlamıştır. Ayrıca yapı elemanlarının sismik dayanıklılığı, zeminle olan uyumu ve bağlantı detaylarının güvenli biçimde tamamlandığı belirtilmiştir. Kurulum sürecinde yapılan testler sonucunda, su yalıtımı, rüzgar dayanımı ve acil tahliye yollarının kullanıma hazır durumda olduğu onaylanmıştır.
Tüm bu bulgular, afet sonrası eğitim yapılarında ön üretimli sistemlerin sunduğu somut avantajları ortaya koymaktadır. Zaman, maliyet, güvenlik, enerji verimliliği ve kullanıcı memnuniyeti gibi kriterler göz önüne alındığında, Hatay Anaokulu Projesi başarılı bir örnek olarak değerlendirilmektedir.

SONUÇ

Bu çalışmada, Türkiye'nin deprem gerçeği karşısında hızlı, güvenli ve sürdürülebilir çözümler sunan ön üretimli yapı sistemlerinin potansiyeli detaylı bir biçimde ele alınmıştır. Özellikle 6 Şubat 2023 depremleri sonrasında büyük yıkım yaşayan Hatay ilinde hayata geçirilen anaokulu projesi üzerinden yapılan değerlendirmeler, bu sistemlerin afet sonrası yeniden yapılanma süreçlerinde ne denli kritik bir rol üstlendiğini ortaya koymuştur.
Ön üretimli yapı sistemlerinin sunduğu en önemli avantajlardan biri, **zaman yönetimi** konusundaki etkinliğidir. Saha koşullarından büyük ölçüde bağımsız olarak fabrikada üretilen elemanların sahaya hızlı ve güvenli şekilde monte edilmesi sayesinde, eğitimin kesintiye uğramaması sağlanabilmiştir. Geleneksel sistemlerle haftalar hatta aylar sürebilecek olan kurulum süreci, bu projede yalnızca 3 hafta içinde tamamlanmış, çocukların yeniden güvenli bir eğitim ortamına kavuşması sağlanmıştır.
Projenin sunduğu bir diğer önemli katkı ise **toplumsal iyileşme sürecine olan desteğidir.** Özellikle küçük yaş gruplarının eğitim gördüğü yapılar, sadece fiziksel mekânlar değil, aynı zamanda psikolojik güvenlik alanlarıdır. Anaokulu projesinde kullanılan modüler tasarım ilkeleri ve insan odaklı yaklaşım sayesinde, hem çocuklar hem de aileler için yeniden aidiyet hissi oluşturulmuştur.
Enerji verimliliği ve **sürdürülebilirlik** açısından da ön üretimli sistemlerin klasik yapı çözümlerine göre daha avantajlı olduğu gözlemlenmiştir. Gerek kullanılan yalıtım malzemeleri gerekse doğayla uyumlu planlama, hem enerji tüketimini azaltmış hem de karbon ayak izini düşürmüştür. Bu durum, yapıların sadece acil durumlara değil, uzun vadeli çevresel hedeflere de hizmet edebileceğini göstermektedir.
Ayrıca, proje sürecinde yapılan mühendislik testleri, ön üretimli yapıların **teknik yeterliliği kadar kullanıcı memnuniyetini de sağlamıştır**. Bu tür yapılar, sadece geçici çözümler değil, kalıcı ve sürdürülebilir kamu yapıları olarak değerlendirilmelidir.
Sonuç olarak, Hatay'da gerçekleştirilen bu ön üretimli anaokulu projesi, **afet sonrası mimarlık** alanında hem fiziksel hem de sosyal sürdürülebilirliğe katkı sağlayan bütüncül bir örnek olarak öne çıkmaktadır. Benzer afet riskine sahip bölgelerde, kamu kurumları ve yerel yönetimler için yol gösterici bir model teşkil edebileceği gibi, eğitim yapılarının dayanıklılık ve erişilebilirlik standartlarını yeniden tanımlamak için de fırsat sunmaktadır. Bu bağlamda, ön üretimli yapı sistemlerinin yaygınlaştırılması, sadece afet sonrası değil, geleceğe dönük kentsel planlama stratejilerinde de önemli bir yer tutmalıdır.

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FROM CEASEFIRE TO CRISIS: THE UNFOLDING OF RECENT VIOLENCE IN GAZA

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Abstract
This research paper examines the progression from relative calm to renewed hostilities in Gaza, analyzing the socio-political, military, and humanitarian dynamics that underlie the recent escalation of violence. Drawing on a multidisciplinary approach grounded in qualitative content analysis of reports, media narratives, the study explores how fragile ceasefires collapse under sustained political tensions, external provocations, and internal pressures. The paper investigates the role of regional actors, shifting alliances, and the impact of unresolved grievances on the cycle of conflict. It also highlights the disproportionate effects on civilians, particularly children and displaced populations, in light of international humanitarian law. The findings point to the inadequacy of current diplomatic interventions and stress the need for a more inclusive peace framework that addresses root causes rather than symptoms. This research contributes to broader discussions on conflict resolution, accountability, and the limitations of ceasefire agreements in protracted territorial conflicts.
Keywords: Gaza conflict, ceasefire breakdown, Middle East politics, humanitarian crisis, international law, armed violence.

GENETIC ENGINEERING OF TOMATOES FOR ENHANCED NUTRIENT CONTENT

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Abstract:
Genetic engineering has emerged as a powerful tool in enhancing the nutritional profile of tomatoes (Solanum lycopersicum), a globally important fruit crop known for its health-promoting phytochemicals. Traditional breeding methods have achieved limited success in significantly increasing nutrient content due to complex genetic traits and long breeding cycles. Through genetic modification, specific genes involved in biosynthetic pathways of vital nutrients—such as vitamins, minerals, amino acids, and antioxidants—can be directly manipulated to achieve targeted enhancement. Notably, biofortification efforts have focused on increasing lycopene, beta-carotene (provitamin A), folate, and vitamin C levels in tomatoes. For instance, overexpression of genes like phytoene synthase and desaturase has resulted in significant elevation of carotenoid content, especially lycopene and beta-carotene, which are known for their antioxidant and vision-protective properties. Additionally, metabolic engineering has enabled the synthesis of novel compounds such as flavonoids and polyphenols that are not naturally abundant in tomatoes. CRISPR/Cas9 technology has further revolutionized this field by allowing precise and efficient genome editing with minimal off-target effects. These nutritionally enhanced tomatoes not only offer health benefits to consumers but also hold potential to address micronutrient deficiencies in populations at risk. However, challenges remain in regulatory approvals, public acceptance, and ensuring environmental biosafety. Continued research and transparent communication are essential to harness the full potential of genetic engineering in improving the nutritional quality of tomatoes while maintaining consumer trust and ecological balance.
Keywords: Genetic engineering, Tomatoes, Nutrient enhancement, Lycopene, Biofortification, CRISPR/Cas9.

NATURAL MODULATION OF THE GUT MICROBIOTA IN PATIENTS WITH FOOD ALLERGIES. IMPACT OF ALERGIPLANT

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ABSTRACT

Background Dysbiosis or microbial imbalance, can predispose individuals to allergies, while a balanced gut microbiome, fosters immune tolerance. The immune mechanisms involved in food allergies are complex and little is known about the possible role of the gut microbiota in the aetiopathogenesis of food allergies.

Objective Alergiplant could modulate the immune system through gut microbiota in food allergies. Advancing knowledge of the gut microbiome and its function in modulating the course of food allergies, might result in novel therapeutic strategies.

Materials and methods The evaluation of the patients was based on history and physical examination. We investigated the effect Alergiplant in patients with food allergies.

Results Environmental factors such as urbanisation, pollution, and dietary habits also significantly contribute to food allergies risk. It is not clear whether microbial change in food allergies is an outcome of barrier defect or the cause of barrier dysfunction and inflammation. Manipulation of the gut microbiota as a method for modifying atopy, may be attempted in many ways including avoidance of certain foods, supplementation with probiotics and prebiotics, optimising nutrient intake, minimising stress, antimicrobial therapy, correction and prevention of low stomach acid, and faecal microbiota transplantation.

Conclusion The resident microbiota is important in maintaining structural and functional integrity of the gut and in immune system regulation. There was an increase of the intestinal permeability reported in patients with food allergies and a reduction of the gut microbiome diversity. Modifying gut microbiome by applying Alergiplant during early years may be a preventive and therapeutic option in high risk groups.

Keywords: food allergies, host-microbiome interaction; immune regulation; Alergiplant

GREEN CHEMISTRY IN PHARMACEUTICAL SYNTHESIS

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ABSTRACT

Green chemistry has emerged as a transformative approach in pharmaceutical synthesis, aiming to minimize environmental impact, enhance process efficiency, and improve safety throughout the drug development lifecycle. By emphasizing the use of renewable resources, reduction of hazardous substances, and energy-efficient processes, green chemistry aligns with sustainable development goals and regulatory expectations. In pharmaceutical synthesis, traditional methods often involve toxic solvents, excess reagents, and generate significant waste, contributing to environmental and health hazards. Green chemistry principles promote alternative synthetic pathways such as solvent-free reactions, biocatalysis, microwave-assisted synthesis, and flow chemistry, which offer cleaner, safer, and more cost-effective production. Additionally, the adoption of atom economy, catalytic over stoichiometric reagents, and non-toxic raw materials contributes to more sustainable processes. The implementation of green solvents like supercritical CO_2, water, and ionic liquids has further advanced eco-friendly practices. Pharmaceutical companies are increasingly investing in green technologies not only to comply with environmental regulations but also to reduce production costs and improve public perception. Moreover, life-cycle assessment (LCA) tools are being employed to evaluate the environmental footprint of drug synthesis and guide greener alternatives. Despite the challenges of scaling up green processes and initial costs, the long-term benefits in terms of sustainability, safety, and efficiency make green chemistry an essential paradigm in the pharmaceutical industry. Its integration into research and manufacturing promises a future of cleaner, safer, and more responsible drug production.

Keywords: Green chemistry, pharmaceutical synthesis, sustainable processes, eco-friendly solvents, biocatalysis

HETEROCYCLIC COMPOUNDS IN DRUG DESIGN

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ABSTRACT:
Heterocyclic compounds play a fundamental role in modern drug design and medicinal chemistry, forming the core structure of a vast majority of therapeutic agents. Characterized by rings containing at least one heteroatom such as nitrogen, oxygen, or sulfur, these compounds exhibit diverse chemical reactivity and biological activity, making them ideal scaffolds for drug development. Their unique electronic, steric, and hydrogen-bonding properties contribute to strong interactions with biological targets such as enzymes, receptors, and nucleic acids. Common heterocycles like pyridine, imidazole, indole, thiazole, and quinoline are found in drugs treating a wide range of conditions, including cancer, infections, cardiovascular diseases, and neurological disorders. Advances in synthetic methodologies, including metal-catalyzed reactions, multicomponent reactions, and green chemistry techniques, have facilitated the efficient and selective synthesis of complex heterocyclic frameworks. Furthermore, structure–activity relationship (SAR) studies have highlighted how subtle modifications to heterocyclic rings can significantly impact pharmacokinetic and pharmacodynamic properties. Heterocycles are also crucial in the design of prodrugs and targeted delivery systems. As drug resistance and unmet medical needs persist, novel heterocyclic scaffolds continue to be a rich source of innovation in pharmaceutical research. With the integration of computational drug design, high-throughput screening, and AI-driven approaches, the exploration of heterocyclic chemistry is expected to yield the next generation of safer, more effective therapeutic agents.
Keywords: Heterocyclic compounds, drug design, medicinal chemistry, bioactive scaffolds, synthetic methods

HIV (HUMAN IMMUNODEFICIENCY VIRUS)

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Abstract:
Human Immunodeficiency Virus (HIV) is a retrovirus that targets the immune system, primarily CD4+ T cells, leading to progressive immune suppression and increasing susceptibility to opportunistic infections and certain cancers. Without treatment, HIV infection can progress to Acquired Immunodeficiency Syndrome (AIDS), the most advanced stage of the disease. Transmission occurs through unprotected sexual contact, sharing of contaminated needles, mother-to-child transmission, and transfusion of infected blood products. Diagnosis is typically confirmed through serological tests, including ELISA and Western blot or rapid diagnostic tests, followed by nucleic acid testing for viral load monitoring. Antiretroviral therapy (ART) has transformed HIV from a fatal illness into a manageable chronic condition, significantly reducing morbidity and mortality. Despite advances in treatment and prevention, including pre-exposure prophylaxis (PrEP), global challenges remain, particularly in resource-limited settings. Continued efforts in public health education, stigma reduction, and vaccine development are essential to achieving the goal of ending the HIV epidemic

Keywords
- HIV
- Human Immunodeficiency Virus
- AIDS
- Acquired Immunodeficiency Syndrome
- HIV-1
- HIV-2
- Retrovirus
- CD4+ T cells
- Viral load
- Immunosuppression

Introduction

Human Immunodeficiency Virus (HIV) is a chronic viral infection that continues to pose a major global health challenge. Discovered in the early 1980s, HIV attacks the immune system, specifically targeting CD4+ T lymphocytes, leading to immune deficiency. Without treatment, HIV infection can progress to Acquired Immunodeficiency Syndrome (AIDS), the most severe phase of the disease. Over the past four decades, the global response to HIV has included advancements in treatment, prevention, and public health education. However, disparities in access to care and persistent social stigma continue to hinder global eradication efforts.

Virology and Pathophysiology

HIV is a retrovirus belonging to the **Lentivirus** genus. It has two main types: **HIV-1**, the most prevalent and pathogenic, and **HIV-2**, which is less transmissible and mainly found in West Africa.

Once inside the body, HIV binds to CD4 receptors on T-helper cells and co-receptors (CCR5 or CXCR4). The virus uses reverse transcriptase to convert its RNA into DNA, which

integrates into the host genome. This integration allows the virus to replicate within host cells, ultimately leading to a decline in CD4+ cells and weakening of the immune system.

Transmission
HIV is transmitted through the exchange of specific body fluids, including:

- **Unprotected sexual contact**
- **Sharing of needles or syringes**
- **Mother-to-child transmission** during childbirth or breastfeeding
- **Blood transfusion** with infected blood (less common today due to screening)

It is important to note that HIV is **not transmitted** through casual contact, hugging, kissing, or sharing utensils.

Stages of HIV Infection
HIV progresses through three main stages:

1. **Acute HIV Infection**: Occurs 2–4 weeks after exposure; symptoms may resemble flu (fever, sore throat, rash).
2. **Chronic HIV Infection (Clinical Latency)**: The virus remains active but reproduces at low levels; can last for several years.
3. **Acquired Immunodeficiency Syndrome (AIDS)**: CD4+ count falls below 200 cells/mm³ or opportunistic infections/cancers develop. This is the final and most severe stage of HIV.

Diagnosis
HIV is diagnosed through a combination of tests:

- **Antibody/Antigen tests** (e.g., ELISA)
- **Rapid diagnostic tests**
- **Nucleic acid tests (NAT)** to detect viral RNA
- **CD4 count** and **HIV viral load** to monitor disease progression

Early detection is crucial for timely treatment and preventing transmission.

Treatment and Management
There is no cure for HIV, but **antiretroviral therapy (ART)** can effectively suppress the virus. ART involves a combination of drugs that:

- Inhibit reverse transcriptase, protease, integrase, or fusion
- Maintain viral suppression
- Restore and preserve immune function

With consistent ART, individuals with HIV can live long, healthy lives and reduce their viral load to undetectable levels, making sexual transmission virtually impossible—a concept known as **U=U (Undetectable = Untransmittable)**.

Prevention Strategies
1. Safe Sex Practices

- Condom use
- Regular testing and communication with partners

2. Pre-exposure Prophylaxis (PrEP)

- Daily medication (e.g., Truvada or Descovy) for HIV-negative individuals at high risk

3. Post-exposure Prophylaxis (PEP)

- Emergency treatment started within 72 hours of potential exposure

4. Harm Reduction

- Needle exchange programs

- Safe injection practices

Prevention of Mother-to-Child Transmission (PMTCT)

- ART during pregnancy, safe delivery, and avoiding breastfeeding (in some contexts)

Social and Psychological Impact

Despite medical advancements, people living with HIV (PLHIV) often face **stigma, discrimination, and mental health challenges**. Stigma can lead to social isolation, delays in testing, and reduced adherence to treatment.

Education campaigns, support groups, and advocacy efforts are crucial to fostering acceptance and improving mental and social outcomes for affected individuals.

Global Burden and Response

As of recent data:

- Approximately **39 million** people live with HIV worldwide.
- Over **75 million** people have been infected since the start of the epidemic.
- Sub-Saharan Africa bears the highest burden, accounting for over 60% of global cases.

International initiatives such as **UNAIDS' 95-95-95 goals** aim to ensure:

- 95% of people with HIV know their status
- 95% of those diagnosed are on treatment
- 95% of those treated achieve viral suppression

Research and Future Directions

Scientific research is focused on:

- **HIV vaccine development**
- **Functional and sterilizing cures**
- **Long-acting injectable ART**
- **Gene editing techniques** like CRISPR to target latent viral reservoirs

Though promising, these developments require extensive clinical trials and long-term studies before wide implementation.

Conclusion

HIV remains a major public health concern, but with effective antiretroviral therapy and comprehensive prevention strategies, it is now a manageable chronic condition rather than a death sentence. Early diagnosis, universal access to treatment, and continued education are essential for controlling the epidemic. Eliminating stigma, addressing global health disparities, and investing in research for a cure are critical steps toward ending the HIV epidemic and ensuring a healthier, more inclusive future for all

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IN VITRO-IN VIVO CORRELATION (IVIVC) IN DRUG DEVELOPMENT

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Abstract :
In Vitro-In Vivo Correlation (IVIVC) plays a pivotal role in modern drug development by establishing a predictive relationship between in vitro drug release profiles and in vivo pharmacokinetic performance. IVIVC serves as a vital tool for formulating controlled-release dosage forms, optimizing bioavailability, and minimizing the need for extensive clinical trials. By correlating dissolution data with absorption characteristics, IVIVC facilitates better understanding of drug behavior in the human body, thereby improving formulation design and regulatory compliance. The Biopharmaceutics Classification System (BCS) provides a framework for developing IVIVC, particularly for BCS Class I and Class II drugs, which exhibit high permeability and variable solubility. Level A correlation, the most robust form, establishes a point-to-point relationship and is often used to justify post-approval changes in formulations without the need for additional in vivo studies. The successful application of IVIVC can significantly reduce development costs, accelerate time-to-market, and support biowaivers. However, developing a reliable IVIVC model requires careful selection of dissolution methods, physiological relevance, and pharmacokinetic modeling techniques. Limitations include difficulties in correlating drugs with complex absorption patterns or site-specific delivery. Despite these challenges, IVIVC remains a powerful tool in pharmaceutical research, allowing for informed decision-making during formulation optimization and regulatory submissions. With advancements in modeling software and mechanistic understanding, IVIVC continues to evolve as an integral component of drug development and quality assurance.

Keywords:
In Vitro-In Vivo Correlation (IVIVC), drug development, bioavailability, dissolution, pharmacokinetics, controlled release, Biopharmaceutics Classification System (BCS), Level A correlation.

INFLUENCE OF TECHNOLOGY INCUBATION SUPPORT SERVICES ON THE GROWTH AND SUSTAINABILITY OF SMALL-SCALE ENTERPRISES IN KANO STATE, NIGERIA

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Abstract
Technology Incubation Centres (TICs) play a vital role in fostering sustainable entrepreneurship through the promotion and support of Small-Scale Enterprises (SSEs). In Nigeria, the government has established TICs as part of its strategy to enhance the entrepreneurial ecosystem and drive innovation. Despite these efforts, the Small and Medium Scale Enterprises Development Agency (SMEDAN) reported in 2023 that 80% of SSEs fail before their fifth anniversary, primarily due to lack of access to capital and poor business practices. This study investigates the effect of technology incubation support services on the sustainability of small-scale enterprises in Kano State. Anchored on the ***Resource-Based View (RBV) theory,*** *the study adopts a* ***cross-sectional survey design*** *with a* ***quantitative approach,*** *targeting a population of 107 SSEs selected using a* ***census-based sampling technique.*** *Data were collected using a structured, 5-point Likert scale questionnaire and analyzed using both descriptive and inferential statistics, specifically* ***Structural Equation Modeling - Partial Least Squares (SEM-PLS) Version 4,*** *at a 95% confidence level. Findings revealed that* ***technical support services*** *and* ***business support services*** *had positive but* ***statistically insignificant effects*** *on the sustainability of SSEs, with t-statistics of 1.62 ($p = 0.104$) and 1.13 ($p = 0.256$), respectively. In contrast,* ***network support services*** *showed a* ***positive and statistically significant effect****, with a t-statistic of 4.658 and a p-value of 0.000 ($p < 0.05$). These results suggest that while technical and business support services offer some benefit, their current design and delivery are insufficiently aligned with the actual needs of enterprises. The study concludes that enhancing the* ***quality, relevance and accessibility*** *of technical and business support services could significantly improve their impact on enterprise sustainability within the incubation ecosystem.*
Keywords: *Technology incubation, business support, network opportunities, sustainability, mentorship*

Introduction

Small-scale enterprises (SSEs) play a vital role in the socio-economic development of Nigeria. They are instrumental in fostering entrepreneurship, generating employment, promoting innovation, and stimulating inclusive economic growth. In a commercial hub like Kano State, SSEs represent a significant segment of the informal and formal economy, contributing meaningfully to household income and local industrialization. However, the sustainability of these enterprises remains a major concern, as many struggle to survive beyond their initial years of establishment.

In recognition of the pivotal role of small enterprises and the challenges they face, the Federal Government of Nigeria, through the National Board for Technology Incubation (NBTI), established Technology Incubation Centres (TICs) to support early-stage businesses, particularly those with technological or innovative orientations. These incubation programmes are designed to provide technical support, business advisory services, market linkage, and access to innovation ecosystems that enhance the survival and competitiveness of small enterprises.

Despite the presence of these initiatives, the actual impact of technology incubation support services on the sustainability of SSEs remains insufficiently examined, particularly within the socio-economic context of Kano State. Sustainability, in this regard, refers not only to the ability of enterprises to continue operations over time but also to their capacity to grow, adapt, and contribute to broader development goals.

There is a growing body of literature on business incubation globally; however, empirical evidence focusing on the effectiveness of incubation services in the Nigerian context, especially in northern Nigeria, is still limited. This gap necessitates a localized investigation into how technology incubation support services influence the sustainability of SSEs in Kano State. The study seeks to evaluate the extent to which technical, business and network support services contribute to the long-term viability of small-scale enterprises.

Statement of the Research Problem

The persistent mortality rate of small-scale enterprises in Nigeria, despite the establishment of support systems such as Technology Incubation Centres (TICs), raises critical questions about the effectiveness of such interventions. In Kano State, where SSEs are essential to economic development, a considerable number of these enterprises either stagnate or cease operations within a few years of establishment. This trend undermines efforts aimed at industrial development, poverty reduction, and employment creation.

Technology incubation programmes are intended to address the core constraints facing small enterprises namely, limited technical expertise, lack of structured business support, weak innovation capacity, and poor access to networks and markets. However, anecdotal evidence and preliminary observations suggest a misalignment between the services provided by incubation centres and the actual needs of the enterprises they serve. Moreover, there is insufficient empirical data on how different dimensions of incubation support—technical, business, and network services—affect the long-term sustainability of these firms.

Without a clear understanding of the effectiveness and responsiveness of these services, policymakers and programme implementers may continue to invest in models that yield limited developmental impact. Therefore, a rigorous inquiry is necessary to assess the influence of technology incubation support services on the sustainability of SSEs in Kano State, identify gaps in service delivery, and propose strategic recommendations for enhancing enterprise resilience and growth.

Objectives of the Study

The aim of this study is to examine the effect of technology incubation support services on the sustainability of small-scale enterprises in Kano State, Nigeria. The specific objectives are to:

1. Assess the effect of technical support services on the sustainability of small-scale enterprises in Kano State.
2. Evaluate the extent to which business support services influence the sustainability of small-scale enterprises.
3. Determine how access to network support services affects the sustainability of small-scale enterprises.

Literature Review

The Technology Incubation

Technology incubations are usually initiated by governments, universities and research institutions to carefully midwife and nurture novel enterprises into maturity (Bergek and Norrman, 2018). In developing countries, the majority of the incubators are funded by government (Akçomak, 2015). **There are several definitions and approaches to business and technology incubation. Conceptually 'incubation' is a diligent and planned process of `co-location' therefore needs careful attention to the problems of entrepreneurs extending well beyond providing infrastructure and office services (Adelowo and Egbetokun, 2016). According to the National Business Incubators Association (NBIA), "Business Incubation catalyses the process of starting and growing companies, providing entrepreneurs with the expertise, networks and tools they need to make their ventures successful. Incubation programmes diversify economies, commercialise technologies, create jobs and create wealth".**

The term incubator is a device for nurturing immature phenomenon to maturity or self-sustenance under a control environment but a business incubator is an initiative that systematizes the process of creating successful new enterprises, by providing entrepreneurs with a comprehensive and integrated range of services, which include floor-space made available on a flexible and affordable, but temporary basis; common services that include secretarial support and shared use of office equipment; hands-on business counselling; access to specialized assistance such as research and development support and venture capital; and networking activities operating as a reference point inside the premises among entrepreneurs and outside to the local community. According to Lalkaka (2019), business incubation is a means by which visions of new businesses are turned into reality with reduced risks. Barbero *et al*. (2021) added that there are five types of incubators which are as follows: regional incubators; university incubators; virtual incubators; independent commercial incubators and company internal-incubators. Barbero *et al.* (2021) also added classifications to these five types of incubators on the basis of whether they are for-profit or not-for-profit. The regional and university incubators are not-for-profit while the virtual, independent commercial incubators and company internal incubators are for-profit. Moreover, some have classified them on the basis of management aspects (Aerts *et al.*, 2017).

Incubators aspire to have a positive impact on a community's economic health, by maximizing the success of emerging companies (Cassim, 2016). Business incubators have proved effective in many parts of the world. According to Lose and Tengah (2015), only 10 business incubators existed in the United States in 1980. There were nearly 500 by 1995, meaning a new incubator has been opening every week. The technology incubators generally focus on nurturing technology intensive enterprises and knowledge-based ventures. The technology incubation system (TIs) is variously represented by entities such as Technopolis, Science Parks, Research Parks, Technology Parks, Technology and/or Business Incubators. These entities operate as separate organisations but are mostly integrated with other players in the innovation system. The terms Science Parks, Research Parks and Technology Parks as well as Technology Incubators (TIs), Technology Innovation Centres (TICs) and Technology Business Incubators (TBIs) are used interchangeably in many countries depending on the level and type of interaction between R&D community, venture funding and industry (Lalkaka, 2019).

2.2 Conceptual Review

Technical Support Services: Technical support services play a critical role in enhancing the operational efficiency and innovative capacity of small-scale enterprises (SSEs). These services include product development, equipment access, quality assurance, and technical

training—all of which are vital for building competitive advantage in a dynamic business environment.

Empirical studies have consistently underscored the importance of technical support to enterprise survival and growth. According to **Afolabi and Laseinde (2019)**, technical training provided through incubation centres in southwestern Nigeria significantly improved product quality, process efficiency, and cost management among small manufacturers. Similarly, **Ezenwakwelu et al. (2020)** found that access to technical infrastructure such as laboratory equipment and fabrication tools within incubation hubs directly influenced the production capacity and innovation readiness of incubated firms.

Furthermore, **Obaji and Olugu (2014)** argued that without sustained technical input, small enterprises are more vulnerable to technological obsolescence, poor product design, and low customer satisfaction. These technical weaknesses reduce their ability to scale and maintain relevance in competitive markets. In Kano State, where many SSEs operate in low-technology environments, the absence or inadequacy of technical support can lead to substandard outputs and high failure rates.

Thus, the provision of appropriate technical support services is not just desirable but essential for ensuring the long-term sustainability of SSEs in the region.

H1. Technical Support Services does not significantly affect the Sustainability of Small-Scale Enterprises in Kano State.

Business Support Services: Business support services—encompassing strategic planning, marketing, financial advisory, and compliance guidance—are fundamental to enterprise sustainability. These services help entrepreneurs make informed decisions, access new markets, manage resources efficiently, and navigate complex regulatory frameworks.

Empirical evidence from **Uzonwanne (2015)** highlights that many SSEs fail not due to lack of ideas, but because of poor business planning and inadequate financial literacy. In a study of incubation centres in Nigeria, **Adegbite *et al.* (2017)** found that enterprises that received structured business development support recorded higher revenue growth and longer business survival compared to non-supported counterparts.

Similarly, **Ogundele et al. (2021)** observed that marketing support services—such as branding, pricing strategies, and digital promotion—significantly improved customer reach and sales volume among incubated small businesses. Moreover, **Eniola and Ektebang (2014)** emphasized that guidance on regulatory compliance helps small enterprises avoid legal sanctions, obtain operational licenses, and build formal credibility, all of which are prerequisites for accessing financial markets and public contracts.

These studies collectively suggest that business support services are a central pillar of enterprise development, and their absence can limit growth potential, especially in resource-constrained environments like Kano State.

H2. Business Support Services does not significantly influence the Sustainability of Small-Scale Enterprises in Kano State.

Network Support Services: Network support services—such as access to partnerships, market linkages, funding connections, and knowledge-sharing platforms—serve as enablers for collaboration, innovation diffusion, and resource mobilization. These networks help small enterprises overcome the limitations of isolation, especially in competitive and uncertain markets.

According to **Ismail and Almajali (2016)**, network support significantly enhances the market orientation and adaptability of SSEs. Their study in Jordanian industrial clusters showed that firms with access to peer networks and external mentors reported higher survival rates and faster time-to-market for new products. In Nigeria, **Okpara and Wynn (2007)** found that

network alliances formed through technology incubation centres provided small firms with critical exposure to suppliers, distributors, and investors, facilitating their scale-up processes.
Furthermore, **Akanbi and Ofoegbu (2019)** demonstrated that social and professional networks contributed to knowledge acquisition and opportunity recognition, which are vital for strategic growth. They argue that without structured access to such networks, SSEs remain disconnected from value chains and technological ecosystems, which impairs their sustainability.
In Kano State, where many small enterprises are located in informal clusters, the strategic provision of network support through incubation platforms can significantly enhance their market presence, collaborative potential, and innovation capability.
Across the reviewed literature, it is evident that **technical**, **business**, and **network support services** collectively influence the sustainability trajectory of small-scale enterprises. While each proxy addresses a different facet of enterprise development, their combined effect is synergistic and essential for long-term resilience. As such, this study anchors its investigation on these three empirically grounded dimensions to assess the role of technology incubation in sustaining SSEs in Kano State.

H3. Network Support Services does not significantly affect the Sustainability of Small-Scale Enterprises in Kano State.

The Concept of Sustainability

Sustainability is an approach that creates long-term stakeholder value by implementing a business strategy that considers every dimension of how a business operates in the society, environment and economic spheres. According to Shi *et al.* (2019) the theory of Sustainable Development (SD) has gone through three periods. The embryonic period (before 1972), the molding period (1972-1987) and the developing period (1987-Date). The Brundtland Report (1987) provides a well-known broad definition of SD as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (UNESCO, 2021). The concept is concerned with maintaining a balance between economic, social, and environmental considerations (the three pillars of sustainability). It is, in fact, about the long-term survival of the planet earth for continued habitation of living organisms that form its ecosystem (Business Resource Lab, 2021). The growth and sustainability of small-scale enterprises can be defined in terms of profits, sales, cash flow, assets, number of employees, number of patents and copyrights, amount of fund raised, graduation/survivability rate of tenant firms Pompa (2018). Mian *et al.* (2016) reported that there is no universal agreement on which success factors should be measured and this complicates the assessment of TICs and their incubatees. However, this study will focus on growth of employment and product innovation as sustainability measures.

Nature of small-scale enterprises

There is no single criterion for defining business enterprises as small or medium scale globally. However, evidence from literature shows that in defining small- scale business, reference is usually made to some quantifiable measures such as: number of people employed by the enterprises, investment outlay, the annual turnover (sales) and the asset value of the enterprise or a combination of these measures. At the moment in Nigeria, following the National Council for Industry (NCI, 2021) classification of small –scale business fall within the following categories of enterprises; Small-scale business, if the enterprise has a capital outlay of between N1.5million and N50million including working but excluding cost of land and or workforce of between 11-100 employees, is the adopted working definition of SSE in Kano.

Theoretical framework - RBV

The Resource-Based View (RBV) theory is well-suited as the theoretical underpinning for the study on the influence of technology incubation support services on the growth and sustainability of small-scale enterprises (SSEs) in Kano State, Nigeria. RBV emphasizes the

strategic importance of internal resources and capabilities in achieving competitive advantage and long-term performance. Technology incubation centres provide critical support services—such as technical assistance, business advisory, and networking opportunities—that constitute valuable, rare, and inimitable resources for SSEs. These services help overcome common challenges faced by Nigerian enterprises, including limited access to skills, finance, and markets. By enabling firms to internalize these resources, TICs enhance their capacity for growth, innovation, and sustainability, aligning closely with RBV's core assumptions. Thus, the RBV offers a robust lens for analyzing how resource acquisition through incubation contributes to enterprise development in emerging economies.

Methodology

This study adopted a cross sectional survey research design with quantitative approach. The population of the study comprise of 107 graduated incubatees of Kano Technology Incubation Center between 2014 and 2018. The entire size of the element under study was used as the number of respondents was not large. Consequently, census sampling technique was adopted. This study utilized a five point closed ended likert scale structured questionnaire to obtain response of the sampled elements. The researcher personally administered the instruments with the help of two research assistants. The data collected was analysed with a two-step process that uses Confirmatory Factor Analysis (CFA) and Structural Equation Modeling- Partial Least Square (SEM-PLS), version to test the hypothesized effects at 0.05 level of significance.

4.0 Results and Discussion

4.1 Descriptive analysis

This section discusses the general demographic features of the respondents. In terms of gender, age, education, and area of innovation. This section begins with the analysis of the response rate of administered and collected questionnaire.

Table 4.1: Distribution of questionnaires

Description	Frequency	Percentage (%)
Retuned	83	77.6
Missing	24	22.4
Total	107	100

Source: Author's Field Survey, 2024

Table 4.1 showed a response rate of (77.6%). The study administered a total of 107 questionnaires. A total of 83 respondents responded to the questionnaire representing a response rate of 77.6% as shown in table 4.1. However, this response rate was considered satisfactory to draw an inference for the study which is in accordance with Cooper and Schindler (2021), where it is stated that the response rates above 50% are acceptable for analysis and publishing, 60% is good, 70% is very good while 80% and above is excellent. Therefore, this response rate, 77.6%%, is accepted for this analysis.

Table 4.2: Demographic Characteristics of Respondents (N = 83)

Variable	Category	Frequency	Percent (%)	Mean
Gender	Male	51	61.7	1.53
	Female	32	38.3	2.03
	Total	**83**	**100.0**	2.71
Age	18–25	21	25.3	
	26–35	50	60.7	
	36–45	7	8.4	
	Above 46	5	5.6	3.06
	Total	**83**	**100.0**	
Education Level	Primary	0	0.0	
	Secondary	3	2.8	
	OND/NCE	25	30.0	
	Degree/HND	46	55.7	
	Master's Degree	7	8.3	
	Other	2	2.2	2.17
	Total	**83**	**100.0**	
Year of Graduation	2014 (10 years)	9	10.3	
	2015 (9 years)	13	15.7	
	2016 (8 years)	12	13.7	
	2017 (7 years)	26	31.3	
	2018 (6 years)	24	29.1	2.74
	Total	**83**	**100.0**	

4.2 Respondents' Demographic Characteristics

Gender: With 61.7% male and 38.3% female, the sample is male-dominated. This may reflect gender disparities in access or participation in the studied sector, possibly indicating a need for more inclusive policy or intervention. **Age:** A significant portion (60.7%) of the respondents fall within the 26–35 age group, suggesting that the majority are in their early working or entrepreneurial years. This age composition implies high energy, openness to innovation, and potential for long-term impact if well supported.

Educational Background: Most respondents possess post-secondary qualifications, particularly Degree/HND (55.7%) and OND/NCE (30%). The absence of respondents with only primary education and the high percentage with tertiary education suggest a skilled and knowledgeable population favorable for tasks requiring technical understanding and innovation. **Year of Graduation:** The distribution leans toward more recent graduates, with over 60% graduating between 2017 and 2018. This suggests that most participants are relatively new in the workforce and may still be navigating early career challenges, with implications for training needs and targeted support interventions.

SEM path coefficient

In Structural Equation Modeling (SEM) with Partial Least Squares (PLS), model path coefficients are essential for interpreting the relationships between latent variables (constructs) within the model. Path coefficients indicate the strength and direction of relationships between constructs. They are similar to standardized regression coefficients, with values typically ranging between -1 and +1. Positive coefficients imply a positive relationship, meaning that as one construct increases, the associated construct also increases. Negative coefficients indicate an inverse relationship, meaning that an increase in the predictor variable corresponds to a reduction in the outcome variable, highlighting an inverse linkage between the predictor and outcome variables. The closer the path coefficient is to +1 or -1, the stronger the relationship. Path coefficients closer to 0 suggest weaker relationships between constructs.

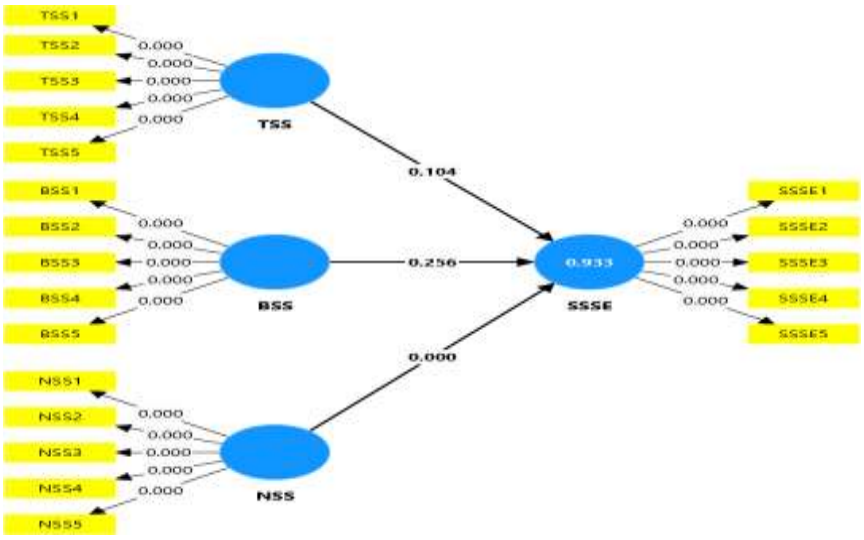

Figure. 4.1: SEM schematic output for significance (p-value)

4.2 Hypotheses Testing

Table 4.3: Table of R-square and R-square Adjusted

Dependent Variable	R-square	R-square adjusted
SSSE	0.933	0.931

Source: Author (2025)

The **R-square value of 0.933** indicates that 93.3% of the variation in the sustainability of small-scale enterprises (SSSE) is explained by technical, business, and network support services. The **adjusted R-square of 0.931** confirms the model's strength while accounting for the number of predictors. This shows the model has a **very high explanatory power** and is **statistically reliable**, highlighting the significant role these support services—especially network support—play in influencing enterprise sustainability.

Table 4.4: Results of hypotheses testing

Hypotheses	Path Coefficient	T Statistics	P Values	Decision
TSS → SSSE	0.167	1.628	0.104	Insignificant
BSS → SSSE	0.191	1.137	0.256	Insignificant
NSS → SSSE	0.932	4.658	0.000	Significant

Discussion of Results

H1: Technical support services have no significant effect on the sustainability of small-scale enterprises' (SSSEs) in Kano State.

The structural model results reveal varying levels of influence among the three support service constructs technical support services (TSS), business support services (BSS), and network support services (NSS) on the sustainability of small-scale enterprises (SSSE) in the study area. The path coefficient for TSS to SSSE was positive ($\beta = 0.167$), indicating a weak positive relationship. However, the relationship was statistically insignificant ($T = 1.628$; $p = 0.104$), leading to the retention of the null hypothesis (H_{01}). This implies that technical support services such as training, product development, equipment access, and quality control do not significantly influence the sustainability of small-scale enterprises within the context of this study. A possible explanation for this could be the inadequate quality, delivery, or relevance of the technical support services being provided. It is also plausible that entrepreneurs are either unaware of these services or find them inaccessible or misaligned with their specific operational needs.

H2: Business support services have no significant effect on the sustainability of small-scale enterprises' (SSEs) in Kano State.

Similarly, the relationship between business support services and enterprise sustainability was also found to be positive but statistically insignificant ($\beta = 0.191$; $T = 1.137$; $p = 0.256$), resulting in the acceptance of the second null hypothesis (H_{02}). This suggests that services such as business planning, marketing advisory, financial management, and regulatory compliance support have not made a statistically meaningful impact on enterprise sustainability in this case. The insignificance of this path could indicate systemic issues in the design or delivery of business support services, or a disconnect between the support offered and the actual business challenges faced by small-scale enterprises.

H3: Network support services have no significant effect on the sustainability of small-scale enterprises' (SSEs) in Kano State

Conversely, the path from network support services to sustainability of small-scale enterprises was highly significant and exhibited a strong positive relationship ($\beta = 0.932$; $T = 4.658$; $p = 0.000$). The null hypothesis (H_{03}) was therefore rejected. This finding underscores the critical role of network-based interventions such as market linkages, strategic partnerships, access to incubation networks, and information sharing platforms in enhancing the long-term viability and growth of SSEs. It suggests that when enterprises are effectively integrated into broader innovation and business ecosystems, they are more likely to survive, scale, and remain sustainable.

Conclusion and Recommendations

5.1 Conclusion

The study examined the influence of technology incubation support services specifically Technical Support Services (TSS), Business Support Services (BSS), and Network Support Services (NSS) on the sustainability of small-scale enterprises (SSSE). The findings from the structural model indicate that **network support services (NSS)** have a **strong and statistically significant positive effect** on the sustainability of small-scale enterprises, leading to the rejection of the third null hypothesis (H_{03}). This implies that access to networks, institutional linkages, and collaborative ecosystems is a critical driver of enterprise sustainability in the study context.

In contrast, the effects of **technical support services (TSS)** and **business support services (BSS)** on SSSE were both **positive but statistically insignificant,** resulting in the acceptance of the first two null hypotheses (H_{01} and H_{02}). This suggests that while these services may contribute marginally to enterprise growth, they **do not significantly influence sustainability** in a measurable way within the current operational framework.

Overall, the findings emphasize the **critical importance of network-based interventions** in ensuring the long-term viability of small-scale enterprises, while also highlighting the need to **reassess and improve the delivery and relevance** of technical and business support services.
Recommendations

1. **Strengthen Networking Platforms and Linkages**
   Policy-makers and incubation centres should prioritize the development of structured **networking opportunities, market linkages, strategic alliances and mentorship platforms**. Facilitating collaboration among entrepreneurs, investors, industry actors, and institutions can significantly enhance enterprise resilience and growth.
2. **Reform Technical Support Delivery**
   Technical support services should be **re-evaluated and redesigned** to meet the evolving needs of small-scale enterprises. This includes upgrading the **quality of training, product development assistance, and access to technology or equipment,** ensuring they are both accessible and tailored to specific industry demands.
3. **Enhance the Relevance of Business Support Services**
   The content and method of delivering business support such as financial literacy, marketing advisory, and regulatory compliance should be made more **practical, sector-specific, and context-driven**. Feedback from entrepreneurs should inform program design to ensure greater impact on sustainability.

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POTASYUM SORBATIN *ENTEROCOCCUS FEACALİS*'E KARŞI ÇOK HEDEFLİ BİR ANTİMİKROBİYAL AJAN OLARAK IN-SILICO DEĞERLENDİRİLMESİ

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ÖZET
Bu çalışma, gıda koruyucu maddesi olan potasyum sorbatın (PS) *Enterococcus faecalis*'e karşı antimikrobiyel potansiyelini, anahtar bakteriyel proteinlerle olan moleküler etkileşimleri üzerinden in silico docking analizleriyle incelemektedir. *E. faecalis*, tıbbi cihazlar ve epitel yüzeylerde dirençli biyofilmler oluşturabilen Gram-pozitif fırsatçı bir patojendir; bu durum, antibiyotik direnci ve kronik enfeksiyon gelişimine katkı sağlar. Moleküler docking çalışmaları için üç önemli hedef protein—DNA Gyrase B alt birimi (PDB ID: 4URO), OmpC porin (PDB ID: 3UU2) ve yüzey adezyon proteini Esp (PDB ID: 6ORI)—seçilmiştir. AutoDock Vina kullanılarak yapılan simülasyonlarda sırasıyla −4.7 kcal/mol, −4.3 kcal/mol ve −5.0 kcal/mol bağlanma afiniteleri elde edilmiştir. En güçlü bağlanma Esp proteini ile gözlemlenmiş olup, PS'nin biyofilm bütünlüğünü bozabileceğini düşündürmektedir. Bu bulgular, PS'nin özellikle biyofilm ilişkili *E. faecalis* enfeksiyonlarının tedavisinde etkili olabilecek çok hedefli bir antimikrobiyal ajan adayı olduğunu göstermektedir.
Anahtar Kelimeler: Potasyum sorbat, *Enterococcus faecalis*, moleküler docking, biyofilm inhibisyonu, antimikrobiyal strateji

IN-SILICO EVALUATION OF POTASSIUM SORBATE AS A MULTI-TARGET ANTIMICROBIAL AGENT AGAINST *ENTEROCOCCUS FAECALIS*

ABSTRACT
This study explores the antimicrobial potential of potassium sorbate (PS) (a food preservatif) against *Enterococcus faecalis*, with a specific focus on its molecular interactions with key bacterial proteins via in silico docking simulations. *E. faecalis* is a Gram-positive opportunistic pathogen notorious for forming resilient biofilms on epithelial tissues and medical devices, contributing to increased antibiotic resistance and persistent infections. Three critical target proteins—DNA gyrase subunit B (PDB ID: 4URO), OmpC porin (PDB ID: 3UU2), and the surface adhesion protein Esp (PDB ID: 6ORI)—were selected for molecular docking analysis

using AutoDock Vina. The calculated binding affinities were −4.7 kcal/mol, −4.3 kcal/mol, and −5.0 kcal/mol, respectively. The strongest interaction was observed with the Esp protein, suggesting that PS may impair biofilm integrity. These findings support the potential of PS as a promising multi-target antimicrobial agent, particularly for treating biofilm-associated E. faecalis infections.
Keywords: Potassium sorbate, *Enterococcus faecalis*, molecular docking, biofilm inhibition, antimicrobial strategy

THE PREDICTION OF TEACHER RELATED VARIABLES ON ACADEMIC ACHIEVEMENT OF COLLEGES OF EDUCATION STUDENTS IN BUSINESS MATHEMATICS IN NORTH-EAST NIGERIA

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ABSTRACT

The study examined the extent to which teacher related variables predict students' academic achievement in business mathematics in selected colleges of Education in North-east Nigeria. Specifically, teacher pedagogical knowledge, adaptability and self-efficacy among teacher related variables were considered. Three objectives, three research questions and three null hypotheses guided the study. Survey and ex-post facto research designs were adopted. The population of the study comprised of 42 Business mathematics teachers and 1,724 NCE I Business Education students. A sample size of 313 was obtained through proportionate random sampling technique. Questionnaire, Test and Achievement Scores were the instruments used. The instruments were validated by three experts from faculty of Technology Education, Abubakar Tafawa Balewa University, Bauchi. Using Cronbach Alpha and split-half method, a reliability coefficients of 0.73, 0.75 & 0.80 were obtained for the three instruments used in this study. Mean, standard deviation and simple linear regression were the statistical tools used. The study revealed that teachers' pedagogical knowledge, Teachers' adaptability and self-efficacy significantly predicted students' achievement in business mathematics. It was concluded that teachers with adequate pedagogical, high adaptability and self-efficacy will improve students' achievement in business mathematics. The study recommends that School management should frequently organize workshops and seminars that will help in boosting pedagogical knowledge, adaptability and self-efficacy of business mathematics teachers in colleges of education in North-east Nigeria.

Keywords: *Pedagogical knowledge, adaptability, self-efficacy, academic achievement*

PEROPERATİF HEMŞİRELİKTE SANAL GERÇEKLİK: ROBOTİK CERRAHİ GEÇİREN OBEZ HASTALARDA AĞRI YÖNETİMİ İÇİN YENİLİKÇİ YAKLAŞIMLAR

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ÖZET
Günümüzde robotik cerrahi tekniklerinin yaygınlaşmasıyla birlikte, özellikle obez hasta popülasyonunda postoperatif iyileşme süreçlerinin optimize edilmesi büyük önem kazanmıştır.Robotik cerrahinin geleneksel açık cerrahiye kıyasla sağladığı avantajlar arasında daha küçük insizyonlar, daha az doku travması ve buna bağlı olarak azalmış postoperatif ağrı düzeyleri sayılabilir. Ancak obez bireylerde, artmış visseral yağ dokusu, değişen farmakokinetik parametreler ve sıklıkla eşlik eden komorbiditeler nedeniyle ağrı yönetimi özel bir uzmanlık gerektirmektedir. Bu hasta grubunda opioid kullanımına bağlı solunum depresyonu ve diğer yan etki risklerinin yüksek olması, non-farmakolojik ağrı kontrol yöntemlerinin geliştirilmesini zorunlu kılmaktadır.Sanal gerçeklik teknolojisi, son yıllarda ağrı yönetimi alanında kabul gören yenilikçi bir yaklaşım olarak karşımıza çıkmaktadır. VR'nin ağrı kontrolündeki etki mekanizmaları üç temel başlık altında incelenebilir: Dikkat dağıtma teorisi sayesinde ağrı algısının modülasyonu, endojen opioid sistemin aktivasyonu yoluyla doğal ağrı kesici mekanizmaların harekete geçirilmesi ve psikolojik etkilerle stres hormon düzeylerinin azaltılması. Randomize kontrollü çalışmalar, VR müdahalelerinin postoperatif ağrı skorlarında %40'a varan oranlarda azalma sağladığını ve opioid gereksinimini %35 oranında düşürdüğünü ortaya koymaktadır.Hemşirelik uygulamaları açısından bakıldığında, VR destekli ağrı yönetimi protokollerinin standart hemşirelik bakımına entegrasyonu önemli klinik faydalar sağlamaktadır. Hemşireler tarafından yönetilen bu programlar, hastanede kalış süresini ortalama 2.3 gün kısaltmakta ve hasta memnuniyet düzeylerini belirgin şekilde artırmaktadır. Ancak, bu teknolojinin yaygın klinik kullanıma girebilmesi için obeziteye özgü VR içeriklerinin standardizasyonu, uygulama protokollerinin geliştirilmesi ve maliyet etkinlik analizlerinin yapılması gerekmektedir. Sonuç olarak, robotik kalp cerrahisi geçiren obez hastalarda VR destekli ağrı yönetimi yaklaşımları, geleneksel yöntemlere kıyasla önemli avantajlar sunmaktadır. Bu yenilikçi yaklaşım, hem farmakolojik ağrı kontrol yöntemlerinin yan etkilerini azaltmakta, hem de hastaların cerrahi sürece uyumunu kolaylaştırmaktadır. Ancak, bu alanda daha geniş örneklemli, uzun dönem takipli randomize kontrollü çalışmalara ihtiyaç duyulmaktadır.
Anahtar Kelimeler: Robotik cerrahi, obezite, sanal gerçeklik, ağrı yönetimi, hemşirelik uygulamaları.

VIRTUAL REALITY IN PERIOPERATIVE NURSING: INNOVATIVE APPROACHES FOR PAIN MANAGEMENT IN OBESE PATIENTS UNDERGOING ROBOTIC SURGERY

ABSTRACT

Today, with the widespread adoption of robotic surgical techniques, optimizing postoperative recovery processes has gained critical importance, particularly in the obese patient population. The advantages of robotic surgery compared to traditional open surgery include smaller incisions, less tissue trauma, and consequently reduced postoperative pain levels. However, in obese individuals, pain management requires specialized expertise due to increased visceral adipose tissue, altered pharmacokinetic parameters, and frequently accompanying comorbidities. In this patient group, the high risk of respiratory depression and other side effects associated with opioid use makes the development of non-pharmacological pain control methods imperative.Virtual reality technology has emerged as an innovative approach recognized in the field of pain management in recent years. The mechanisms of VR's effect on pain control can be examined under three main headings: modulation of pain perception through distraction theory, activation of natural pain-relief mechanisms via endogenous opioid system activation, and reduction of stress hormone levels through psychological effects. Randomized controlled studies demonstrate that VR interventions reduce postoperative pain scores by up to 40% and decrease opioid requirements by 35%.From the perspective of nursing practices, the integration of VR-supported pain management protocols into standard nursing care provides significant clinical benefits. These nurse-managed programs shorten hospital stays by an average of 2.3 days and markedly increase patient satisfaction levels. However, for this technology to enter widespread clinical use, standardization of obesity-specific VR content, development of application protocols, and cost-effectiveness analyses are required.In conclusion, VR-supported pain management approaches offer significant advantages over traditional methods for obese patients undergoing robotic heart surgery. This innovative approach both reduces the side effects of pharmacological pain control methods and facilitates patients' adaptation to the surgical process. However, there is a need for larger-sample, long-term follow-up randomized controlled studies in this field.

Keywords: Robotic surgery, obesity, virtual reality, pain management, nursing practices

GİRİŞ

Robotik Kalp Cerrahisinin Tanımı ve Önemi

Robotik kalp cerrahisi, minimal invaziv cerrahi tekniklerinin en gelişmiş örneklerinden biri olarak kabul edilen ve özellikle da Vinci Cerrahi Sistemi (Intuitive Surgical Inc., Sunnyvale, CA) gibi robotik platformlar kullanılarak gerçekleştirilen kardiyak girişimleri ifade etmektedir (Gudeloglu & Parekattil, 2021; Şenol Çelik vd., 2024). Bu yöntem, cerrahlara üç boyutlu, yüksek çözünürlüklü görüntüleme ve 7 derece serbestlik derecesine sahip enstrümanlarla artırılmış hareket hassasiyeti sağlayarak özellikle dar anatomik alanlarda daha kesin ve kontrollü müdahalelere olanak tanımaktadır (Harky vd., 2020; İnce vd., 2020). Geleneksel açık kalp cerrahisine kıyasla küçük insizyonlarla (5-10 mm) gerçekleştirilen bu teknik, doku travmasını minimize ederek kan kaybını azaltmakta, postoperatif ağrıyı önemli ölçüde azaltmakta ve hastanın iyileşme sürecini hızlandırmaktadır (Harky vd., 2020; Moloney vd., 2020; Şenol Çelik vd., 2024). Mitral kapak tamiri, koroner arter baypas greftleme, atriyal septal defekt onarımı ve kardiyak tümör eksizyonu gibi kompleks kardiyak prosedürlerde giderek artan sıklıkla uygulanmaktadır (Güre & Güçlüel, 2025; İnce vd., 2020).

1.1. Dünyada ve Türkiye'de Tarihsel Gelişim

Robotik yardımlı cerrahinin (RAS) kökenleri 1990'ların sonlarına dayanmakta olup, ilk uygulamalar AESOP (Automated Endoscopic System for Optimal Positioning) ve ZEUS

robotik sistemleriyle Birleşik Krallık'ta gerçekleştirilmiştir(Şenol Çelik vd., 2024). 2000 yılında FDA onaylı ilk ticari robotik cerrahi sistemi olan da Vinci'nin piyasaya sürülmesiyle birlikte bu alanda önemli bir dönüm noktası yaşanmıştır(Gudeloglu & Parekattil, 2021). Günümüzde 70'ten fazla ülkede 12 milyondan fazla robotik destekli prosedür gerçekleştirilmiş olup, Amerika Birleşik Devletleri'ndeki hastanelerin yaklaşık %60'ında en az bir da Vinci sistemi bulunmaktadır (Gudeloglu & Parekattil, 2021; Şenol Çelik vd., 2024). Türkiye'de ise robotik cerrahi uygulamaları ilk olarak 2003 yılında bypass cerrahisi alanında başlamış, son yıllarda hızla yaygınlaşarak günümüzde sekiz ilde (İstanbul, Ankara, İzmir, Kocaeli, Bursa, Adana, Antalya ve Samsun) 32 merkezde rutin olarak uygulanır hale gelmiştir(Uslu vd., 2019). Ülke genelinde yaklaşık 132 cerrah ve 90-100 robotik cerrahi hemşiresi bu alanda hizmet vermekte olup, özellikle büyük eğitim ve araştırma hastanelerinde robotik kalp cerrahisi programları aktif olarak yürütülmektedir (Uslu vd., 2019; Yeşilyurt vd., t.y.). Bu gelişmeler, robotik cerrahinin küresel ve ulusal sağlık sistemlerinde giderek artan önemini ortaya koymaktadır.

1.2.Robotik Kalp Cerrahisinin Avantajları ve Dezavantajları

Robotik kalp cerrahisinin hasta ve cerrah açısından pek çok avantajı bulunmaktadır. Hasta tarafında en önemli avantajlar; %70-80 daha az kan kaybı, geleneksel yöntemlere kıyasla %60 daha düşük enfeksiyon riski, hastanede kalış süresinin 3-5 gün kısalması ve normal yaşantıya dönüş süresinin belirgin şekilde hızlanması olarak sıralanabilir (Harky vd., 2020; Moloney vd., 2020; Şenol Çelik vd., 2024). Harky ve arkadaşlarının (2020) çalışmasına göre, robotik mitral kapak cerrahisinde mortalite oranları %0.5-1.2 aralığında olup, bu oran geleneksel yöntemlerle karşılaştırıldığında istatistiksel olarak anlamlı derecede düşüktür(Harky vd., 2020). Cerrahlar açısından ise üç boyutlu görüntüleme, el titremesi filtrasyonu ve ergonomik çalışma pozisyonu gibi avantajlar sunmaktadır (Harky vd., 2020; İnce vd., 2020). Ancak yöntemin önemli kısıtlılıkları da bulunmaktadır. Sistemin yüksek maliyeti (1-2.5 milyon dolar), uzun öğrenme eğrisi (150-200 vaka deneyimi) ve deneyimli cerrahi ekibe duyulan ihtiyaç başlıca dezavantajlardır (Fida vd., 2024; Harky vd., 2020). Prattia ve ark. (2020) meta-analizinde, robotik mitral kapak cerrahisinde %3-5 oranında teknik zorluklar nedeniyle konvansiyonel cerrahiye geçiş gerektiği belirtilmiştir (Pratita vd., 2022). Ayrıca, ameliyat sürelerinin %20-30 daha uzun olması, haptik feedback eksikliği ve hasta pozisyonlamasındaki zorluklar diğer önemli sınırlılıklar olarak karşımıza çıkmaktadır (Harky vd., 2020; Moloney vd., 2020; Şenol Çelik vd., 2024). Bu avantaj ve dezavantajların dikkatli değerlendirilmesi, robotik kalp cerrahisinin uygun hasta seçiminde belirleyici rol oynamaktadır.

1.3.Robotik Kalp Cerrahisinde Hemşirenin Rolü ve Önemi

Robotik kalp cerrahisinde hemşireler, multidisipliner cerrahi ekibin vazgeçilmez bir üyesi olarak preoperatif, intraoperatif ve postoperatif süreçlerde kritik roller üstlenmektedir (Uslu vd., 2019; Yeşilyurt & Durmaz, 2023). Akaltun ve ark. (2023) tarafından vurgulandığı üzere, robotik teknolojiler hemşirelik uygulamalarını teknik beceri gelişimi, ekip koordinasyonu ve hasta eğitimi gibi çok boyutlu bir dönüşüme zorlamaktadır (Akaltun vd., 2025). Preoperatif dönemde hasta eğitimi ve psikolojik destekle birlikte robotik sistem kurulumu ve sterilizasyon protokollerinin uygulanması temel sorumluluklar arasındadır (Güzel & Yava, 2022; Lee & Hong, 2023; Özyürek & Göktaş, 2021; Uslu vd., 2019). Intraoperatif süreçte hemşireler, hasta pozisyonlaması (özellikle steep Trendelenburg pozisyonunda sinir hasarının önlenmesi), cerrahi ekibe dinamik destek ve acil durum yönetimi (elektrik kesintisinde hex wrench kullanımı gibi) gibi hayati roller üstlenir (Güre & Güçlüel, 2025; Lee & Hong, 2023; Moloney vd., 2020). Postoperatif dönemde ise komplikasyon izlemi (kanama, enfeksiyon, atrial fibrilasyon), ağrı yönetimi ve erken mobilizasyon hemşirelik bakımının temel bileşenlerini oluşturur (Alcan vd., 2019; Güre & Güçlüel, 2025; Yeşilyurt vd., t.y.). Ancak Türkiye'de robotik cerrahi hemşireliği alanında standart eğitim programlarının eksikliği, yasal yeterliliklerin belirsizliği ve informal öğrenme yöntemlerinin yaygınlığı önemli bir sorun teşkil

etmektedir (Uslu vd., 2019). Uslu ve ark. (2019) çalışmasında hemşirelerin %85'inin robotik cerrahi eğitimi almadığını ve bilgi düzeylerinin yetersiz olduğunu tespit etmiştir ki bu durum hasta güvenliği ve cerrahi başarı açısından ciddi risk oluşturmaktadır (7). Bu nedenle, robotik cerrahi hemşireliğinin standartlaştırılması ve resmi bir uzmanlık alanı olarak tanınması acil bir ihtiyaç haline gelmiştir (Uslu vd., 2019).

AMELİYAT ÖNCESİ (PREOPERATİF) HEMŞİRELİK YAKLAŞIMLARI

Hasta Eğitimi ve Psikolojik Destek

Robotik kalp cerrahisi öncesinde hemşirelerin hasta eğitimi ve psikolojik destek süreçleri kritik önem taşımaktadır. Literatürde, hemşirelerin genellikle ameliyattan bir gün önce hasta eğitimini gerçekleştirdiği belirtilmektedir (Güzel & Yava, 2022). Eğitim içeriği; cerrahi sürecin aşamaları, beklenen sonuçlar, olası komplikasyonlar, postoperatif ağrı yönetimi ve iyileşme sürecine ilişkin detayları kapsamalıdır(Güre & Güçlüel, 2025; Güzel & Yava, 2022).Hastaların cerrahiye ilişkin anksiyete düzeylerinin yönetimi, hemşirelerin önemli sorumlulukları arasındadır. Araştırmalar, preoperatif dönemde verilen psikolojik desteğin hastaların anksiyete düzeylerini %40-60 oranında azalttığını ve bu durumun postoperatif iyileşme sürecini olumlu yönde etkilediğini göstermektedir(Özyürek & Göktaş, 2021). Özellikle robotik cerrahi gibi yeni teknolojilerle ilgili hasta endişelerinin giderilmesi, cerrahiye uyumu artırmaktadır. Hemşireler, hastaların bireysel ihtiyaçlarına göre danışmanlık sağlamalı ve aile üyelerini de sürece dahil etmelidir(Alcan vd., 2019; Özyürek & Göktaş, 2021).

1.4.Teknik Hazırlık

Robotik kalp cerrahisi öncesi teknik hazırlık, hemşirelerin cerrahi güvenliğini sağlamadaki temel sorumluluklarından biridir. Bu süreç kapsamında da Vinci sisteminin cerrah konsolu, hasta yanı ünite ve görüntüleme sisteminin fonksiyonel kontrolü yapılmalı, kabloların bağlantıları kontrol edilmeli ve steril örtüler uygun şekilde yerleştirilmelidir (Güre & Güçlüel, 2025; Lee & Hong, 2023; Uslu vd., 2019). Sterilizasyon protokollerine özellikle robotik kollar ve kamera adaptörleri için titizlikle uyulmalıdır (Lee & Hong, 2023). Hasta güvenliği açısından acil durum setlerinin (hex wrench, konvansiyonel cerrahi setleri) hazır bulundurulması ve tüm ekip tarafından bilinirliğinin sağlanması gerekmektedir (Güre & Güçlüel, 2025; Moloney vd., 2020). Literatürde %7'ye varan ekipman arıza oranları bildirilmesi, bu hazırlıkların önemini ortaya koymaktadır (Zeuschner vd., 2023). Steep Trendelenburg pozisyonu için gerekli yastık ve destek malzemelerinin hazırlanması, sinir hasarı ve bası yaraları gibi komplikasyonların önlenmesinde kritik rol oynar (Güre & Güçlüel, 2025). Time-out prosedüründe hasta kimliği doğrulaması, cerrahi bölge işaretlemesi ve ekipman kontrollerinin eksiksiz yapılması standart uygulama olarak benimsenmelidir (Zeuschner vd., 2023). Bu kapsamlı hazırlık süreci, robotik kalp cerrahisinin güvenli şekilde gerçekleştirilmesinin temelini oluşturmaktadır.

AMELİYAT SIRASI (İNTRAOPERATİF) HEMŞİRELİK ROLÜ

Robotik Sistem Kurulumu ve Kontrolü

Hemşirelerin intraoperatif dönemdeki en kritik sorumluluklarından biri, robotik sistemin doğru şekilde kurulumunu sağlamaktır. Bu süreç, cerrah konsolu, hasta yanı ünite ve görüntüleme sisteminin birbirine entegrasyonunu içerir (Gudeloglu & Parekattil, 2021; Lee & Hong, 2023). Özellikle robotik kolların steril örtülerle kaplanması ve kamera adaptörlerinin yerleştirilmesi enfeksiyon kontrolü açısından hayati önem taşır (Lee & Hong, 2023; Uslu vd., 2019). Hemşireler, üretici firmanın talimatlarına uygun olarak görüntüleme ünitesi ile cerrah konsolu arasındaki kabloları bağlamalı ve bu kabloların cerrahi alanı engellemeyecek şekilde düzenlendiğinden emin olmalıdır (Gudeloglu & Parekattil, 2021; Lee & Hong, 2023). Ayrıca, robotik enstrüman sepetinin tam donanımlı olduğunu ve yedek enstrümanların hazır bulunduğunu kontrol etmelidir(Moloney vd., 2020; Uslu vd., 2019).

1.5.Hasta Pozisyonlama ve Güvenliği

Robotik kalp cerrahisinde hasta pozisyonlaması, cerrahi başarı ve komplikasyonların önlenmesi açısından kritik bir unsurdur. Özellikle steep Trendelenburg pozisyonunda (25-45

derece baş aşağı) hastanın kaymasını önlemek ve brakial pleksus yaralanması, peroneal sinir hasarı ile dekübit ülseri riskini minimize etmek için uygun yastık ve destek sistemlerinin kullanılması gerekmektedir (Bjøro vd., 2023; Güre & Güçlüel, 2025). Bjøro ve ark. (2023), bu pozisyonun aynı zamanda intraoküler basınç artışı ve dil ödemi gibi komplikasyon risklerini de beraberinde getirdiğini belirtmişlerdir(Bjøro vd., 2023). Hemşirelerin pozisyonlama sırasında tüm eklemlerin anatomik pozisyonda olduğundan emin olması ve basınç noktalarını koruyucu önlemler alması esastır (Güre & Güçlüel, 2025; Moloney vd., 2020). Ayrıca, uzun süreli pozisyonun yol açabileceği komplikasyonların erken tespiti için hastanın sürekli monitorizasyonu büyük önem taşımaktadır (Güre & Güçlüel, 2025). Bu önlemlerin titizlikle uygulanması, robotik kalp cerrahisinde hasta güvenliğini artıran temel faktörlerdendir.

1.6.Cerrahi Asistans ve Ekip Koordinasyonu

Robotik cerrahide cerrahın konsolda konumlanması, hasta başındaki hemşirenin operasyonel liderlik rolünü ön plana çıkarmaktadır. Hemşirelerin cerrahi ekibin ihtiyaç duyduğu enstrümanları zamanında temin etmesi, steril alan bütünlüğünü koruması ve robotik kolların hareket alanını kontrol ederek ekip güvenliğini sağlaması kritik önem taşımaktadır(Moloney vd., 2020; Uslu vd., 2019; Yeşilyurt & Durmaz, 2023). Cerrahi görüşü engelleyen buhar veya kanama gibi durumların hızla yönetilmesi de hemşirenin sorumluluk alanına girmektedir (Güre & Güçlüel, 2025; Yeşilyurt & Durmaz, 2023). Akaltun ve ark. (2023) ile Bjøro ve ark. (2023)'ün vurguladığı gibi, cerrah-anestezi-hemşire üçlüsü arasındaki kusursuz senkronizasyon ve net iletişim hasta güvenliğinin temelini oluşturmaktadır(Akaltun vd., 2025; Bjøro vd., 2023). Özellikle acil durumlarda kısa ve anlaşılır komutlarla cerrahın durumu hızla kavraması sağlanmalıdır (Moloney vd., 2020; Uslu vd., 2019). Bu dinamik çalışma ortamında hemşirelerin liderlik becerileri ve ekip koordinasyon yetkinlikleri cerrahi başarıyı doğrudan etkilemektedir (Akaltun vd., 2025; Bjøro vd., 2023).

1.7.Acil Durum Yönetimi

Robotik cerrahi süreçlerinde acil durumlara hazırlıklı olunması hasta güvenliği açısından kritik önem taşımaktadır. Hemşirelerin, elektrik kesintisi veya sistem arızası durumunda acil durum hex wrench'in yerini bilmesi ve robotik kolların manüel olarak serbest bırakılmasını sağlaması gerekmektedir (Moloney vd., 2020). Konvansiyonel cerrahiye acil geçiş için gerekli enstrüman setlerinin hazır bulundurulması ve kanama gibi komplikasyonlarda kan ürünlerinin hızla temin edilmesi esastır(Güre & Güçlüel, 2025; Moloney vd., 2020; Uslu vd., 2019). Özellikle kardiyak prosedürlerde potansiyel ritim bozukluklarına karşı defibrilatör ve acil ilaçların ameliyathanede hazır konumda tutulması zorunludur (İnce vd., 2020; Moloney vd., 2020). Bu önlemlerin alınması, olası komplikasyonların hızla kontrol altına alınmasını sağlayarak cerrahi güvenliği artırmaktadır.

1.8. Sterilizasyon ve Enfeksiyon Kontrolü

Robotik cerrahide steril alanın korunması, geleneksel cerrahiye göre daha karmaşık bir süreç gerektirmektedir. Hemşirelerin öncelikle robotik kolların steril ve steril olmayan bölümlerini ayırt edebilmesi ve ameliyat boyunca steril örtülerin bütünlüğünü sürekli kontrol etmesi gerekmektedir (4,6). Görüntüleme kalitesinin korunması açısından, kamera lensinin buğulanmasını önlemek için özel antifog solüsyonlar kullanılmalı ve görüntü kalitesi operasyon süresince düzenli olarak değerlendirilmelidir (Lee & Hong, 2023). Robotik cerrahi enstrümanlarının her kullanım sonrası sterilizasyon protokollerine uygun şekilde temizlenmesi ve bakımının yapılması enfeksiyon kontrolü açısından kritik öneme sahiptir (Uslu vd., 2019). Çalışmalar, robotik cerrahide enfeksiyon oranlarının geleneksel yöntemlere göre %30-40 daha düşük olduğunu göstermekle birlikte, bu avantajın sürdürülebilmesi sterilizasyon kurallarına sıkı uyuma bağlıdır (Güre & Güçlüel, 2025; Lee & Hong, 2023).

1.9.Hasta Monitörizasyonu ve Kayıt Tutma

Hemşireler, ameliyat süresince hastanın vital bulgularını (EKG, kan basıncı, SpO2) sürekli izlemeli ve anormal değerleri anestezi ekibine bildirmelidir (Güre & Güçlüel, 2025; İnce vd.,

2020). Özellikle karbondioksit insüflasyonuna bağlı gelişebilecek hiperkarbi ve asidoz belirtilerine dikkat edilmelidir (Güre & Güçlüel, 2025). Ayrıca, kullanılan enstrümanların kaydı, ameliyat süresi ve cerrahi süreçteki önemli olaylar (örneğin robotik sistem arızası, konvansiyonel cerrahiye geçiş) titizlikle kaydedilmelidir (Uslu vd., 2019; Zeuschner vd., 2023). Bu kayıtlar, hem hasta güvenliği hem de kalite iyileştirme çalışmaları için kritik öneme sahiptir (Zeuschner vd., 2023).

AMELİYAT SONRASI (POSTOPERATİF) BAKIM STRATEJİLERİ

1.10. Yoğun Bakım Yönetimi

Robotik kalp cerrahisi sonrası yoğun bakım sürecinde hemşirelik bakımı multidisipliner bir yaklaşım gerektirmektedir. Hemşireler, postoperatif dönemde hastanın hemodinamik stabilizasyonunu sağlamak amacıyla kan basıncı, kalp hızı, solunum sayısı ve SpO2 gibi vital parametreleri sık aralıklarla monitorize etmeli ve anormal değerleri acil olarak bildirmelidir (Güre & Güçlüel, 2025; Gürel & Koçaşlı, 2022). Solunum fonksiyonlarının değerlendirilmesi, derin inspiryum egzersizlerinin öğretilmesi ve uygun öksürük tekniklerinin uygulanması erken ekstübasyon sürecini kolaylaştırmaktadır(Gürel & Koçaşlı, 2022; Yanık & Yılmaz, 2019). Kardiyak outputun optimize edilmesi için sıvı-elektrolit dengesinin yakın takibi ve doktor istemleri doğrultusunda diüretik tedavinin uygulanması gerekmektedir (Gürel & Koçaşlı, 2022). Ağrı yönetiminde hasta kontrollü analjezi (PCA) protokolleri uygulanmalı ve ağrı skorları düzenli olarak değerlendirilmelidir(Yanık & Yılmaz, 2019; Yeşilyurt vd., t.y.). Robotik cerrahinin minimal invaziv doğası, hastaların yoğun bakımda kalış sürelerini geleneksel cerrahi yöntemlere kıyasla belirgin şekilde kısaltmaktadır (Moloney vd., 2020; Şenol Çelik vd., 2024). Bu avantajın korunabilmesi için hemşirelerin komplikasyonların erken tanı ve yönetiminde dikkatli olması ve protokollere uygun davranması kritik önem taşımaktadır.

1.11. Komplikasyon Önleme

Robotik kalp cerrahisi sonrası komplikasyonların erken tanı ve yönetimi, hemşirelik bakımının kritik bileşenlerini oluşturmaktadır. Literatürde en sık karşılaşılan postoperatif komplikasyonlar arasında atrial fibrilasyon (%15-30), enfeksiyon (%3-5) ve kanama (%2-4) bildirilmektedir (Güre & Güçlüel, 2025; Gürel & Koçaşlı, 2022). Atrial fibrilasyonun erken saptanması için hemşirelerin düzenli EKG monitorizasyonu yapması ve antiaritmik tedavi protokollerine hakim olması gerekmektedir (Güre & Güçlüel, 2025). Enfeksiyon kontrolü kapsamında cerrahi insizyon bölgesinin günlük değerlendirilmesi, erken mobilizasyonun sağlanması ve derin ven trombozu profilaksisinin uygulanması önem taşımaktadır (Güre & Güçlüel, 2025; Yeşilyurt vd., t.y.). Kanama komplikasyonları açısından drenaj miktarı ve karakteri yakından izlenmeli, hemoglobin ve hematokrit değerleri takip edilmelidir (Güre & Güçlüel, 2025). CO_2 insüflasyonuna bağlı gelişebilen abdominal distansiyon ve omuz ağrısı gibi durumlar için uygun pozisyonlama teknikleri ve analjezi protokolleri uygulanmalıdır (Güre & Güçlüel, 2025). Robotik cerrahinin geleneksel yöntemlere kıyasla daha düşük komplikasyon oranları sunmasına rağmen, hemşirelerin bu potansiyel risklere karşı hazırlıklı olması hasta güvenliğinin temel gerekliliğidir (Harky vd., 2020; Moloney vd., 2020; Şenol Çelik vd., 2024).Taburculuk öncesi dönemde hastalara yara bakımı, ilaç yönetimi ve aktivite kısıtlamaları konusunda kapsamlı eğitim verilmesi, komplikasyonların önlenmesinde kritik rol oynamaktadır (Albayram vd., 2022; Güre & Güçlüel, 2025).

TABURCULUK VE EVDE BAKIM PLANLAMASI

1.12. Hasta/Aile Eğitimi

Robotik kalp cerrahisi sonrası taburculuk sürecinde hasta ve aile eğitimi, iyileşmenin sürekliliği ve komplikasyonların önlenmesi açısından kritik rol oynamaktadır. Hemşireler tarafından verilecek eğitimlerde öncelikle yara bakımı üzerinde durulmalı; insizyon bölgesinin temizliği, enfeksiyon bulguları (kızarıklık, şişlik, akıntı veya ateş) ve pansuman teknikleri detaylı şekilde açıklanmalıdır (Albayram vd., 2022; Güre & Güçlüel, 2025). İlaç yönetimi

konusunda ise özellikle antikoagülan tedavinin önemi vurgulanmalı, dozlar, alım zamanları ve olası yan etkiler (anormal kanama, morarma) hakkında bilgi verilmelidir. Warfarin kullanan hastalar için INR takibi ve beslenme kısıtlamaları mutlaka anlatılmalıdır (Albayram vd., 2022). Eğitimlerin etkinliğini artırmak amacıyla görsel materyaller (eğitim broşürleri, maketler) kullanılmalı ve "geri anlatım" yöntemiyle hastanın anlama düzeyi değerlendirilmelidir (Albayram vd., 2022; Güzel & Yava, 2022).

Psikososyal Destek

Robotik kalp cerrahisi sonrası psikososyal destek sürecinde hemşireler, hastaların beden imajına ilişkin kaygılarını (minimal skarların iyileşme süreci gibi) yönetmeli ve adaptasyon sürecine destek olmalıdır (Özyürek & Göktaş, 2021; Yeşilyurt vd., t.y.). Anksiyete ve depresyon belirtilerinin taranması için Edinburgh Postnatal Depresyon Ölçeği gibi standart araçlar kullanılmalı, özellikle postoperatif ilk 3 ayda psikolojik destek ihtiyacı olan hastalar psikiyatri konsültasyonuna yönlendirilmelidir (Özyürek & Göktaş, 2021). Hasta ve aile eğitimlerinde acil durum yönetimi (göğüs ağrısı, nefes darlığı gibi semptomlarda izlenecek adımlar) gibi temel bilgiler net şekilde aktarılmalıdır (Albayram vd., 2022; Güre & Güçlüel, 2025). Taburculuk sonrası bakım sürecinin etkinliğini artırmak için entegre bir yaklaşım benimsenmelidir (Albayram vd., 2022). ilk 72 saatte günlük telefon takipleri (ağrı skoru, enfeksiyon bulguları ve vital parametrelerin değerlendirilmesi), birinci haftada yara kontrolü için poliklinik randevusu, 2-4 hafta arasında kademeli mobilizasyon planı (30 dakika/gün yürüyüş) ve altıncı haftada kardiyak rehabilitasyon değerlendirmesi yapılmalıdır (Albayram vd., 2022; Güre & Güçlüel, 2025). Hastaların yaklaşık %30'unda görülebilen ilaç uyumsuzluğu riski göz önünde bulundurularak eğitimler tekrarlanmalı ve hasta destek gruplarına katılım teşvik edilmelidir (Güre & Güçlüel, 2025; Yeşilyurt vd., t.y.). Tüm eğitim ve destek süreçleri, hastaların ve ailelerin öğrenme kapasiteleri ile bireysel ihtiyaçlarına göre uyarlanmalı ve kayıt altına alınmalıdır (Güre & Güçlüel, 2025; Güzel & Yava, 2022). Bu kapsamlı yaklaşım, robotik kalp cerrahisi geçiren hastaların güvenli iyileşme süreci tamamlamalarını ve yaşam kalitelerini artırmalarını sağlayacaktır.

TÜRKİYE BAĞLAMINDA ÖNERİLER VE SONUÇ

1.13. Yerel Uygulamalara Yansımalar

Türkiye'de robotik kalp cerrahisi uygulamalarının artmasına rağmen, hemşirelik alanında standart protokol eksikliği ve eğitim yetersizliği önemli sorunlar olarak öne çıkmaktadır. Silveira ve Catal'ın (2021) 12 ülkeyi kapsayan çalışmasında, Türkiye'den katılan hemşirelerin %73'ü standart protokol olmamasını temel problem olarak belirtmiş (Silveira Thomas Porto & Catal, 2021), bu durum ülkedeki merkezlerin %85'inde formal eğitim bulunmamasıyla örtüşmektedir (Uslu vd., 2019). Nirgiz (2025) ise Türk hemşirelerin %62'sinin robotik teknoloji eğitiminden yoksun olduğunu tespit ederek sorunun boyutunun giderek büyüdüğünü vurgulamıştır (Nirgiz, 2025). Mevcut durumda, Türkiye genelinde yalnızca 90-100 robotik cerrahi hemşiresinin bulunması, alandaki ciddi insan kaynağı açığını ortaya koymaktadır (Uslu vd., 2019). Eğitimlerin çoğunlukla "usta-çırak" modeliyle sınırlı kalması ve teorik altyapıdan yoksun olması, hemşirelerin yeterlilik kazanmasını engellemektedir (Uslu vd., 2019). Ayrıca, robotik cerrahi hemşirelerinin görev tanımlarının net olmaması, farklı merkezlerde tutarsız uygulamalara yol açmakta ve hasta güvenliğini riske atmaktadır (Uslu vd., 2019). Ülkedeki 32 robotik cerrahi merkezinde standart bir hemşirelik yaklaşımının bulunmayışı ise kalite kontrolünü zorlaştırmakta ve hizmet sunumunda eşitsizliklere neden olmaktadır (Uslu vd., 2019).

1.14. Standart Protokol İhtiyacı

Türkiye'de robotik kalp cerrahisi hemşireliği uygulamalarının standardizasyonu, kapsamlı protokollerin geliştirilmesini acilen gerektirmektedir. Bu protokollerin temelini, robotik sistemlerle çalışma becerilerini içeren eğitim standartları oluşturmalıdır (Nirgiz, 2025; Uslu vd., 2019). Nirgiz (2025) tarafından önerildiği üzere, robotik cerrahi becerilerinin temel

hemşirelik yeterlilikleri arasına alınması ve yıllık sertifikasyon yenileme zorunluluğu getirilmesi, özellikle simülasyon tabanlı acil durum eğitimleriyle (sistem arızaları, konvansiyonel cerrahiye geçiş) desteklenmelidir (Güre & Güçlüel, 2025; Nirgiz, 2025). Klinik uygulama rehberleri; preoperatif hazırlık (ekipman kontrolü, hasta pozisyonlama), sterilizasyon protokolleri ve acil durum algoritmalarını (kanama, kardiyak arrest) kapsayacak şekilde standardize edilmeli, hasta güvenliği için pozisyonlama standartları ve komplikasyon izlem protokolleri oluşturulmalıdır (Albayram vd., 2022; Güre & Güçlüel, 2025; Moloney vd., 2020; Uslu vd., 2019). Bu standartların etkin uygulanması, Sağlık Bakanlığı onaylı ulusal rehberler ve düzenli denetim mekanizmalarıyla sağlanmalıdır (Uslu vd., 2019). Güdeloğlu ve Parekattil (2021) tarafından desteklendiği gibi, robotik cerrahi hemşireliğinin resmi uzmanlık dalı olarak tanınması, yüksek lisans programlarının açılması ve yeterlilik kriterlerinin belirlenmesi, hem klinik özgüveni artıracak hem de bakım kalitesini yükseltecektir(Gudeloglu & Parekattil, 2021; Güre & Güçlüel, 2025; Uslu vd., 2019). Multidisipliner ekip çalışmasının güçlendirilmesi ve yasal düzenlemelerin yapılması, Türkiye'nin robotik kalp cerrahisinde uluslararası standartlara ulaşmasını sağlayacak kritik adımlardır (Alcan vd., 2019; Güre & Güçlüel, 2025; Uslu vd., 2019).

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ROBOTİK KALP CERRAHİSİNDE HEMŞİRELİK ROLÜ: SÜREÇLER, AVANTAJLAR, DEZAVANTAJLAR VE TÜRKİYE'DEKİ UYGULAMALARA YÖNELİK ÖNERİLER

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ÖZET
Robotik kalp cerrahisi, da Vinci Cerrahi Sistemi gibi gelişmiş platformlarla uygulanan minimal invaziv bir tekniktir. Bu yöntem, üç boyutlu görüntüleme ve artırılmış hassasiyet avantajları sayesinde dar anatomik bölgelerde güvenli müdahalelere olanak tanımaktadır. Özellikle mitral kapak tamiri ve koroner bypass gibi kompleks prosedürlerde geleneksel yöntemlere kıyasla önemli klinik avantajlar sunmaktadır. Robotik cerrahi teknolojisi 1990'larda AESOP ve ZEUS sistemleriyle başlamış, 2000 yılında da Vinci sisteminin FDA onayı almasıyla önemli bir aşama kaydetmiştir. Türkiye'de ise bu alandaki uygulamalar 2003 yılında başlamış olup, günümüzde 8 ildeki 32 merkezde aktif olarak yürütülmektedir. Hasta açısından azalmış kan kaybı, düşük enfeksiyon riski ve kısalmış hastane yatış süresi gibi avantajlar sunarken, cerrahi ekip için üç boyutlu görüntüleme ve el titremesi filtrasyonu sağlamaktadır. Ancak yüksek maliyetler, uzun öğrenme eğrisi ve dokunma hissi eksikliği gibi önemli sınırlılıkları bulunmaktadır. Robotik kalp cerrahisinde hemşireler; preoperatif dönemde hasta eğitimi ve teknik hazırlık, intraoperatif süreçte cerrahi asistan ve acil durum yönetimi, postoperatif dönemde komplikasyon izlemi ve taburculuk planlaması gibi kritik roller üstlenmektedir. Türkiye'de bu alanda karşılaşılan temel zorluklar formal eğitim eksikliği ve standart protokol yokluğudur. Bu sorunların aşılması için; kapsamlı klinik rehberlerin geliştirilmesi Robotik cerrahi hemşireliğinin uzmanlık alanı olarak tanınması, multidisipliner ekip işbirliğinin güçlendirilmesi gerekmektedir. Bu önlemlerin uygulanmasıyla hemşirelik standartlarının yükseltilmesi ve hasta güvenliği ile cerrahi başarının artırılması mümkün olacaktır.
Anahtar Kelimeler: Robotik kalp cerrahisi, hemşirelik rolü, minimal invaziv cerrahi, hasta güvenliği, Türkiye'de robotik cerrahi

THE ROLE OF NURSING IN ROBOTIC CARDIAC SURGERY: PROCESSES, ADVANTAGES, DISADVANTAGES, AND RECOMMENDATIONS FOR PRACTICES IN TURKEY

ABSTRACT
Robotic cardiac surgery is a minimally invasive technique performed using advanced platforms such as the da Vinci Surgical System. This method enables safe interventions in confined anatomical spaces, owing to its advantages of three-dimensional imaging and enhanced precision. Particularly in complex procedures such as mitral valve repair and coronary artery bypass grafting, it offers significant clinical benefits compared to conventional techniques.

Robotic surgical technology began in the 1990s with the AESOP and ZEUS systems and achieved a major milestone in 2000 when the da Vinci system received FDA approval. In Turkey, applications in this field commenced in 2003, and today, they are actively conducted across 32 centers in 8 provinces. While providing patients with advantages such as reduced blood loss, lower infection risk, and shorter hospital stays, it also offers three-dimensional visualization and tremor filtration for the surgical team. However, notable limitations include high costs, a steep learning curve, and the lack of tactile feedback. In robotic cardiac surgery, nurses assume critical roles, including patient education and technical preparation in the preoperative phase, surgical assistance and emergency management during the intraoperative process, and complication monitoring and discharge planning in the postoperative period. The primary challenges in Turkey in this field are the lack of formal training and standardized protocols. To address these issues, it is essential to develop comprehensive clinical guidelines, recognize robotic surgical nursing as a specialized field, and strengthen multidisciplinary team collaboration. Implementing these measures will enhance nursing standards, improve patient safety, and increase surgical success.
Keywords: Robotic cardiac surgery, nursing role, minimally invasive surgery, patient safety, robotic surgery in Turkey

GİRİŞ

1.15. Robotik Kalp Cerrahisi ve Tarihsel Gelişimi

Robotik yardımlı cerrahinin kökenleri 1990'ların sonlarına dayanmakta olup, ilk uygulamalar AESOP (Automated Endoscopic System for Optimal Positioning) ve ZEUS robotik sistemleriyle Birleşik Krallık'ta gerçekleştirilmiştir(Şenol Çelik vd., 2024). 2000 yılında FDA onaylı ilk ticari robotik cerrahi sistemi olan da Vinci'nin piyasaya sürülmesiyle birlikte bu alanda önemli bir dönüm noktası yaşanmıştır(Gudeloglu & Parekattil, 2021). Günümüzde 70'ten fazla ülkede 12 milyondan fazla robotik destekli prosedür gerçekleştirilmiş olup, Amerika Birleşik Devletleri'ndeki hastanelerin yaklaşık %60'ında en az bir da Vinci sistemi bulunmaktadır (Gudeloglu & Parekattil, 2021; Şenol Çelik vd., 2024). Türkiye'de ise robotik cerrahi uygulamaları ilk olarak 2003 yılında bypass cerrahisi alanında başlamış, son yıllarda hızla yaygınlaşarak günümüzde sekiz ilde (İstanbul, Ankara, İzmir, Kocaeli, Bursa, Adana, Antalya ve Samsun) 32 merkezde rutin olarak uygulanır hale gelmiştir(Uslu vd., 2019). Ülke genelinde yaklaşık 132 cerrah ve 90-100 robotik cerrahi hemşiresi bu alanda hizmet vermekte olup, özellikle büyük eğitim ve araştırma hastanelerinde robotik kalp cerrahisi programları aktif olarak yürütülmektedir (Uslu vd., 2019; Yeşilyurt vd., t.y.). Bu gelişmeler, robotik cerrahinin küresel ve ulusal sağlık sistemlerinde giderek artan önemini ortaya koymaktadır.

Robotik kalp cerrahisi, minimal invaziv cerrahi tekniklerinin en gelişmiş örneklerinden biri olarak kabul edilen ve özellikle da Vinci Cerrahi Sistemi (Intuitive Surgical Inc., Sunnyvale, CA) gibi robotik platformlar kullanılarak gerçekleştirilen kardiyak girişimleri ifade etmektedir (Gudeloglu & Parekattil, 2021; Şenol Çelik vd., 2024). Bu yöntem, cerrahlara üç boyutlu, yüksek çözünürlüklü görüntüleme ve 7 derece serbestlik derecesine sahip enstrümanlarla artırılmış hareket hassasiyeti sağlayarak özellikle dar anatomik alanlarda daha kesin ve kontrollü müdahalelere olanak tanımaktadır (Harky vd., 2020; İnce vd., 2020). Burayı avantajlara ekle

1.16. Robotik Kalp Cerrahisinin Kullanım Alanları, Avantajları ve Dezavantajları

Robotik kalp cerrahisi, mitral kapak tamiri, koroner arter baypas greftleme, atriyal septal defekt onarımı ve kardiyak tümör eksizyonu gibi kompleks kardiyak prosedürlerde giderek artan sıklıkla uygulanmaktadır(Güre & Güçlüel, 2025; İnce vd., 2020). .

Robotik kalp cerrahisinin hasta ve cerrah açısından pek çok avantajı bulunmaktadır. Geleneksel açık kalp cerrahisine kıyasla küçük insizyonlarla (5-10 mm) gerçekleştirilen bu teknik, doku travmasını minimize ederek kan kaybını azaltmakta, postoperatif ağrıyı önemli ölçüde

azaltmakta ve hastanın iyileşme sürecini hızlandırmaktadır (Harky vd., 2020; Moloney vd., 2020; Şenol Çelik vd., 2024). Hasta tarafında en önemli avantajlar; %70-80 daha az kan kaybı, geleneksel yöntemlere kıyasla %60 daha düşük enfeksiyon riski, hastanede kalış süresinin 3-5 gün kısalması ve normal yaşantıya dönüş süresinin belirgin şekilde hızlanması olarak sıralanabilir (Harky vd., 2020; Moloney vd., 2020; Şenol Çelik vd., 2024). Harky ve arkadaşlarının (2020) çalışmasına göre, robotik mitral kapak cerrahisinde mortalite oranları %0.5-1.2 aralığında olup, bu oran geleneksel yöntemlerle karşılaştırıldığında istatistiksel olarak anlamlı derecede düşüktür(Harky vd., 2020). Cerrahlar açısından ise üç boyutlu görüntüleme, el titremesi filtrasyonu ve ergonomik çalışma pozisyonu gibi avantajlar sunmaktadır (Harky vd., 2020; İnce vd., 2020).

Robotik kalp cerrahisinin bazı kısıtlılıkları bu yöntemi dezavantajlı hale getirebilmektedir. Bunlardan bazıları; sistemin yüksek maliyeti (1-2.5 milyon dolar), uzun öğrenme eğrisi (150-200 vaka deneyimi) ve deneyimli cerrahi ekibe ihtiyaç duyulmasıdır (Fida vd., 2024; Harky vd., 2020). Prattia ve ark. (2020) meta-analizinde, robotik mitral kapak cerrahisinde %3-5 oranında teknik zorluklar nedeniyle konvansiyonel cerrahiye geçiş gerektiği belirtilmiştir (Pratita vd., 2022). Ayrıca, ameliyat sürelerinin %20-30 daha uzun olması, haptik feedback eksikliği ve hasta pozisyonlamasındaki zorluklar diğer önemli sınırlılıklar olarak karşımıza çıkmaktadır (Harky vd., 2020; Moloney vd., 2020; Şenol Çelik vd., 2024). Bu avantaj ve dezavantajların dikkatli değerlendirilmesi, robotik kalp cerrahisinin uygun hasta seçiminde belirleyici rol oynamaktadır.

1.17. Robotik Kalp Cerrahisinde Hemşirenin Rolü ve Önemi

Robotik kalp cerrahisinde hemşireler, multidisipliner cerrahi ekibin vazgeçilmez bir üyesi olarak preoperatif, intraoperatif ve postoperatif süreçlerde kritik roller üstlenmektedir (Uslu vd., 2019; Yeşilyurt & Durmaz, 2023). Akaltun ve ark. (2023) tarafından vurgulandığı üzere, robotik teknolojiler hemşirelik uygulamalarını teknik beceri gelişimi, ekip koordinasyonu ve hasta eğitimi gibi çok boyutlu bir dönüşüme zorlamaktadır (Akaltun vd., 2025). Preoperatif dönemde hasta eğitimi ve psikolojik destekle birlikte robotik sistem kurulumu ve sterilizasyon protokollerinin uygulanması temel sorumluluklar arasındadır (Güzel & Yava, 2022; Lee & Hong, 2023; Özyürek & Göktaş, 2021; Uslu vd., 2019). Intraoperatif süreçte hemşireler, hasta pozisyonlaması (özellikle steep Trendelenburg pozisyonunda sinir hasarının önlenmesi), cerrahi ekibe dinamik destek ve acil durum yönetimi (elektrik kesintisinde hex wrench kullanımı gibi) gibi hayati roller üstlenir (Güre & Güçlüel, 2025; Lee & Hong, 2023; Moloney vd., 2020). Postoperatif dönemde ise komplikasyon izlemi (kanama, enfeksiyon, atrial fibrilasyon), ağrı yönetimi ve erken mobilizasyon hemşirelik bakımının temel bileşenlerini oluşturur (Alcan vd., 2019; Güre & Güçlüel, 2025; Yeşilyurt vd., t.y.). Ancak Türkiye'de robotik cerrahi hemşireliği alanında standart eğitim programlarının eksikliği, yasal yeterliliklerin belirsizliği ve informal öğrenme yöntemlerinin yaygınlığı önemli bir sorun teşkil etmektedir (Uslu vd., 2019). Uslu ve ark. (2019) çalışmasında hemşirelerin %85'inin robotik cerrahi eğitimi almadığını ve bilgi düzeylerinin yetersiz olduğunu tespit etmiştir ki bu durum hasta güvenliği ve cerrahi başarı açısından ciddi risk oluşturmaktadır (7). Bu nedenle, robotik cerrahi hemşireliğinin standartlaştırılması ve resmi bir uzmanlık alanı olarak tanınması acil bir ihtiyaç haline gelmiştir (Uslu vd., 2019).

AMELİYAT ÖNCESİ (PREOPERATİF) HEMŞİRELİK ROLÜ

1.18. Hasta Eğitimi ve Psikolojik Destek

Robotik kalp cerrahisi öncesinde hemşirelerin hasta eğitimi ve psikolojik destek süreçleri kritik önem taşımaktadır. Literatürde, hemşirelerin genellikle ameliyattan bir gün önce hasta eğitimini gerçekleştirdiği belirtilmektedir (Güzel & Yava, 2022). Eğitim içeriği; cerrahi sürecin aşamaları, beklenen sonuçlar, olası komplikasyonlar, postoperatif ağrı yönetimi ve iyileşme sürecine ilişkin detayları kapsamalıdır(Güre & Güçlüel, 2025; Güzel & Yava, 2022).Hastaların cerrahiye ilişkin anksiyete düzeylerinin yönetimi, hemşirelerin önemli sorumlulukları

arasındadır. Araştırmalar, preoperatif dönemde verilen psikolojik desteğin hastaların anksiyete düzeylerini %40-60 oranında azalttığını ve bu durumun postoperatif iyileşme sürecini olumlu yönde etkilediğini göstermektedir(Özyürek & Göktaş, 2021). Özellikle robotik cerrahi gibi yeni teknolojilerle ilgili hasta endişelerinin giderilmesi, cerrahiye uyumu artırmaktadır. Hemşireler, hastaların bireysel ihtiyaçlarına göre danışmanlık sağlamalı ve aile üyelerini de sürece dahil etmelidir(Alcan vd., 2019; Özyürek & Göktaş, 2021).

1.19. Teknik Hazırlık

Robotik kalp cerrahisi öncesi teknik hazırlık, hemşirelerin cerrahi güvenliğini sağlamadaki temel sorumluluklarından biridir. Bu süreç kapsamında da Vinci sisteminin cerrah konsolu, hasta yanı ünite ve görüntüleme sisteminin fonksiyonel kontrolü yapılmalı, kabloların bağlantıları kontrol edilmeli ve steril örtüler uygun şekilde yerleştirilmelidir (Güre & Güçlüel, 2025; Lee & Hong, 2023; Uslu vd., 2019). Sterilizasyon protokollerine özellikle robotik kollar ve kamera adaptörleri için titizlikle uyulmalıdır (Lee & Hong, 2023). Hasta güvenliği açısından acil durum setlerinin (hex wrench, konvansiyonel cerrahi setleri) hazır bulundurulması ve tüm ekip tarafından bilinirliğinin sağlanması gerekmektedir (Güre & Güçlüel, 2025; Moloney vd., 2020). Literatürde %7'ye varan ekipman arıza oranları bildirilmesi, bu hazırlıkların önemini ortaya koymaktadır (Zeuschner vd., 2023). Steep Trendelenburg pozisyonu için gerekli yastık ve destek malzemelerinin hazırlanması, sinir hasarı ve bası yaraları gibi komplikasyonların önlenmesinde kritik rol oynar (Güre & Güçlüel, 2025). Time-out prosedüründe hasta kimliği doğrulaması, cerrahi bölge işaretlemesi ve ekipman kontrollerinin eksiksiz yapılması standart uygulama olarak benimsenmelidir (Zeuschner vd., 2023). Bu kapsamlı hazırlık süreci, robotik kalp cerrahisinin güvenli şekilde gerçekleştirilmesinin temelini oluşturmaktadır.

AMELİYAT SIRASI (İNTRAOPERATİF) HEMŞİRELİK ROLÜ

1.20. Robotik Sistem Kurulumu ve Kontrolü

Hemşirelerin intraoperatif dönemdeki en kritik sorumluluklarından biri, robotik sistemin doğru şekilde kurulumunu sağlamaktır. Bu süreç, cerrah konsolu, hasta yanı ünite ve görüntüleme sisteminin birbirine entegrasyonunu içerir (Gudeloglu & Parekattil, 2021; Lee & Hong, 2023). Özellikle robotik kolların steril örtülerle kaplanması ve kamera adaptörlerinin yerleştirilmesi enfeksiyon kontrolü açısından hayati önem taşır (Lee & Hong, 2023; Uslu vd., 2019). Hemşireler, üretici firmanın talimatlarına uygun olarak görüntüleme ünitesi ile cerrah konsolu arasındaki kabloları bağlamalı ve bu kabloların cerrahi alanı engellemeyecek şekilde düzenlendiğinden emin olmalıdır (Gudeloglu & Parekattil, 2021; Lee & Hong, 2023). Ayrıca, robotik enstrüman sepetinin tam donanımlı olduğunu ve yedek enstrümanların hazır bulunduğunu kontrol etmelidir(Moloney vd., 2020; Uslu vd., 2019).

1.21. Hasta Pozisyonlama ve Güvenliği

Robotik kalp cerrahisinde hasta pozisyonlaması, cerrahi başarı ve komplikasyonların önlenmesi açısından kritik bir unsurdur. Özellikle steep Trendelenburg pozisyonunda (25-45 derece baş aşağı) hastanın kaymasını önlemek ve brakial pleksus yaralanması, peroneal sinir hasarı ile dekübit ülseri riskini minimize etmek için uygun yastık ve destek sistemlerinin kullanılması gerekmektedir (Bjøro vd., 2023; Güre & Güçlüel, 2025). Bjøro ve ark. (2023), bu pozisyonun aynı zamanda intraoküler basınç artışı ve dil ödemi gibi komplikasyon risklerini de beraberinde getirdiğini belirtmişlerdir(Bjøro vd., 2023). Hemşirelerin pozisyonlama sırasında tüm eklemlerin anatomik pozisyonda olduğundan emin olması ve basınç noktalarını koruyucu önlemler alması esastır (Güre & Güçlüel, 2025; Moloney vd., 2020). Ayrıca, uzun süreli pozisyonun yol açabileceği komplikasyonların erken tespiti için hastanın sürekli monitorizasyonu büyük önem taşımaktadır (Güre & Güçlüel, 2025). Bu önlemlerin titizlikle uygulanması, robotik kalp cerrahisinde hasta güvenliğini artıran temel faktörlerdendir.

1.22. Cerrahi Asistans ve Ekip Koordinasyonu

Robotik cerrahide cerrahın konsolda konumlanması, hasta başındaki hemşirenin operasyonel liderlik rolünü ön plana çıkarmaktadır. Hemşirelerin cerrahi ekibin ihtiyaç duyduğu

enstrümanları zamanında temin etmesi, steril alan bütünlüğünü koruması ve robotik kolların hareket alanını kontrol ederek ekip güvenliğini sağlaması kritik önem taşımaktadır (5,7,11). Cerrahi görüşü engelleyen buhar veya kanama gibi durumların hızla yönetilmesi de hemşirenin sorumluluk alanına girmektedir (Güre & Güçlüel, 2025; Yeşilyurt & Durmaz, 2023). Akaltun ve ark. (2023) ile Bjøro ve ark. (2023)'ün vurguladığı gibi, cerrah-anestezi-hemşire üçlüsü arasındaki kusursuz senkronizasyon ve net iletişim hasta güvenliğinin temelini oluşturmaktadır(Akaltun vd., 2025; Bjøro vd., 2023). Özellikle acil durumlarda kısa ve anlaşılır komutlarla cerrahın durumu hızla kavraması sağlanmalıdır (Moloney vd., 2020; Uslu vd., 2019). Bu dinamik çalışma ortamında hemşirelerin liderlik becerileri ve ekip koordinasyon yetkinlikleri cerrahi başarıyı doğrudan etkilemektedir (Akaltun vd., 2025; Bjøro vd., 2023).

1.23. Acil Durum Yönetimi

Robotik cerrahi süreçlerinde acil durumlara hazırlıklı olunması hasta güvenliği açısından kritik önem taşımaktadır. Hemşirelerin, elektrik kesintisi veya sistem arızası durumunda acil durum hex wrench'in yerini bilmesi ve robotik kolların manüel olarak serbest bırakılmasını sağlaması gerekmektedir (Moloney vd., 2020). Konvansiyonel cerrahiye acil geçiş için gerekli enstrüman setlerinin hazır bulundurulması ve kanama gibi komplikasyonlarda kan ürünlerinin hızla temin edilmesi esastır(Güre & Güçlüel, 2025; Moloney vd., 2020; Uslu vd., 2019). Özellikle kardiyak prosedürlerde potansiyel ritim bozukluklarına karşı defibrilatör ve acil ilaçların ameliyathanede hazır konumda tutulması zorunludur (İnce vd., 2020; Moloney vd., 2020). Bu önlemlerin alınması, olası komplikasyonların hızla kontrol altına alınmasını sağlayarak cerrahi güvenliği artırmaktadır.

1.24. Sterilizasyon ve Enfeksiyon Kontrolü

Robotik cerrahide steril alanın korunması, geleneksel cerrahiye göre daha karmaşık bir süreç gerektirmektedir. Hemşirelerin öncelikle robotik kolların steril ve steril olmayan bölümlerini ayırt edebilmesi ve ameliyat boyunca steril örtülerin bütünlüğünü sürekli kontrol etmesi gerekmektedir (4,6). Görüntüleme kalitesinin korunması açısından, kamera lensinin buğulanmasını önlemek için özel antifog solüsyonlar kullanılmalı ve görüntü kalitesi operasyon süresince düzenli olarak değerlendirilmelidir (Lee & Hong, 2023). Robotik cerrahi enstrümanlarının her kullanım sonrası sterilizasyon protokollerine uygun şekilde temizlenmesi ve bakımının yapılması enfeksiyon kontrolü açısından kritik öneme sahiptir (Uslu vd., 2019). Çalışmalar, robotik cerrahide enfeksiyon oranlarının geleneksel yöntemlere göre %30-40 daha düşük olduğunu göstermekle birlikte, bu avantajın sürdürülebilmesi sterilizasyon kurallarına sıkı uyuma bağlıdır (Güre & Güçlüel, 2025; Lee & Hong, 2023).

1.25. Hasta Monitörizasyonu ve Kayıt Tutma

Hemşireler, ameliyat süresince hastanın vital bulgularını (EKG, kan basıncı, SpO2) sürekli izlemeli ve anormal değerleri anestezi ekibine bildirmelidir (Güre & Güçlüel, 2025; İnce vd., 2020). Özellikle karbondioksit insüflasyonuna bağlı gelişebilecek hiperkarbi ve asidoz belirtilerine dikkat edilmelidir (Güre & Güçlüel, 2025). Ayrıca, kullanılan enstrümanların kaydı, ameliyat süresi ve cerrahi süreçteki önemli olaylar (örneğin robotik sistem arızası, konvansiyonel cerrahiye geçiş) titizlikle kaydedilmelidir (Uslu vd., 2019; Zeuschner vd., 2023). Bu kayıtlar, hem hasta güvenliği hem de kalite iyileştirme çalışmaları için kritik öneme sahiptir (Zeuschner vd., 2023).

AMELİYAT SONRASI (POSTOPERATİF) HEMŞİRELİK BAKIM ROLÜ

1.26. Yoğun Bakım Yönetimi

Robotik kalp cerrahisi sonrası yoğun bakım sürecinde hemşirelik bakımı multidisipliner bir yaklaşım gerektirmektedir. Hemşireler, postoperatif dönemde hastanın hemodinamik stabilizasyonunu sağlamak amacıyla kan basıncı, kalp hızı, solunum sayısı ve SpO2 gibi vital parametreleri sık aralıklarla monitorize etmeli ve anormal değerleri acil olarak bildirmelidir (Güre & Güçlüel, 2025; Gürel & Koçaşlı, 2022). Solunum fonksiyonlarının değerlendirilmesi,

derin inspiryum egzersizlerinin öğretilmesi ve uygun öksürük tekniklerinin uygulanması erken ekstübasyon sürecini kolaylaştırmaktadır(Gürel & Koçaşlı, 2022; Yanık & Yılmaz, 2019). Kardiyak outputun optimize edilmesi için sıvı-elektrolit dengesinin yakın takibi ve doktor istemleri doğrultusunda diüretik tedavinin uygulanması gerekmektedir (Gürel & Koçaşlı, 2022). Ağrı yönetiminde hasta kontrollü analjezi (PCA) protokolleri uygulanmalı ve ağrı skorları düzenli olarak değerlendirilmelidir(Yanık & Yılmaz, 2019; Yeşilyurt vd., t.y.). Robotik cerrahinin minimal invaziv doğası, hastaların yoğun bakımda kalış sürelerini geleneksel cerrahi yöntemlere kıyasla belirgin şekilde kısaltmaktadır (Moloney vd., 2020; Şenol Çelik vd., 2024). Bu avantajın korunabilmesi için hemşirelerin komplikasyonların erken tanı ve yönetiminde dikkatli olması ve protokollere uygun davranması kritik önem taşımaktadır.

1.27. Komplikasyon Önleme

Robotik kalp cerrahisi sonrası komplikasyonların erken tanı ve yönetimi, hemşirelik bakımının kritik bileşenlerini oluşturmaktadır. Literatürde en sık karşılaşılan postoperatif komplikasyonlar arasında atrial fibrilasyon (%15-30), enfeksiyon (%3-5) ve kanama (%2-4) bildirilmektedir (Güre & Güçlüel, 2025; Gürel & Koçaşlı, 2022). Atrial fibrilasyonun erken saptanması için hemşirelerin düzenli EKG monitorizasyonu yapması ve antiaritmik tedavi protokollerine hakim olması gerekmektedir (Güre & Güçlüel, 2025). Enfeksiyon kontrolü kapsamında cerrahi insizyon bölgesinin günlük değerlendirilmesi, erken mobilizasyonun sağlanması ve derin ven trombozu profilaksisinin uygulanması önem taşımaktadır (Güre & Güçlüel, 2025; Yeşilyurt vd., t.y.). Kanama komplikasyonları açısından drenaj miktarı ve karakteri yakından izlenmeli, hemoglobin ve hematokrit değerleri takip edilmelidir (Güre & Güçlüel, 2025). CO_2 insüflasyonuna bağlı gelişebilen abdominal distansiyon ve omuz ağrısı gibi durumlar için uygun pozisyonlama teknikleri ve analjezi protokolleri uygulanmalıdır (Güre & Güçlüel, 2025). Robotik cerrahinin geleneksel yöntemlere kıyasla daha düşük komplikasyon oranları sunmasına rağmen, hemşirelerin bu potansiyel risklere karşı hazırlıklı olması hasta güvenliğinin temel gerekliliğidir (Harky vd., 2020; Moloney vd., 2020; Şenol Çelik vd., 2024).Taburculuk öncesi dönemde hastalara yara bakımı, ilaç yönetimi ve aktivite kısıtlamaları konusunda kapsamlı eğitim verilmesi, komplikasyonların önlenmesinde kritik rol oynamaktadır (Albayram vd., 2022; Güre & Güçlüel, 2025).

TABURCULUK VE EVDE BAKIM PLANLAMASI

1.28. Hasta/Aile Eğitimi

Robotik kalp cerrahisi sonrası taburculuk sürecinde hasta ve aile eğitimi, iyileşmenin sürekliliği ve komplikasyonların önlenmesi açısından kritik rol oynamaktadır. Hemşireler tarafından verilecek eğitimlerde öncelikle yara bakımı üzerinde durulmalı; insizyon bölgesinin temizliği, enfeksiyon bulguları (kızarıklık, şişlik, akıntı veya ateş) ve pansuman teknikleri detaylı şekilde açıklanmalıdır (Albayram vd., 2022; Güre & Güçlüel, 2025). İlaç yönetimi konusunda ise özellikle antikoagülan tedavinin önemi vurgulanmalı, dozlar, alım zamanları ve olası yan etkiler (anormal kanama, morarma) hakkında bilgi verilmelidir. Warfarin kullanan hastalar için INR takibi ve beslenme kısıtlamaları mutlaka anlatılmalıdır (Albayram vd., 2022). Eğitimlerin etkinliğini artırmak amacıyla görsel materyaller (eğitim broşürleri, maketler) kullanılmalı ve "geri anlatım" yöntemiyle hastanın anlama düzeyi değerlendirilmelidir (Albayram vd., 2022; Güzel & Yava, 2022).

1.29. Psikososyal Destek

Robotik kalp cerrahisi sonrası psikososyal destek sürecinde hemşireler, hastaların beden imajına ilişkin kaygılarını (minimal skarların iyileşme süreci gibi) yönetmeli ve adaptasyon sürecine destek olmalıdır (Özyürek & Göktaş, 2021; Yeşilyurt vd., t.y.). Anksiyete ve depresyon belirtilerinin taranması için Edinburgh Postnatal Depresyon Ölçeği gibi standart araçlar kullanılmalı, özellikle postoperatif ilk 3 ayda psikolojik destek ihtiyacı olan hastalar psikiyatri konsültasyonuna yönlendirilmelidir (Özyürek & Göktaş, 2021). Hasta ve aile

eğitimlerinde acil durum yönetimi (göğüs ağrısı, nefes darlığı gibi semptomlarda izlenecek adımlar) gibi temel bilgiler net şekilde aktarılmalıdır (Albayram vd., 2022; Güre & Güçlüel, 2025). Taburculuk sonrası bakım sürecinin etkinliğini artırmak için entegre bir yaklaşım benimsenmelidir (Albayram vd., 2022). ilk 72 saatte günlük telefon takipleri (ağrı skoru, enfeksiyon bulguları ve vital parametrelerin değerlendirilmesi), birinci haftada yara kontrolü için poliklinik randevusu, 2-4 hafta arasında kademeli mobilizasyon planı (30 dakika/gün yürüyüş) ve altıncı haftada kardiyak rehabilitasyon değerlendirmesi yapılmalıdır (Albayram vd., 2022; Güre & Güçlüel, 2025). Hastaların yaklaşık %30'unda görülebilen ilaç uyumsuzluğu riski göz önünde bulundurularak eğitimler tekrarlanmalı ve hasta destek gruplarına katılım teşvik edilmelidir (Güre & Güçlüel, 2025; Yeşilyurt vd., t.y.). Tüm eğitim ve destek süreçleri, hastaların ve ailelerin öğrenme kapasiteleri ile bireysel ihtiyaçlarına göre uyarlanmalı ve kayıt altına alınmalıdır (Güre & Güçlüel, 2025; Güzel & Yava, 2022). Bu kapsamlı yaklaşım, robotik kalp cerrahisi geçiren hastaların güvenli iyileşme süreci tamamlamalarını ve yaşam kalitelerini artırmalarını sağlayacaktır.

Sonuç olarak, robotik kalp cerrahisi hem hasta hem de sağlık profesyonelleri açısından önemli avantajlar sunmakta; minimal invaziv yapısı sayesinde iyileşme sürecini hızlandırmakta, komplikasyon riskini azaltmakta ve hasta memnuniyetini artırmaktadır (Harky vd., 2020; Moloney vd., 2020; Şenol Çelik vd., 2024). Bu süreçte hemşireler, preoperatif hazırlıktan postoperatif bakıma kadar uzanan geniş bir yelpazede kritik roller üstlenmekte; teknik bilgi, klinik beceri ve iletişim yetkinlikleriyle multidisipliner ekiplerin ayrılmaz bir parçası haline gelmektedir (Güre & Güçlüel, 2025; Uslu vd., 2019)(Ancak Türkiye'de bu alanda karşılaşılan eğitim eksiklikleri, standart protokol yetersizlikleri ve yasal düzenlemelerin belirsizliği, hemşirelik uygulamalarının etkinliğini sınırlamaktadır (Alcan vd., 2019; Uslu vd., 2019).Bu nedenle, robotik cerrahi hemşireliğinin uzmanlık alanı olarak tanınması, yapılandırılmış eğitim programlarının geliştirilmesi ve ulusal düzeyde standart bakım protokollerinin oluşturulması, hem hasta güvenliğini artırmak hem de cerrahi başarıyı sürdürülebilir kılmak açısından büyük önem taşımaktadır (Albayram vd., 2022; Güzel & Yava, 2022; Uslu vd., 2019).

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OPTIMAL CONTROL OF A COCAINE–HEROIN EPIDEMIOLOGICAL MODEL INVOLVING THE PSI-CAPUTO FRACTIONAL TIME-DERIVATIVE

CHANNAN Khadija
HILAL Khalid
KAJOUNI Ahmed

In this work we study a fractional SEIR biological model for the cocaine–heroin of a reaction–diffusion, using the non-singular kernel Psi-Caputo fractional derivative in the Caputo sense and employing the Laplacian operator. the governement seeks immunity through the vaccination program, which is considered a control variable. Our study aims to identify the ideal control pair that reduces the number of infected/infectious people and the associated vaccine and treatment costs over a limited time and space. In addition, the local stability of both drug-free and drug-addiction equilibria is analyzed by studying the corresponding characteristic equations. The research provides conclusive evidence that when the basic reproductive number R0 exceeds 1, then the drug-addiction equilibrium is globally asymptotically stable. Conversely, using comparative arguments, it is shown that if R0 is less than 1, then the drug-free equilibrium is globally asymptotically stable. Furthermore, the paper includes a series of numerical simulations to visually convey and support the analytical results.

KRANİYOTOMİ YAPILAN HASTALARDA CERRAHİ ALAN ENFEKSİYONLARININ ÖNLENMESİNDE KULLANILAN ÖNLEM PAKETLERİ VE HEMŞİRENİN ROLLERİ

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Özet
Beyin ve sinir cerrahisi hastaları cerrahi girişim sırasında ve sonrasında enfeksiyonlara karşı duyarlıdır. Kraniyotomi, yapılan hastalarda cerrahi alan enfeksiyonları (CAE) ciddi morbidite ve mortaliteye neden olabilmektedir. Genel olarak hastane enfeksiyonları içinde az bir oranda görüldüğü düşünülen menenjit enfeksiyonları, kraniyotomi ameliyatlarından sonra oldukça sık görülmektedir. Bu durum hastanede yatış süresini uzatmakta, tedavi maliyetini ve mortaliteyi arttırmaktadır. Kraniyotomi yapılan hastalarda cerrahi alan enfeksiyonları, önlenebilir komplikasyonlardır. CAE önlenmesinde önlem paketleri önemli yer tutmaktadır. Önlem paketleri mümkün olan en iyi bakımı sağlamak ve olumlu sonuçlar elde etmek için belli bir ekip tarafından ve bütün olarak uygulanmayı gerektirir. Önlem paketlerinin eksiksiz uygulanması ve hemşirelerin sürece etkin katılımı, enfeksiyon oranlarını anlamlı şekilde azaltmaktadır. Hemşirelerin sürekli eğitim alması, protokollere tam uyum göstermesi ve hasta merkezli bir yaklaşım benimsemesi önemlidir. Sağlık kurumları, hemşirelerin enfeksiyon kontrolündeki rolünü destekleyici politikalar geliştirmelidir.
Bu çalışmada, kraniyotomi sonrası CAE'lerin önlenmesinde kullanılan kanıta dayalı önlem paketleri ve hemşirelerin bu süreçteki kritik rolleri ele alınmıştır. Enfeksiyon kontrol protokollerinin uygulanması, hastanın eğitimi ve multidisipliner iletişim hemşirelik bakımının temel unsurlarıdır. Hemşireler, hasta güvenliği ve bakım kalitesini artırmak için enfeksiyon önleme stratejilerinin merkezinde yer almaktadır.
Anahtar Kelimeler: Kraniyotomi, cerrahi alan enfeksiyonu, enfeksiyon kontrolü, hemşirelik, önlem paketleri

PRECAUTIONARY PACKAGES USED TO PREVENT SURGICAL SITE INFECTIONS IN PATIENTS UNDERGOING CRANIOTOMY AND THE ROLES OF THE NURSE

Abstract
Neurosurgery patients are susceptible to infections during and after surgery. Surgical site infections (SSI) can cause serious morbidity and mortality in patients who undergo craniotomy. Meningitis infections, which are generally thought to be a small proportion of hospital infections, are quite common after craniotomy surgeries. This prolongs the length of hospital stay, increases treatment costs and mortality. Surgical site infections in patients who undergo craniotomy are preventable complications. Precaution packages play an important role in preventing SSI. Precaution packages require implementation by a specific team and as a whole in order to provide the best possible care and achieve positive results. Complete implementation of precaution packages and active participation of nurses in the process significantly reduce infection rates. It is important for nurses to receive continuous education,

fully comply with protocols and adopt a patient-centered approach. Healthcare institutions should develop policies that support the role of nurses in infection control.
This study discusses evidence-based precaution packages used in the prevention of SSIs after craniotomy and the critical roles of nurses in this process. Implementation of infection control protocols, patient education, and multidisciplinary communication are essential elements of nursing care. Nurses are at the center of infection prevention strategies to improve patient safety and quality of care.
Keywords: Craniotomy, surgical site infection, infection control, nursing, precaution packages

GİRİŞ

Sağlık hizmetiyle ilişkili enfeksiyonlar, hasta güvenliği için en ciddi tehditlerden biri olup dünya çapında sağlık hizmeti sağlayıcıları için büyük bir zorluk oluşturmaya devam etmektedir. CAE terimi ilk kez 1990'lı yıllarda "cerrahi yara enfeksiyonu" terimi yerine kullanılmaya başlanmıştır. Dünya Sağlık Örgütü (DSÖ) tarafından CAE, ameliyatın gerçekleştiği vücut ölümünde, ameliyat sonrası dönemde ortaya çıkan enfeksiyon olarak tanımlanmıştır. CAE'ler bazen sadece cilt tabakasında meydana gelen yüzeyel enfeksiyonlar şeklinde olabileceği gibi cilt altındaki dokuları, organları veya implante edilmiş materyali kapsayacak şekilde daha ciddi derin doku enfeksiyonları olarak da görülebileceği bildirilmektedir (Bashaw MA, Keister KJ. 2019). Uzun süreli hastane yatışı, yoğun bakım gereksiniminde ve sağlık bakım harcamalarında önemli artışlara yol açan CAE, yeniden hastane yatışlarının da en sık nedenlerinden birini oluşturmaktadır (De Simone B. Et al. 2020; Ling ML. et al., 2019).

Hastalık Kontrol ve Önleme Merkezi, SHİE sürveyans ve kontrol önlemlerini izlemek için UHESA'yı kurmuş ve CAE için yaygın olarak kullanılan tanı kriterlerini tanımlamıştır. Bu tanı kriterleri "yüzeyel insizyonel CAE", "derin insizyonel CAE" ve "organ/boşluk CAE" olmak üzere üç ana başlık altında sınıflandırılmıştır (CDC 2017; Cerrahi Alan Enfeksiyonu Sürveyansı Rehberi 2018; Kılıç Saray. H. Koçak Özdemir. F. 2022). Cerrahi Alan Enfeksiyonları tanı kriterleri Çizelge 1'de verilmiştir (CDC 2017).

Çizelge 1. Cerrahi Alan Enfeksiyonları Tanı Kriterleri

Tanı	Tanı Tanı Kriterleri
Yüzeyel İnsizyonel CAE	Ameliyattan sonraki 30 gün içinde gelişen ve sadece insizyon bölgesinde dermis ve dermis altı dokuda oluşan CAE' dir. Aşağıdakilerden en az birinin olduğu enfeksiyon, 1. Yüzeyel insizyondan pürülan drenaj varlığı, 2. Yüzeyel insizyondan aseptik olarak elde edilen sıvı (akıntı) veya doku kültüründe mikroorganizma izolasyonu, 3. Cerrahın cerrahi alanı yeniden açması ve kültür pozitif ya da kültür alınmamış olması ve ağrı-hassasiyet, lokal şişlik, kızarıklık, ısı artışı gibi enfeksiyon semptomlarından en az birinin varlığı, 4. Cerrah ya da uzman hekim tarafından yüzeyel insizyonel cerrahi alan enfeksiyonu tanısı konulması

Derin İnsizyonel CAE	Hastanın geçirdiği cerrahi prosedürünün tipine göre ameliyattan 30 gün içerisinde veya ameliyat bölgesine implant, kalp plağı gibi yabancı cisim yerleştirildi ise 1 yıl içerisinde meydana gelen CAE'dir. Enfeksiyon kas ve fasya gibi derin yumuşak dokuları ilgilendirir ve aşağıdakilerden en az birinin varlığı enfeksiyon tanısı için gereklidir; 1. Derin insizyondan pürülan drenaj olması. 2. Derin insizyon suturlarının spontan olarak veya cerrah tarafından planlı olarak açılması ve kültür pozitif ya da kültür alınmamış olması ve şu belirti ve bulgulardan en az birinin olması; Ateş (>38 derece), Lokal ağrı veya hassasiyet. 3. Direkt muayenede, invaziv işlem sırasında veya histopatolojik ya da radyolojik incelemeyle apse veya enfeksiyon semptomlarından birinin görülmesi 4. Uzman doktor veya ilgili hekim tarafından derin insizyonel CAE tanısının konmas
Organ /Boşluk Tipi CAE	Hastanın geçirdiği cerrahi prosedürünün tipine göre implant yoksa ameliyattan 30 gün içerisinde; implant varsa 1 yıl içerisinde gelişen ameliyat esnasında manipüle edilen ya da açılan, cilt insizyonu, fasya veya kas tabakaları dışında kalan herhangi bir boşluğunu CAE'dir. Aşağıdakilerden en az birinin varlığı enfeksiyon tanısı için gereklidir; 1. Organ ya da boşluğa yerleştirilmiş bir drenden pürülan drenaj olması. 2. Organ/boşluktan aseptik olarak alınmış doku veya sıvı kültüründe üreme olması. 3. Direkt muayenede, invaziv prosedür sırasında veya histopatolojik ya da radyolojik incelemeyle apse ya da organ/boşluğu ilgilendiren diğer enfeksiyon kanıtlarının olması. 4. Uzman doktor veya cerrahın organ/boşluk CAE tanısını koyması gerekmektedir

Cerrahi alan enfeksiyonları dünya çapında önemli bir morbidite ve mortalite nedeni olmakla birlikte önemli bir epidemiyolojik yük oluşturmaktadır (Mengistu DA. et. al. 2023; Allegranzi B. et. al. 2016). Tek bir CAE ile ilişkili yeniden yatışın maliyetinin 12.835 dolar olarak hesaplanması nedeniyle sağlık bakım sistemine önemli bir mali yük getirir (Rencüzoğulları A. et. al. 2018). CAE oranları ülkeye ve cerrahi müdahalenin türüne göre farklılık göstermekte olup, DSÖ'ne göre CAE' nin genel birleştirilmiş insidansı %2,7'dir. Amerika Birleşik Devletleri'ndeki (ABD) tahmini yıllık 80 milyon ameliyatın yaklaşık %2'sinde meydana gelirken, Avrupa'da oranlar %0,6 ile %9,5 arasında değişmekte, Afrika Bölgesi'nde %7,2, Türkiye'de ise %4,5 olduğu bildirilmiştir (Mengistu DA. et. al. 2023; Aktaş FO, Damar HT. 2022).

CERRAHİ ALAN ENFEKSİYONLARININ ÖNLENMESİNDE BAKIM PAKETİ YAKLAŞIMI

Cerrahi alan enfeksiyon oranlarını azaltmaya yönelik müdahaleler, hem hasta bakımını hem de sağlık bütçelerini optimize etmek için gereklidir. Bu önlemler, çok sayıda ameliyat öncesi, sırası ve sonrası risk faktörünü ele almalıdır. Yayınlanan rehberler tüm cerrahi uzmanlık alanlarında CAE oranlarını azaltan bir dizi temel müdahaleyi desteklemektedir (Ramsay G, Watson A. 2022). Bu uygulamaların kanıt temelli olması hasta bakımında denetim imkanı sunarken aynı zamanda hasta morbiditesinin azaltılmasının yanı sıra hastane maliyetlerini ve kaynak kullanımını azaltılmasını sağlar (Hoang SC. et. al. 2019; Jörger AK. et. al. 2018).

BAKIM PAKETİ TANIMI VE OLUŞTURULMASI

Enfeksiyonları önlemek için çeşitli stratejiler vardır. En büyük etki, farklı önlemlerin bir bakım paketinde birleştirilmesinde bulunmuştur (Weiser MR. Et. el. 2018; WHO 2018; NICE 2020; Tanner J. et. al. 2015; Erden S, Akoğlu CA, Belgin B. 2024; Eğilmez H. 2022). Bakım paketi, "her biri tek tek uygulandığında hastanın iyileşme sürecini ve sonuçlarını olumlu yönde etkileyen; hepsi birlikte uygulandığında ise teker teker uygulanmalarına oranla daha iyi bir sonuca ulaşılmasını sağlayan birkaç parametrenin birlikte uygulanmasından" oluşmaktadır. Bakım paketi uygulaması ile mümkün olan en iyi bakımın verilmesi amaçlanmaktadır (Kalkan N, Karadağ M. 2017). Yoğun bakım hastalarında klinik sonuçların iyileştirilmesi amacıyla ilk kez 2001 yılında, IHI tarafından tanımlanmıştır (Weiser MR. Et. el. 2018;, NICE 2020). İlk olarak ventilatör ilişkili pnömoni önleme bakım paketi ve santral kateter ilişkili enfeksiyonların önlenmesi bakım paketi olarak geliştirilmiştir. Oluşturulan ilk paketlerde kanıt temelli yaklaşımlardan daha çok sağlık çalışanları tarafından kabul edilen/onaylanan hasta bakım uygulamalarına yer verilmiştir (Kandemir D, Ak ES, Ayoğlu T. 2017).

Hasta sonuçlarının iyileştirilmesinde etkili olan bakım paketleri, bilimsel olarak etkinliği kanıtlanmış girişimlerin bir paket halinde birlikte uygulanmasını gerektirir. Paket içinde yer alan uygulamalardan birine uyulmadığı durumlarda, diğer uygulamalar da uygulanmamış kabul edilir. Bu özelliğinden dolayı bakım paketi "ya hep, ya hiç" standardı olarak da bilinir ve adımları "evet" ve "hayır" şeklinde kontrol listeleri oluşturularak kullanılır (Kandemir D, Ak ES, Ayoğlu T. 2017). Buradaki amaç klinik sonuçların iyileştirilmesi için gerekli olan bazı bilimsel temelli parametreleri bir araya getirmektir. Paketin her bir parametresi genelde 3-5 maddeden oluşmakta ve paketin başarıya ulaşması için tüm parametrelerin uygulanması gerekmektedir (Yiğit R.N. 2021).

BAKIM PAKETİ UYGULAMASINDA UYUM VE UYUMU ETKİLEYEN FAKTÖRLER

Bakım paketlerinin uygulanması, hastalara kanıta dayalı ve güvenli sağlık hizmeti sunmak adına bir fırsat yaratmaktadır. Bakım paketi uygulaması SHİE önlenmesinde kullanılan basit, uygun maliyetli, zaman açısından verimli ve güvenilir bir yaklaşımdır (Yiğit R.N. 2021).

Bakımın bir standardizasyonu olmadığında bakım vericinin bilgi, beceri ve tutumlarından etkilenir. Bu durum hemşirelik bakımının kişiden kişiye farklılık oluşturmasına yol açmaktadır. Kişiden kişiye değişen bakımda hasta memnuniyeti azalır ve bakımın kalitesi düşer. Bakım paketi uygulandığında bütün sağlık çalışanları tarafından aynı hasta bakımı uygulaması benimsenir, hemşirelik bakımında standardizasyon sağlanır ve bu durum bakımın kalitesini arttırır (Kutluğ S. 2021). Ancak CAE için önleyici protokollerin sağlık çalışanları tarafından uygulanması ve bu protokollere uyum düzeyi oldukça değişkenlik göstermektedir. Çünkü kabul ve uyum kazanmak önemli bireysel, kültürel ve örgütsel değişiklikler gerektirir (Badia J M. et. al. 2020).

Multimodal bakım paketine uyumu değerlendirmek ve kolon rezeksiyonlarında CAE önlem paketinin etkisini değerlendirmek amacıyla 1516 hastanın dahil edildiği bir çalışmada bakım paketine genel uyum %77 olarak hesaplanmıştır (Jurt J. et. al. 2021). Bakım paketi uyumunun değerlendirildiği Milano ve arkadaşları tarafından yapılan başka bir çalışmada, sepsisi olan hastalarda bakım paketi uygulamasının septik şok/şiddetli sepsis yönetiminde paket uyumunun sağ kalımla ilişkili olduğu bulunmuştur. Pakete uyum arttıkça hastalarda sağ kalım oranının arttığı görülmüştür (Milano PK. 2018).

CERRAHİ ALAN ENFEKSİYONLARININ ÖNLENMESİNDE BAKIM PAKETLERİNİN UYGULANMASI

Cerrahi alan enfeksiyonlarının önlenmesine yönelik uygulamalar hem bakteriyel kontaminasyon riskini azaltmaya hem de hastanın enfeksiyona karşı savunmasını iyileştirmeye yönelik girişimlere dayanmaktadır. Bu önlemler hasta ve cerrahi süreç ile ilgili birçok risk

faktörüne dikkat edilmesinde bir dizi kanıt temelli uygulamanın birlikte uygulanması yaklaşımını gerektirmektedir (Badia J M. et. al. 2020).
Kolorektal cerrahi sonrası CAE'leri azaltmak için hazırlanan önlem paketlerinin etkinliğini değerlendirmek için yapılan bir çalışmada, önlem paketlerinin kullanılması ile CAE oranlarında %10,6'dan %3,2'ye, anlamlı düşme sağlandığı görülmüştür (Rencüzoğulları A. et. al. 2018). Önlem paketlerinin etkinliğini araştırmak için yapılmış 18 çalışmanın dahil edildiği bir meta analizde ise perioperatif bakım paketlerinin CAE'yi önlediği gösterilmiştir. Ayrıca bakım paketi yüksek oranda kanıta dayalı müdahaleler içeriyorsa daha etkin olabileceği sonucuna ulaşılmıştır (Wolfhagen N, Boldingh QJJ, Boermeester MA, de Jonge SW. 2022). Literatüre bakıldığında CAE'lerin %60'ı kanıt temelli uygulamalar ile önlenebilmektedir (CDC 2017; , Aktaş FO, Damar HT. 2022; WHO 2018). Bu bağlamda kurumlar ameliyat öncesi, sırası ve sonrası için bakım protokolleri oluşturmalı ve uygulanması sağlanmalıdır.

KRANİYAL CERRAHİ ALAN ENFEKSİYONLARININ ÖNLENMESİNDE BAKIM PAKETİ KULLANIMI

Beyin ve sinir cerrahisi hastaları cerrahi girişim sırasında ve sonrasında enfeksiyonlara karşı duyarlıdır. Nöroşirurjik girişimlerde mikroorganizmalara karşı savunma mekanizması olarak görev yapan fiziksel ve mekanik bariyerler bozulmaktadır. Bu hastalar çoklu travma, kafa travması, nörolojik defisitler, koma ve immobilizasyon gibi risk faktörleri nedeni ile çoğu zaman birden fazla hastane enfeksiyonu riski taşımaktadırlar. Genel olarak hastane enfeksiyonları içinde az bir oranda görüldüğü düşünülen menenjit enfeksiyonları, kraniyotomi oldukça sık görülmektedir (Rubeli SL. et. al. 2019). Bu durum hastanede yatış süresini uzatmakta, tedavi maliyetini ve mortaliteyi arttırmaktadır (Jimenez-Martinez E. et. al. 2019). Kraniyal cerrahi sonrası enfeksiyonlar hastaların %0,5-%7,2'sinde görülür ve ameliyatların tekrarlanmasına, uzun süreli antibiyotik tedavisine, hastanede yatış süresinin artmasına neden olup sıklıkla yaşamı tehdit etmektedir (Rubeli SL. et. al. 2019).
Kraniyal CAE'lerin insidansını değerlendirmek üzere 2000-2020 yılları arasında yapılmış 21 çalışmanın meta analizinde CAE oranlarının düşürülmesinde paket uygulamalarının etkili olduğu sonucuna ulaşılmıştır (Mann M. et. al. 2021). Üçüncü basamak bir hastanede beyin cerrahisi ameliyatlarından sonra gelişen CAE ve enfeksiyon önleme paketinin etkisini değerlendirmek için yapılan çalışmada 322 hasta paket uygulama öncesi ve sonrası değerlendirilmiştir. Paket uygulamasından 1 yıl sonra enfeksiyon oranlarının %7,8'den %3,7'ye düştüğü gözlenmiştir (Hoang SC. et. al. 2019) .
Kraniyal cerrahi sonrası uygulanan bakım paketinin etkinliğini değerlendirmek için yapılan başka bir çalışmada önleme paketinin uygulanmasından önce ameliyat edilen 321 vakadan 13 vakada (%4) CAE geliştiği görülmüştür. Uygulamadan sonra, 288 hastadan sadece 6'sında (%2) CAE saptanmıştır (Jörger AK. et. al. 2018).
Literatürde bakım paketi kullanımı ile kolorektal, kardiyak, ortopedik veya obstetrik cerrahi gibi pek çok cerrahi girişim sonrası CAE oranlarının azaldığı ve paket yaklaşımının CAE insidansını azaltmada tek başına etkili olduğu bildirilmiştir (Rubeli SL. et. al. 2019; (Jimenez-Martinez E. et. al. 2019; Balcı F. 2023; Liu H, Dong X, Yin Y, Chen Z, Zhang J. 2017; Ma N. et. al. 2017). Perioperatif enfeksiyon önleme paketleri genel cerrahi, ortopedi gibi alanlarda sıklıkla uygulanmasına rağmen mikroorganizmalara karşı savunma mekanizmasının çok düşük olduğu beyin cerrahisi ameliyatlarında uygulandığını gösteren çalışma sayısı azdır.

CERRAHİ ALAN ENFEKSİYONU ÖNLEME BAKIM PAKETİ KULLANIMINDA HEMŞİRENİN ROLÜ

Ameliyathaneler, enfeksiyon riskinin yüksek olduğu bilinen karmaşık ortamlardır. Cerrahlar, anestezistler, steril ve sirküle hemşireler, perianestezi hemşireleri, teknisyenler ve diğer ameliyathane personeli gibi farklı sağlık profesyonelleri, ekipteki diğer uzmanlarla birlikte perioperatif bakımdan sorumludur (Aktaş FO, Damar HT. 2022). Ancak hemşireler, hastalara

en fazla temas eden sağlık personelleridir. Bu nedenle hemşireler ameliyat öncesi, sırası ve sonrası multidisipliner bir ekiple ve kanıta dayalı yaklaşımlarla önlenebilecek bir durum olan CAE'in önlenmesinde önemli bir rol oynarlar (Topaktaş D. 2019).

Perioperatif hemşireler cerrahinin tüm aşamalarında birçok hayati rol üstlenir. Bu çabaların çoğu CAE önlenmesi etrafında yoğunlaşır. Perioperatif hemşire, kanıta dayalı uygulamaları uygulamak ve hasta sonuçlarını iyileştirmek için çeşitli rollerde (klinisyen, eğitimci ve lider) hizmet vererek CAE'lerin önlenmesinde olmazsa olmazdır (Kalkan N, Karadağ M. 2017) .

Hemşirelerin bakım paketi oluşturulması ve uygulanmasındaki rolleri:

- ✓ Bakım paketi oluşturmak ve uygulamak konusunda disiplinler arası bir ekibe katılarak hastalar için savunucu rol üstlenir.
- ✓ Ameliyat öncesi dönemde, CAE'leri azaltmak için cilt hazırlığı ve enfeksiyon riskini azaltmaya yönelik hasta bilgilendirmesini sağlar.
- ✓ Multidisipliner ekip iletişimi sağlayarak bakım paketinin uygulanmasını diğer meslek grupları arasında koordine eder.
- ✓ Enfeksiyon önleme paketlerinin güvenilir ve tutarlı bir şekilde uygulandığından emin olmak için gerekli takip ve uyarıları yapar.
- ✓ Bakım paketlerinin uygulanmasının önündeki engeller konusunda fikir beyan eder.
- ✓ Hasta ve cerrahla doğrudan çalışan perioperatif hemşireler, hasta sonuçlarını ve perioperatif ekip üyelerinin girişimlere uyumunu izler ve en fazla uyumsuzluk olan müdahaleleri belirler.
- ✓ Bakım paketinin uygulanması konusunda yeterli bilgisi olmayan personele eğitim bilgisi sağlar.
- ✓ Paket uyumluluğunu sağlamaya yardımcı olmak için ilgili ekip üyelerine hatırlatmalar yapar (Goldberg L. 2020).

SONUÇ

Bakım paketleri mümkün olan en iyi bakımı sağlamak ve olumlu sonuçlar elde etmek için belli bir ekip tarafından ve bütün olarak uygulanmayı gerektirir. Enfeksiyonların önlenmesinde önemli yeri olan bakım paketlerine uyumda henüz istenilen seviyeye ulaşılamamıştır. Bakımın öncüsü olan hemşireler bu konuda rol model olmalı, rehberleri takip etmeli, bakım paketlerine uyumu denetlemelidir. Hemşireler primer bakımın öncüleridir. Bu nedenle güncel bilgileri takip etmeli, bakım paketin oluşturulması ve kullanılmasında yer almalıdır. Hemşirelik, hasta bireyi sürekli yakın takip eden ve birebir bakım sorumluluğunu üstlenen bir meslek grubudur. Bu nedenle uygulanan bakım paketinin eksik yönlerini ve aksaklıklarını fark edebilecek kişilerdir. Bu şekilde bakım paketinin gelişmesini sağlayacaklardır. Ayrıca bakım paketinin kullanılması hasta memnuniyetini ve bakım kalitesini arttırarak hemşirelerinde memnuniyet düzeylerinin ve iş doyumlarının da artmasını sağlamaktadır.

Kraniyotomi yapılan hastalarda cerrahi alan enfeksiyonları, önlenebilir komplikasyonlardır. Önlem paketlerinin eksiksiz uygulanması ve hemşirelerin sürece etkin katılımı, enfeksiyon oranlarını anlamlı şekilde azaltmaktadır. Hemşirelerin sürekli eğitim alması, protokollere tam uyum göstermesi ve hasta merkezli bir yaklaşım benimsemesi önemlidir. Sağlık kurumları, hemşirelerin enfeksiyon kontrolündeki rolünü destekleyici politikalar geliştirmelidir.

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GÜÇLÜ SEPTİK DUFFING DENKLEMİNİ ÇÖZMEK İÇİN MULTIPLE SCALES LINDSTEDT POINCARE YÖNTEMİ

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ÖZET
Çoklu Ölçekler Lindstedt–Poincaré (MSLP) tekniği, klasik Çoklu Ölçekler Yöntemi ile Lindstedt–Poincaré prosedürünün temel ilkelerini sentezleyen gelişmiş bir perturbasyon çerçevesi oluşturmaktadır. Bu analitik hibrit yaklaşım, özellikle güçlü doğrusal olmayan koşulları altında bile geçerli yaklaşık çözümler üretmede oldukça etkilidir. Mevcut çalışmada, MSLP yöntemi sistematik olarak septik Duffing osilatörü için analitik yaklaşık çözümler elde etmek amacıyla uygulanmıştır. Elde edilen çözümler daha sonra yüksek doğrulukta sayısal simülasyonlarla gerçekleştirilen karşılaştırmalı bir inceleme ile değerlendirilmiştir. Bulgular, MSLP tekniğinin doğruluk ve güvenilirliğini vurgulayarak, zayıf ve güçlü doğrusal olmayan davranışların her iki rejiminde sayısal sonuçlarla yakından uyumlu analitik çözümler üretme yeteneğini göstermektedir.
Anahtar Kelimeler: Perturbasyon Metodları, Sayısal Çözümler, Kuvvetli Septik Duffing Denklemi

MULTIPLE SCALES LINDSTEDT POINCARE METHOD FOR SOLVING STRONGLY SEPTIC DUFFING EQUATION

ABSTRACT
The Multiple Scales Lindstedt–Poincaré (MSLP) technique constitutes an advanced perturbation framework that synthesizes the core principles of the classical Method of Multiple Scales and the Lindstedt–Poincaré procedure. This analytical hybrid approach is particularly adept at generating uniformly valid approximations, even under conditions of strong nonlinearity. In the current investigation, the MSLP method is systematically applied to derive analytical approximations for the septic Duffing oscillator. The derived solutions are subsequently evaluated through a comparative study involving high-precision numerical simulations. The findings underscore the accuracy and reliability of the MSLP technique, demonstrating its capability to produce analytical results that closely correspond with numerical outcomes across regimes characterized by both weak and strong nonlinear behaviors.
Keywords: Perturbation Methods, Numerical Solutions, Strong Septic Duffing Equation

PREVALENCE AND ASSOCIATION BETWEEN HYPERURICEMIA, ABDOMINAL OBESITY AND METABOLIC SYNDROME IN ADULT POPULATION LIVING IN TETOUAN NORTHERN MOROCCO

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Introduction: Polycystic ovarian syndrome (PCOS) is a common endocrine disorder that affects approximately 5–10% of women in reproductive age. Overproduction of androgens can contribute to menstrual disorders and hirsutism . Women with this condition are at higher risk for anxiety, depression, and metabolic syndrome. Chronic dysovulation and anovulation lead to prolonged exposure to estrogen which leads to infertility.
Objective: To describe the self-reported diagnostic criteria used in the practice of PCOS management among gynecologists in comparison with their counterparts in other specialties in Morocco.
Materials and Methods: This is a cross-sectional survey among 212 physicians (endocrinologists, dermatologists, general practitioners) involved in the treatment of PCOS and infertility.
Results:. Among them, 61.8% were female, 37.7% were obstetrician-gynecologists. The most frequently used criteria for diagnosing PCOS were the Rotterdam criteria (63.2%), followed by the Androgen Excess and Polycystic Ovary Syndrome Society (AE-PCOS) criteria (17.9%). A statistically significant difference was detected in the assessment of risk factors for PCOS between the Obstetrician-Gynecologists and other Physicians in diabetes screening (83.7% versus 93.9%; P = 0.05) and dyslipidemia screening (46.2% versus 76.5%; P = 0.0001). For both groups of respondents, measures to improve lifestyle were recommended through dietary changes (93.87%), taking food supplements (93.8%), and physical activity (97.17%).
Conclusion: Despite variations in diagnostic and treatment approaches among specialists, all healthcare professionals face challenges diagnosing PCOS due to the high cost of tests and symptom similarities with other conditions.
***Keywords**:* Polycystic ovarian syndrome, Obstetricians and gynecologists, Survey, Morocco

BIODIVERSITY OF MACROPHYTES IN THE COASTAL WATER FROM ALGERIAN WEST COAST

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Abstract

The Oran coastline is increasingly attacked these days by various forms of nuisance: industrial activities, intensive tourism and massive urbanization with the corollary of an ever-increasing scale of pollution of anthropogenic origin. It is in this context, to have an overview of the state of the Oran coastal ecosystem, we surveyed four sites, chosen according to their proximity to the urban and/or industrial fabric, in order to assess the state of the algal flora and the impact of human activities on these coastal areas.

Thus, an inventory was carried out with the objective of monitoring the spatial evolution of macroalgal communities and their taxonomic composition. Our sampling campaign made it possible to list 37 species from three major groups of thallophytes: 11 Phaeophyceae, 8 Chlorophyceae and 18 Rhodophyceae.

The results obtained revealed that the overall average coverage of Rhodophyceae at the four stations is very high compared to the other two groups of algae. The Mars El Hadjaj station is marked by a high frequency of Caulerpa cylindracea and Caulerpa prolifera shows the invasive nature of these chlorophyceae, which are gradually establishing themselves along the western Algerian coast. The total absence of Caulerpa cylindracea is noted in the two stations Kristel and Bousfer. However, the stations of Kristel, Ain Franin and Bousfer are characterized by the presence of a bioindicator of choice for environmental studies: Cystoseirae.

Keywords: Macroalgae, Phaeophyceae, Chlorophyceae, Florideophyceae, ecological status, Algerian west coast.

TRA2 BÖLGESİNİN KOYUNCULUK PROFİLİ

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ÖZET
Koyun yetiştiriciliği, Türkiye hayvancılık sektörünün önemli bileşenlerinden biridir. Koyunculuk hem kırsal gelir kaynağı hem de hayvansal protein ihtiyacının karşılanması açısından kritik öneme sahiptir. Doğu Anadolu Bölgesi sınırları içerisinde kalan TRA2 bölgesi ülkenin koyunculuğunda özel bir yere sahiptir. Bu çalışmada, TRA2 bölgesinde yapılan koyunculuğun mevcut yapısı değerlendirilmiştir. Bu değerlendirmeye göre, TRA2 bölgesinin illeri özelinde incelendiğinde, genel olarak nüfus ile koyun varlığı arasında ters yönlü bir eğilim dikkat çekmektedir. Son 15 yıllık süreçte Ağrı ilinde nüfus 542.022 'den 499.801'e gerilemiş; aynı dönemde koyun sayısı %41,8 artarak artış göstermiştir. İlde kişi başına düşen koyun sayısı 1,96'dan 3,02'ye çıkmıştır. Kars ilinde nüfus %9,8 azalarak 301.766'dan 272.300'e düşmüş, koyun sayısı ise %243 artışla 195.992 baştan 673.375 başa çıkmıştır. Kişi başına koyun sayısı 0,65'ten 2,47'ye yükselmiştir. Iğdır ilinde nüfus %12,2 artarak 184.418'den 206.857'ye ulaşırken, koyun varlığı dalgalanmalı bir seyir izlese de 2024'te 997.101 kişiye ulaşarak, 2010'a kıyasla %111 artış göstermiştir. Kişi başına düşen koyun sayısı 2,56'dan 4,82'ye çıkmıştır. Ardahan ilinde ise, nüfus %13,4 azalarak 105.454'ten 91.354'e düşerken, koyun varlığı %447 oranında artarak 29.483'ten 161.519 başa yükselmiştir. Kişi başına düşen koyun sayısı 0,28'den 1,77'ye çıkmıştır. Sonuç olarak, TRA2 bölgesinde tarım olanaklarının sınırlılığı nedeniyle halkın temel geçim kaynaklarından biri olarak küçükbaş hayvancılığa yöneldiğini görülmektedir. Bu çalışmanın, bölgede sürüdürülebilir koyun yetiştiriciliğinin yapılabilmesi adına politika yapıcılar ve yetiştiriciler için bir kaynak olacağı düşünülmektedir.
Anahtar Kelimeler: Ekonomi, Kırsal kalkınma, Koyunculuk, TRA2 bölgesi

SHEEP FARMING PROFILE OF THE TRA2 REGION

ABSTRACT
Sheep farming is one of the essential components of Türkiye's livestock sector. It is critically important both as a source of rural income and in meeting the need for animal-based protein. The TRA2 region, within the borders of the Eastern Anatolia Region, has a special place in the sheep breeding of the country. This study evaluates the current structure of sheep farming in the TRA2 region. Analysis across the provinces of the TRA2 region reveals an inverse trend between population and sheep numbers. Over the past 15 years, the population of Ağrı has declined from 542,022 to 499,801, while the sheep population increased by 41.8%. Sheep per capita rose from 1.96 to 3.02. In Kars province, the population decreased by 9.8% from 301,766 to 272,300, while the number of sheep increased by 243% from 195,992 to 673,375 head. The number of sheep per capita increased from 0.65 to 2.47. In Iğdır province, the population increased by 12.2% from 184,418 to 206,857, while the number of sheep fluctuated, reaching 997,101 people in 2024, an increase of 111% compared to 2010. The number of sheep per

capita increased from 2.56 to 4.82. In Ardahan province, the population decreased by 13.4% from 105,454 to 91,354, while the number of sheep increased by 447% from 29,483 to 161,519. The number of sheep per capita increased from 0.28 to 1.77. In conclusion, it is seen that due to the limited agricultural opportunities in the TRA2 region, people turn to small livestock farming as one of their main sources of income. This study is expected to serve as a valuable resource for policymakers and producers aiming to ensure the sustainability of sheep farming in the region.
Keywords: Economy, Rural Development, Sheep Farming, TRA2 Region

MECHANISMS AND MANAGEMENT OF DRUG INDUCED HEPATOTOXIC

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ABSTRACT:
Drug-induced hepatotoxicity (DIH) represents a significant challenge in clinical practice and drug development, being a leading cause of acute liver failure and drug withdrawal. The liver, as the central organ for drug metabolism, is particularly vulnerable to chemical injury. Hepatotoxicity can occur through direct, intrinsic toxicity or via idiosyncratic reactions, which are unpredictable and dose-independent. The primary mechanisms involve the formation of reactive metabolites during phase I metabolism, especially by cytochrome P450 enzymes. These reactive intermediates can bind covalently to cellular proteins, leading to oxidative stress, mitochondrial dysfunction, lipid peroxidation, and apoptosis. In some cases, the immune system may recognize drug-protein adducts as foreign, triggering an inflammatory response that exacerbates liver injury. Genetic polymorphisms, pre-existing liver disease, and drug interactions can influence individual susceptibility. Common hepatotoxic drugs include acetaminophen, isoniazid, amiodarone, and certain herbal products. Understanding the underlying mechanisms of DIH is essential for developing safer drugs, improving diagnostic biomarkers, and implementing preventive strategies. Advances in omics technologies, liver organoids, and in vitro screening models offer promising tools for early detection and mechanistic studies of hepatotoxicity. This review highlights the key molecular pathways involved in DIH and emphasizes the need for continued research in predictive toxicology.

MEDICATION SAFETY

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Abstract

In the medical field, pharmacotherapy is the most often used therapeutic approach to enhance patient outcomes. Nevertheless, there are numerous cases where the drugs that were recommended actually caused patient morbidity and death. A significant burden of drug-related harm is concentrated on three key areas of healthcare delivery: high-risk settings, polypharmacy, and transitions of care. However, medication errors can occur at any stage of the medication use process. This chapter outlines common medication errors, the prevalence of problems in these three key areas, and risk mitigation techniques to enhance service delivery.Understanding these inherent dangers can help healthcare professionals avoid the traps and work to maintain pharmaceutical safety while offering medical services.

Keywords: High-risk circumstances, medication mistakes, medication inconsistencies, medication reconciliation, polypharmacy, high-quality healthcare, and care transitions

METAMALZEME TABANLI DAİRESEL HALKA REZONATÖRLÜ FREKANS SEÇİCİ YAPI

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ÖZET
Bu çalışmada, terahertz (THz) frekans bandında çalışan, metamalzeme (MTM) tabanlı bir frekans seçici yapı (FSY) tasarımı sunulmuştur. Tasarlanan yapı, dairesel halka rezonatör geometrisine sahip olup yaklaşık 1.0 THz frekansında -60 dB seviyesine ulaşan düşük yansıma (S_{22}) özelliği göstermektedir. Sayısal analizler, 0.4–1.1 THz frekans aralığında geniş bantlı ve yüksek soğurma yeteneğine sahip bir performans sergilendiğini ortaya koymuştur. Özellikle 1.0 THz civarında elde edilen derin rezonans noktası, yapının elektromanyetik dalgaları etkili bir şekilde iletme veya soğurma kapasitesine sahip olduğunu göstermektedir. Bu sonuçlar, önerilen MTM tabanlı FSY yapısının THz bandında biyomedikal görüntüleme, güvenlik taramaları ve malzeme karakterizasyonu gibi uygulamalarda kullanılabilecek yüksek seçicilik ve düşük yansıma özelliklerine sahip potansiyel bir aday olduğunu ortaya koymaktadır.
Anahtar Kelimeler: Metamalzeme, frekans seçici yapı(fsy), terahertz(thz)

META-MATERIAL BASED CIRCULAR RING RESONATOR FREQUENCY SELECTIVE STRUCTURE

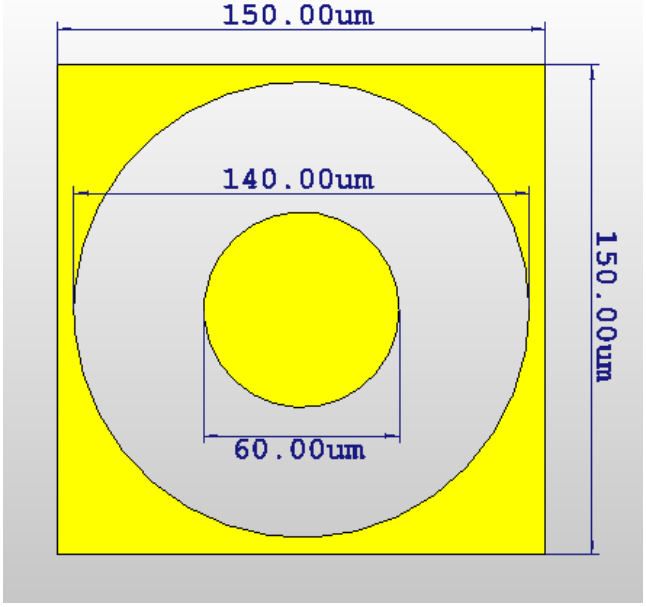
ABSTRACT
In this study, a metamaterial (MTM)-based frequency selective surface (FSS) operating in the terahertz (THz) frequency band is proposed and analyzed. The designed structure features a circular ring resonator geometry and demonstrates a significant low reflection level, reaching approximately -60 dB at around 1.0 THz. Numerical analyses reveal that the structure exhibits broadband performance with efficient absorption characteristics within the 0.4–1.1 THz frequency range. The deep resonance observed near 1.0 THz indicates that the MTM-based design effectively transmits or absorbs incident electromagnetic waves at this frequency. These results suggest that the proposed FSS structure is a strong candidate for THz applications requiring high selectivity and minimal reflection, such as biomedical imaging, security screening, and material characterization.
Keywords: Metamaterial, frequency selective structure(fsy), terahertz(thz)

INTRODUCTION
Metamalzemeler (MTM), doğada bulunmayan, negatif kırılma indisi gibi özgün ve olağanüstü fiziksel özelliklere sahip olacak şekilde periyodik yapılar temelinde tasarlanmış yapay malzemelerdir. Negatif dielektrik sabiti ile negatif manyetik geçirgenlik özelliklerini aynı anda gösterebilen metamalzemeler, ilk kez 1968 yılında Veselago tarafından teorik olarak öne

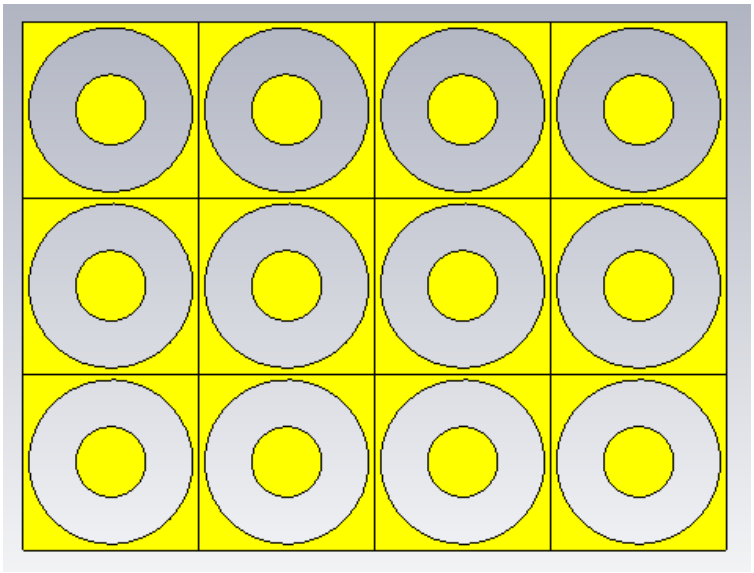
sürülmüştür [1]. Ancak bu kuramsal yaklaşım, uzun yıllar boyunca sınırlı ilgi görmüştür. 1996 ve 1999 yıllarında Pendry ve arkadaşlarının [2], 2000'li yıllarda ise Smith, Shelby ve çalışma arkadaşlarının [3] gerçekleştirdiği deneysel çalışmalar sayesinde teorik temeller doğrulanarak bu alana olan ilgi önemli ölçüde artmıştır. Günümüzde metamalzemeler; görünmezlik pelerinleri (cloaking) [4], süper lens sistemleri [5], yüksek performanslı mikrodalga sensör tasarımları [6], elektromanyetik sensör[7], sıvı sensör[8], akaryakıt sensörü[9] gibi pek çok yenilikçi uygulama alanında etkin bir şekilde kullanılmaktadır. Bununla birlikte, metamalzemelerin bu tür ileri düzey teknolojilere sunduğu yüksek düzeyde kontrol, uyarlanabilirlik ve performans avantajları, yapılan çok sayıda teorik ve deneysel çalışma ile bilimsel olarak ortaya konmuştur. Terahertz (THz) frekans bandı (yaklaşık 0.1–10 THz), elektromanyetik spektrumun mikrodalga ve kızılötesi bölgesi arasında yer almasıyla son yıllarda önemli bir araştırma konusu hâline gelmiştir. Özellikle alt seviye (düşük mesafeli veya kısa menzilli) iletişim, güvenlik taramaları ve biyomedikal görüntüleme gibi uygulamalar, THz teknolojilerinin pratik kullanım potansiyelini gözler önüne sermektedir. Ancak THz bandında yüksek verimlilikle çalışan, kompakt boyutlu ve çok işlevli bileşenlerin geliştirilmesi hâlâ zorlu bir mühendislik problemidir. Bu noktada, metamalzeme tabanlı frekans seçici yapılar (FSY), tasarım esnekliği ve performans iyileştirmesi açısından öne çıkmaktadır. Metamalzemeler, doğal malzemelerde rastlanmayan elektromanyetik özellikleri sunabilen yapay olarak tasarlanmış hücresel yapılardır. Özellikle iletim (transmisyon), yansıma (refleksiyon) ve absorpsiyon (soğurma) özelliklerini belirli bir frekansta kontrol edebilme kabiliyetleri, THz bandında istenilen darbe şekillendirme (pulse shaping), filtreleme ve modülasyon gibi işlevler için büyük bir avantaj sağlamaktadır. Bu çalışmada, metamalzemelerin frekans seçici yapı (FSY) uygulamalarına entegre edilmesi konusu ele alınmış ve kullanılmıştır.

MATERIAL AND METHODS

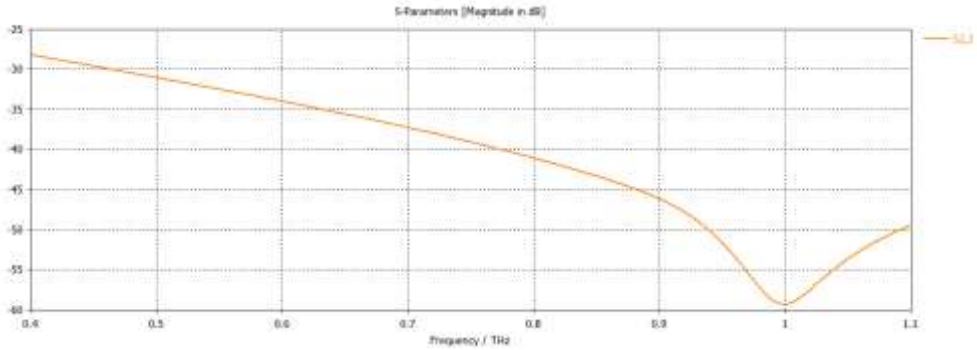
Çalışmamızda yaklaşık 1 THz'de -60 dB de absorptiviteye sahip bir FSY tasarlanmıştır. Metamalzeme tabanlı FSY'nin birim hücre hali ve dizisi sırasıyla Şekil 1 ve Şekil 2'de gösterilmektedir. Aynı zamanda Şekil 1 de metamalzeme bazlı soğurucunun birim hücresinin fiziksel parametreleri de gösterilmektedir. Dielektrik sabiti 1 F/m ve manyetik geçirgenliği 1 H/m olan gold isimli malzemeden oluşan yapının görünüşü Şekil 2 de gösterilmektedir.



Şekil 1. Metamalzeme tabanlı birim hücre FSY ve fiziksel parametreler.



Şekil 2. Metamalzeme tabanlı FSY dizisi.



Şekil 3. Metamalzeme tabanlı FSY dizisinin S22(dB) parametre grafiği

Bu çalışmamızda, şekil 3 deki grafikte de görüldüğü gibi 0.4–1.1 THz arasında değişen frekanslara karşılık gelen yansıma davranışı (S_{22}) dB cinsinden gösterilmektedir.

- **S_{22} Nedir?**

Genellikle S_{22}, iki portlu bir sistemde Port 2'den yansıyan dalganın Port 2'ye gelen dalgaya oranını ifade eder. FSY yapılarında Port 1 ve Port 2 sıklıkla giriş-çıkış düzlemleri olarak tanımlandığından, S_{22} değeri bize yapının "diğer ucundaki" yansıma karakteristiğini verir.

- **dB Ölçeğinde Negatif Değerler**: Grafiğin dikey ekseninde dB cinsinden negatif değerler yer alır. Daha düşük (daha negatif) dB değeri, yansıma miktarının o kadar az olduğunu; dolayısıyla gelen enerjinin o frekansta büyük ölçüde ileri yönde (iletim veya soğrulma şeklinde) harcandığını gösterir.

Şekil 4.3 deki grafiğe bakıldığında, 0.4 THz civarında -25 dB seviyesinde olan S_{22}, frekans arttıkça giderek daha negatif değerlere doğru iniyor (yani yansıma düşüyor). Yaklaşık 1.0 THz civarında -58 ila -60 dB arasına kadar inen bir minimum gözlemleniyor. Sonrasında frekans 1.1 THz'e doğru arttıkça grafik kısmen yükselip -55 dB seviyelerine geri çıkıyor.

- **0.4–0.7 THz Arası (Düzenli Azalış)**

-25 dB'den -40 dB, -45 dB seviyelerine doğru düzenli ve nispeten yumuşak bir geçiş var. Bu aralıkta henüz "keskin" bir rezonans görülmüyor; fakat yansıma miktarının sürekli azaldığı fark ediliyor.

- **0.9–1.0 THz Civarı (Derin Minimum)**

1.0 THz civarındaki derin çukur (yaklaşık -60 dB), yapının belirgin bir rezonans veya çok güçlü yutma (soğurma) özelliği sergilediğini gösterebilir. Metamalzeme/FSY tasarımında, bu frekans bölgesinde istenmeyen sinyali yansıtmak yerine iletmek veya soğurmak için bir geometri ve malzeme optimizasyonu yapılmıştır.

- **1.0–1.1 THz Arası (Kısmi Toparlanma)**

En dip noktadan sonra yansıma değeri -55 dB seviyelerine geri yükseliyor. Bu, rezonansın ana merkez frekansının 1.0 THz civarında olduğunu ve sistemin bu frekansın dışında biraz daha fazla (ama yine de düşük seviyede) yansıma yaptığını ima eder.

- **Rezonans Frekansı (1.0 THz Civarı)**

Grafikteki en düşük seviye yapıdaki bir rezonans durumunu işaret ediyor. Eğer S_{22} değeri çok düşükse o frekansta yansıma da çok az demektir. Bu, söz konusu dalganın büyük oranda iletildiğini veya soğrulduğunu gösterebilir.

RESULTS AND DISCUSSION

Şekil 4.3 deki grafiğe bakıldığında, 0.4 THz civarında -25 dB seviyesinde olan S_{22}, frekans arttıkça giderek daha negatif değerlere doğru iniyor (yani yansıma düşüyor). Yaklaşık 1.0 THz civarında -58 ila -60 dB arasına kadar inen bir minimum gözlemleniyor. Sonrasında frekans 1.1 THz'e doğru arttıkça grafik kısmen yükselip -55 dB seviyelerine geri çıkıyor.

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CONCLUSIONS

Çalışmamızdaki, 1.0 THz civarındaki -60 dB'lik derin dip, yapının yansıtıcı olmaktan ziyade geçirici veya soğurucu bir özellik sergilediğini gösterir. 0.4 THz'den 1.1 THz'e kadar uzanan bantta, genel eğilim yansımanın sürekli azaldığı ve 1.0 THz civarında en düşük seviyeye ulaştığı yönündedir. Bu tür keskin düşüşlerin elde edilebilmesi, yüksek hassasiyetli geometri boyutlandırması, doğru malzeme seçimi ve potansiyel olarak kayıp yönetimi (absorpsiyon) ile ilgilidir. Bu şekilde değerlendirildiğinde grafiğin gösterdiği temel mesaj; 0.4–1.1 THz arasında çalışan bir metamalzeme tabanlı FSY'nin, özellikle 1.0 THz yakınlarında çok düşük yansıma ($S_{22} \approx$ -60 dB) sergileyecek biçimde tasarlandığıdır. Bu, metamalzeme tasarımındaki yüksek seçicilik ve istenmeyen yansımayı bastırma hedefine başarılı şekilde ulaşıldığını ortaya koyar. 0.4–1.1 THz aralığı, malzeme karakterizasyonu, biyolojik doku görüntüleme ve güvenlik taramaları gibi alanlarda önemlidir. Düşük yansıma (yüksek iletim veya soğurma) özellikleri bu tür sistemlerde kullanılabilir. Özellikle 1.0 THz civarında yüksek seçiciliğe ihtiyaç duyulan

filtre uygulamalarında, S_{22} değeri çok düşük olduğunda ek yansımalar minimize edilir ve sistem istenen dalgaboyunda daha az parazitle çalışır. Eğer iletim de düşükse (S_{21} aynı frekansta çok düşükse), bu frekansta dalga büyük oranda soğruluyor demektir. Terahertz bandında verimli soğurma yapabilen metamalzeme yapıları, elektromanyetik gürültü bastırma, kamuflaj vb. amaçlarla değerlendirilebilir.

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IMPACT OF DESALINATION OF SEA WATER ON A COASTAL ENVIRONMENT FROM ALGERIAN WEST COAST

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Abstract

Around the Mediterranean coast, 79% of the production of fresh water is assured by reverse osmosis (SWRO). The great units are located in Spain, Israel and in Algeria, who chose the desalination of sea water as solution to solve the problems of drinking water shortage. Desalination thus will be essential like a resource alternative essential with the perenniality of great coastal cities where the need is felt. For to illustrate its strategic importance from now on it desalination became a vital need for great Algerian urban cities of the Mediterranean coastal such as Oran, Algiers, and Arzew. A number which the authorities aim to increase to 43 by 2019 but much of questions is currently posed on the impact of these installations on the environment. The principal environmental impact associated the processes of desalination comes from the production of the brine (salt concentrations maximum 36375mg/l). The other environmental impacts are: problems of landscape degradation, harmful effects sound, the emission of gas, or discharges associated like water coming from cleaning with the filter.

The present study concerns a qualitative assessment of wastewater from desalination 6 plants in western Algeria (Bousfer, Bouzedjar, Chatt el Hillal, Honaine, Ghazaouet and Ouled Ben ayad) to determine the potential impact of pollution on the coastal environment.

Keywords: desalination; sea water; fresh water; reverse osmosis; environmental impacts; brine; Algerian west coast.

MITIGATING MISINFORMATION IN NIGERIA USING MACHINE LEARNING AND INFORMATION LITERACY

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Abstract:
Nigeria's digital landscape is profoundly challenged by the rapid spread of misinformation, particularly on social media platforms, with significant implications for electoral integrity, public health, and social cohesion. While machine learning (ML) offers promising tools for automated fact-checking, their efficacy, accessibility, and ethical implications within Nigeria's complex socio-linguistic context remain critically underexplored. This study investigates the potential and limitations of ML-driven solutions—such as natural language processing (NLP), image verification, and Deepfake detection—in combating Nigerian misinformation. Through a mixed-methods approach, including quantitative analysis of ML tool performance on locally relevant datasets (containing English, Pidgin, Hausa, Yoruba, and Igbo content) and qualitative interviews with diverse stakeholders (citizens, journalists, librarians, and tech developers), the research evaluates: Accuracy & Bias, Accessibility & Trust, Ethical Risks and Literacy Integration. Findings reveal significant gaps in the cultural and linguistic adaptability of existing ML tools, highlighting challenges in processing Pidgin English and contextual nuances in indigenous languages. Trust issues stem from low digital literacy and skepticism toward automated systems. Crucially, the study argues that ML tools alone are insufficient; sustainable mitigation requires coupling technology with contextually tailored IL education that empowers citizens to understand algorithmic limitations and critically assess information ecosystems. The paper concludes with actionable recommendations for developing ethically aligned, linguistically inclusive ML fact-checking systems and designing IL programs that leverage these tools as pedagogical aids within Nigeria's unique digital democracy.
Keywords: Machine Learning, Misinformation, Fact-Checking, Information Literacy, Digital Citizenship, Nigeria, Natural Language Processing,

5 KATLI SİSMİK İZOLASYONLU BİR YAPININ ÜLKEMİZDE GERÇEKLEŞMİŞ OLAN 4 FARKLI DEPREM ETKİSİNDE DAVRANIŞI

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ÖZET
Bu çalışma kapsamında Van ili, Çaldıran ilçesinde 24 Kasım 1976 tarihinde gerçekleşmiş olan 7,5 Mw büyüklüğündeki deprem, Kocaeli ili, Gölcük ilçesinde 17 Ağustos 1999 tarihinde gerçekleşmiş olan 7,4 Mw büyüklüğündeki deprem, Düzce ilindeki 12 Kasım 1999 tarihinde gerçekleşmiş olan 7,2 Mw büyüklüğündeki deprem, Kahramanmaraş İli, Pazarcık İlçesinde 6 Şubat 2023 tarihinde gerçekleşmiş olan 7,7 Mw büyüklüğündeki depremlerin verileri TADAS(AFAD) ve Peer Ground Motion Database Center (PEER NGA)'den alınarak depremlerin zaman tanım alanına göre Adıyaman ili Merkez ilçesi Yeni Mahallesi 26390 sokakta yer alan Enlem: 37,775000 ve Boylam 38,245723 koordinatları için Türkiye Deprem Tehlike Haritaları İnteraktif Web Uygulaması üzerinden Deprem yer hareketi düzeyi DD2, Yerel zemin sınıfı ZC olarak alınmış olan spektrum değerleriyle yapılması muhtemel olan Sürtünmeli Sarkaç Tipi sismik izolasyonlu bir binanın 4 farklı deprem etkisinde ki davranışları incelenmiştir. Maksimum Kat ötelenmeleri, yer değiştirmeleri ve taban kesme kuvvetleri karşılaştırılmıştır.
Anahtar Kelimeler: Sismik İzolasyon, Sürtünmeli Sarkaç Tipi İzolatör, Deprem, Çaldıran Depremi, Gölcük Depremi, Düzce Depremi, Kahramanmaraş Depremi, Düşey Deprem

BEHAVIOR OF A 5-STOREY SEISMIC ISOLATED BUILDING UNDER THE EFFECT OF 4 DIFFERENT EARTHQUAKES THAT TOOK PLACE IN OUR COUNTRY

ABSTRACT
Within the scope of this study, the data of the 7.5 Mw earthquake that occurred on November 24, 1976 in Çaldıran district of Van province, the 7.4 Mw earthquake that occurred on August 17, 1999 in Gölcük district of Kocaeli province, the 7.2 Mw earthquake that occurred on November 12, 1999 in Düzce province, and the 7.7 Mw earthquake that occurred on February 6, 2023 in Pazarcık district of Kahramanmaraş province were taken from TADAS (AFAD) and Peer Ground Motion Database Center (PEER NGA) according to the time domain of the earthquakes. The possible hazard maps were prepared using the spectrum values taken as Earthquake ground motion level DD2 and Local ground class ZC for the coordinates of Latitude: 37.775000 and Longitude: 38.245723 in Yeni Neighborhood, Central District of Adıyaman province, according to the latitude: 37.775000 and Longitude: 38.245723 in 26390th Street via Turkey Earthquake Hazard Maps Interactive Web Application. The behavior of a Friction Pendulum Type seismic isolated building under 4 different earthquake effects was investigated. Maximum floor drifts, displacements and base shear forces were compared.
Keywords: Seismic Isolation, Friction Pendulum Type Isolator, Earthquake, Çaldıran Earthquake, Gölcük Earthquake, Düzce Earthquake, Kahramanmaraş Earthquake, Vertical Earthquake

LEARNING ENVIRONMENT AS MODERATOR OF UNIVERSITY STUDENTS ATTITUDE TOWARDS ACHIEVEMENT IN BUSINESS AND SELF-RELIANCE IN THE NORTH-EAST OF NIGERIA

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ABSTRACT

The study has two objectives, with corresponding research questions and null hypotheses guiding the study. Descriptive survey design was used for the study. The population of the study consists of 334 final year business education students. Total Population Sample was used in the study. While instrument for the study was Business Education Students' Attitude towards Achievement in Business Questionnaire" (BESAAQ). The reliability coefficient of the instrument stood at .87. The data collected was analyzed using descriptive and inferential statistics for the research questions and the null hypotheses. They were tested at 0.05 level of significance. Statistical Package for Social Sciences (SPSS) version 2.5 was used to analyze the data. The results showed that the variables Need for achievement, has significant positive influence on business education student's attitude toward self-reliance. Learning environment has moderated the relationship between the variables. It was therefore, recommended that, Business educators should improve the curriculum content because achievement was not a strong predictor of business education students' attitude toward self-reliance. Authorities and business educators in their various institutions should enrich the curriculum content. Authorities/school management and heads of department/section should strive to improve and strengthen learning environment in order to enhance students' attitude toward self-reliance.

Key words: Learning environment, Students attitude, Achievement in business.

THE ROLE OF NETWORKING IN JOB OPPORTUNIIES; A CROSS SECTIONAL STUDY

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ABSTRACT:
Networking plays a pivotal role in uncovering job opportunities and advancing professional careers. In today's competitive job market, qualifications and experience alone are often not enough; who you know can be just as important as what you know. Networking involves building and maintaining professional relationships that can provide valuable information, advice, referrals, and access to unadvertised job openings. These connections may arise through industry events, social media platforms like LinkedIn, alumni networks, or informal social gatherings. Effective networking enables job seekers to learn about company cultures, gain insider insights, and receive personal recommendations, significantly improving their chances of securing interviews and job offers. Moreover, it allows professionals to stay informed about industry trends and best practices, enhancing their value in the marketplace. Networking is a two-way street that also involves offering help, sharing knowledge, and building trust, which can result in long-term professional alliances. For employers, employee referrals from trusted networks often yield higher quality candidates and reduce recruitment costs. In essence, networking is not merely a job search strategy but a vital career development tool that fosters mutual support, knowledge sharing, and opportunity creation within professional communities. For this purpose, a questionnaire has been set to get more reliable opinion from respondents.
KEYWORDS: Networking, Job opportunities, Referrals, Recommendations

NOVEL CONCEPTS REGARDING DIABETES AND END-STAGE RENAL DISEASE

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ABSTRACT:
It is commonly known that in both industrialized and developing nations, diabetic nephropathy is the leading cause of end-stage renal disease (ESRD), either alone or in conjunction with hypertensive nephropathy. From January 1990 to December 2014, we searched PubMed, Embase, Scopus, Current Content, and Iran Medex to find a range of sources for this review. Significant cardiovascular disease, issues with vascular access, increased susceptibility to infections, foot ulcers, and hemodynamic instability during HD are some of the factors contributing to the poor prognosis of diabetic individuals with ESRD. While diabetic ESRD patients may experience numerous kidney transplant-related problems.
Keywords: Diabetic nephropathy, End-stage renal disease, Renal replacement therapy, Hemodialysis

INTRODUCTION:

A considerable percentage of individuals with type 1 diabetes, formerly known as insulin-dependent diabetes, and type 2 diabetes, formerly known as non-insulin-dependent diabetes mellitus (DM), develop diabetic nephropathy, which is traditionally characterized by the presence of proteinuria. If the duration of DM is long enough and the level of glycemia is high enough to cause diabetic complications, it can also happen to individuals with secondary types of DM, such as those who have had pancreatitis or a pancreatectomy. About 20% to 30% of patients with type 1 diabetes may develop microalbuminuria after an average of 15 years of diabetes, and less than half of these patients will progress to macroalbuminuria, commonly referred to as overt nephropathy. Many patients may progress to end-stage renal disease (ESRD) after developing overt nephropathy; rates have been found to range from 4% to 17% after 20 years and approximately 16% at 30 years from the time of the initial diagnosis of diabetes mellitus. Recent data indicates that the renal risk is currently equivalent, and the time to proteinuria from the onset of diabetes and the time to ESRD from the onset of proteinuria were comparable in this population, even though the prevalence of progressive renal disease is frequently lower in type 2 diabetes. Numerous studies have demonstrated that normalizing blood pressure, ideally with renin-angiotensin system (RAS) blockade by angiotensin converting enzyme inhibitors (ACEI) and angiotensin II receptor blockers (ARB), as well as the use of other agents like spironolactone and aldosterone antagonists, pentoxifylline, a non-selective phosphodiesterase inhibitor, and stringent control of plasma glucose levels, can slow the onset and progression of diabetic nephropathy. Nevertheless, a significant proportion of patients still develop end-stage renal disease (ESRD). The main causes of ESRD in developed nations have been the subject of numerous studies. Several types of glomerulonephritis (GN) were the most frequent cause of ESRD in various nations during the previous few decades. However, it is well known that diabetic nephropathy is currently the leading cause of end-stage renal disease (ESRD) in developed countries, and that hypertensive nephropathy and diabetic

nephropathy are likely the most common causes of ESRD due to more aggressive treatment of GN and possibly the rapid rise in the prevalence of obesity and diabetes. For instance, diabetes is the most common cause of end-stage renal disease (ESRD), accounting for around 45% of cases, according to the results of the US renal data system. However, it seems that the number of Danish individuals who acquire ESRD as a result of diabetes has stabilized. This could be because rigorous renoprotective therapies, like better blood pressure and glucose management, are widely used. Although there is a dearth of information regarding the etiology of end-stage renal disease (ESRD) in developing nations, it seems that diabetes and hypertension are the main causes of ESRD in these nations as well, reflecting the devastating effects of these two silent killers. For instance, the proportion of new patients in Iran who needed renal replacement treatment due to diabetic nephropathy doubled between 1997 and 2006, rising from 16% in 1997 to 31% in 2006. . Another Iranian study found that DM was the leading cause of end-stage renal disease (ESRD), accounting for about 35% of cases in people 40 years of age and beyond. Furthermore, hypertensive nephrosclerosis and diabetic nephropathy jointly account for 55% of the development of ESRD. Diabetic nephropathy is the cause of a considerable percentage of individuals with end-stage renal disease (ESRD), according to the findings of various research conducted in developing nations. Other Arab nations have also recorded high prevalence rates of diabetes mellitus, such as Kuwait (21.2%), Egypt (35%), and Lebanon (46.8%).

Survival of diabetic patients with ESRD:

Although maintenance dialysis prevents death from uremia and the life expectancy of patients with ESRD including diabetic patients has improved since the introduction of dialysis in the 1960s, it is still far below that of the general population. In addition, patient survival in diabetics on maintenance dialysis including HD and PD is lower than that seen in nondiabetics with ESRD in developed and developing countries .The poor outcome of diabetic ESRD patients has demonstrated in many studies. As an example, according to the report of 2009 United States Renal Data System (USRDS), the 5 years survival of diabetes patients with ESRD is catastrophic and only 30% after initiation of HD. In comparison 1, 3, 5, and 10-year survival of ESRD patients on maintenance HD in the United States is 79%, 53%, 35%, and 11.2%, respectively. These values are also much far below than the general population (which the range of the expected remaining life span is 30 to 40 years for those aged 40 to 44, and 17 to 22 years for individuals aged 60 to 64).The result of Chantrel et al study also showed the poor survival of diabetic patients with ESRD in developed countries with relatively high survival rates. According to the result of this study which performed in a center in France, 32% of patients with type 2 diabetes requiring dialysis died after a mean follow-up of 211 days .While many studies about the survival of diabetic ESRD patients on maintenance dialysis have been done in developed countries, however, there is few data from developing countries has been existed. According to the two reports from Iran, the long-term survival among diabetic dialysis patients is catastrophic and lower than that seen in nondiabetic ESRD patients. In the first study, survival of 185 ESRD patients on intermittent HD was evaluated. Although, one-year survival of diabetic patients is approximately similar to nondiabetic patients, however, 3 and 5-year survival of diabetic patients is significantly lower (52.2% vs. 73.8%) and no one of diabetic patients had 5-year survival (0% vs. 56.9%). In the other study, long-term survival of 1861 ESRD patients in multicenter of HD in southwest of Iran was investigated. The survival of diabetic patients was significantly lower than nondiabetic patients and 1, 5, 10 and 15 year survival of diabetic and nondiabetic patients are 79.2 vs. 85%, 32.3 vs. 11.5%, 5.8 vs. 0.4, and 1.7 vs. 0% respectively. In summary, according to the results of above studies, the survival of diabetic dialysis patients is lower than nondiabetic patients. There is an important question now. Is there any difference between survivals of dialysis patients with DM as primary cause of ESRD with dialysis patients with DM as a comorbid condition?There are few studies which

compare this issue among dialysis patients. In a large international cohort study with using of data from the European Renal Association-European Dialysis and Transplant Association Registry, Schroijen et al compare the survival of 15 419 dialysis patients; 3624 dialysis patients with diabetes as primary renal disease, 1193 dialysis patients with diabetes as a comorbid condition, and 10 602 dialysis patients without diabetes.

Dialysis modality in diabetics:

A number of factors influence diabetics' decision to use HD, chronic ambulatory peritoneal dialysis (CAPD), or automated peritoneal dialysis (APD). These factors also apply to nondiabetics. Some of them are availability and convenience, comorbid conditions, socioeconomic and dialysis centre factors, patient independence and motivation, ability to tolerate volume shifts, risk and history of infection, peripheral vasculature status to create adequate vascular access for HD, and abdomen status for PD. Patients with diabetes Patients in their later years are more likely to have severe peripheral vascular disease, which limits their ability to create and maintain an adequate arteriovenous fistula for chronic HD. Furthermore, many diabetic patients have autonomic neuropathy, making them more likely to have frequent hypotensive episodes during HD, particularly during ultrafiltration dialysis, where fluid removal is the primary goal. Intradialytic hypotension usually necessitates intravenous fluid replacement therapy, resulting in volume overload in these patients. Hypotensive episodes during HD, on the other hand, usually necessitate a decrease in blood flow rate and, in some cases, discontinuation of HD, resulting in inadequate dialysis and other significant complications in these patients.Finally, diabetic patients can be treated with either PD or HD in a way that maximises the benefits of each modality. However, given the above complication, it may be suggested that diabetic dialysis patients begin with PD and then transition to HD if complications arise. This is based in part on the hypothesis that, when compared to HD, PD may provide better residual renal function preservation and shorter-term survival.However, analysis of data provided by the United States Renal Data Systems (USRDS) and other studies have found that survival benefit associated with PD is during the first few years on dialysis and is lost over time.

Dialysis versus kidney transplantation:

Many kidney transplant complications can occur in diabetic ESRD patients.Diabetes has a higher incidence of cardiovascular disease than nondiabetic transplant recipients, and it causes the highest rates of adverse cardiac events in the early and late posttransplant period.Furthermore, diabetic transplant recipients are more likely to develop bacterial and fungal infections, including posttransplant urinary tract infections, than nondiabetic transplant recipients.Glycemic control after transplantation is another challenge in diabetic ESRD patients.Because of the immunosuppressive regimens used after transplantation and their negative effects on pancreatic beta cell function and peripheral insulin action, glycemic control and achievement of target glucose levels are frequently more difficult after transplantation, making prevention of recurrence of diabetic lesions in the transplanted kidney difficult as well. Furthermore, diabetic patients who underwent transplantation had a projected life expectancy of 11 years longer than diabetics on the waiting list. A survival analysis from another study in Scotland among 1732 patients waiting for their first kidney transplant produced similar results. The risk of death among approximately 250 diabetic patients who underwent transplantation was lower at 12 months posttransplantation, and the projected increase in life was significantly higher compared to diabetics who remained on dialysis.It is hypothesised that the lower mortality rate among dialysis patients who underwent kidney transplantation compared to those who remained on dialysis is due in part to a lower risk of fatal and nonfatal cardiovascular complications, particularly among diabetic patients.

Preemptive kidney transplantation:

The current evidence suggests that all patients with chronic kidney disease (CKD) have a survival advantage with preemptive transplantation (before dialysis is required) when compared to dialysis followed by transplantation, and preemptive kidney transplantation is recommended if possible rather than transplantation after a period of dialysis.Preemptive kidney transplantation appears to be preferred among diabetic patients with CKD rather than dialysis followed by transplantation, and it is also associated with significant improvements in patient survival.According to the USRDS report, there is a 21%,28%,41%,53%, and 72% increase in risk of death after transplantation compared to preemptive transplants among 73,103 patients, including nearly 20 000 diabetic patients, with waiting times ranging from 6 to 12 months, 12 to 24 months, and so on. There is also an association between the risk of graft loss and increasing time on dialysis in all patients with ESRD, including patients with diabetes .According to the results of current studies, it is not clear whether the better patient and allograft survival of preemptive transplantation among ESRD diabetic patients are achieved when either living donor or deceased donor kidneys are used. For example, the result of Meier-Kriesche et al study showed that preemptive kidney transplantation is associated with better patient and allograft survival among both living and deceased donors. In contrast to the result of this study, Becker et al in a retrospective study of over 20 000 diabetic patients have suggested that the benefit of preemptive transplantation is limited to living donor recipients. In this study, ESRD diabetic patients who received preemptive kidney transplantation from living donors had lower mortality (with relative risks of 0.57 and 0.65 for type 1 and type 2 diabetes recipients, respectively) than either type 1 or type 2 diabetic recipients of cadaveric donor kidneys.

Conclusion:

Diabetic kidney disease affects a significant number of patients with type 1 and type 2 diabetes. Although the prevalence of progressive renal disease is generally lower in type 2 diabetes, recent data suggest that the renal risk is now equivalent, and the time to ESRD from the onset of proteinuria was comparable in the two types of diabetes. The fact that diabetic nephropathy, particularly type 2, and hypertensive nephropathy are the leading causes of ESRD in both developed and developing countries reflects the disastrous consequences of these two silent killers.Diabetics on maintenance dialysis, including HD and PD, have lower patient survival than nondiabetics with ESRD. It appears that dialysis patients with diabetes as the primary renal disease have a lower survival rate than patients with diabetes as a comorbid condition.Diabetic patients can receive either PD or HD treatment. It is possible that diabetic dialysis patients should start with PD because it preserves residual renal function and improves short-term survival. However, a review of numerous studies found that the survival benefit associated with PD is only present during the first few years of dialysis and fades over time.Although there are many risks associated with kidney transplantation in diabetic ESRD patients, multiple studies have found that kidney transplantation is the preferred renal replacement therapy for diabetic ESRD patients and in these patients, it is associated with significantly better survival and quality of life than dialysis.

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OPTIMIZING SOLAR IRRADIANCE FORECASTING IN BATMAN, TURKEY USING ARTIFICIAL NEURAL NETWORKS WITH HYPERPARAMETER TUNING

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ÖZET
Güneş enerjisi, yenilenebilir enerji kaynakları arasında kritik bir konuma sahiptir ve küresel enerji üretimine katkısı giderek artmaktadır. Bununla birlikte, güneş enerjisinin kesintili doğası, enerji şebekesi yönetimi ve planlaması için zorluklar ortaya çıkarmaktadır. Bu çalışmada, Batman, Türkiye'de küresel yatay ışınımı (GHI) tahmin etmek için bir yapay sinir ağı (YSA) modeli geliştirilmiş ve optimize edilmiştir. Solcast platformundan alınan ve 1 Ocak 2022 ile 1 Ocak 2025 tarihlerini kapsayan saatlik veriler kullanılmış ve model hiperparametreleri rastgele arama optimizasyon tekniği kullanılarak belirlenmiştir. Üç gizli katman, 192 giriş nöronu ve 0,001 öğrenme oranı ile yapılandırılan optimum model, test setinde 81,17 W/m² Ortalama Mutlak Hata (MAE), 105,42 W/m² Ortalama Karesel Hatanın Kökü (RMSE) ve 0,87 Belirleme Katsayısı (R^2) dahil olmak üzere sağlam performans ölçümleri elde etmiştir. Bu bulgular, YSA tabanlı modellerin güvenilir GSH tahminleri sunabileceğini ve yenilenebilir enerjinin modern güç sistemlerine entegrasyonunu destekleyebileceğini doğrulamaktadır.
Anahtar Kelimeler: Güneş ışınımı tahmini, yapay sinir ağları, hiperparametre optimizasyonu, yenilenebilir enerji, zaman serisi tahmini

ABSTRACT
Solar energy holds a critical position among renewable energy sources, with its contribution to global energy production steadily increasing. The intermittent nature of solar energy, however, poses challenges for energy grid management and planning. This study develops and optimizes an artificial neural network (ANN) model for predicting global horizontal irradiance (GHI) in Batman, Turkey. Hourly data from the Solcast platform, spanning January 1, 2022, to January 1, 2025, were employed, with model hyperparameters determined using a random search optimization technique. The optimal model, configured with three hidden layers, 192 input neurons, and a learning rate of 0.001, achieved robust performance metrics on the test set, including a Mean Absolute Error (MAE) of 81.17 W/m², Root Mean Square Error (RMSE) of 105.42 W/m², and Coefficient of Determination (R^2) of 0.87. These findings confirm that ANN-based models can deliver reliable GHI forecasts, supporting the integration of renewable energy into modern power systems.
Keywords: Solar irradiance forecasting, artificial neural networks, hyperparameter optimization, renewable energy, time series prediction

INTRODUCTION
Energy serves as a critical driver of industrialization and urbanization, playing a pivotal role in economic and technological advancements. Rapid population growth has significantly intensified the global energy crisis (Duffy et al., 2015; Kılınç et al., 2023). Fossil fuels continue to dominate the global energy mix. However, their rapid depletion and significant contribution to greenhouse gas emissions intensify global warming. The growing awareness of

environmental impacts has increased the demand for sustainable energy alternatives. (Abomohra et al., 2016; Canpolat & Altunkaynak, 2025; Korkmaz et al., 2024) As a result, renewable energy production has grown rapidly in recent years. Numerous international organizations have introduced regulatory measures and policies to promote renewable energy adoption. Carbon taxation, for instance, has been employed to encourage the integration of renewable sources (Kilic & Yaman, 2024; Mendonça et al., 2018; Mutlu & Altunkaynak, 2024).The Earth possesses abundant solar energy resources. Nevertheless, challenges such as the intermittent nature of solar energy and the unpredictability of solar generator outputs raise concerns about its widespread adoption (Pommeret & Schubert, 2022) These challenges have spurred growing interest in modeling and forecasting solar energy. Solar irradiance, defined as the power per unit area, is a fundamental measure of solar energy. Accurate forecasting of solar irradiance enables grid operators to enhance the quality and control of solar energy production (Taggart et al., 2012) Such data also facilitate improved scheduling, dispatch, and power regulation to accommodate variable electricity generation. Precise solar irradiance forecasting plays a critical role in power distribution planning. Thus, accurate modeling and prediction of solar irradiance remain essential for future energy systems(Krishnan et al., 2023)

The literature offers a variety of methods for solar irradiance forecasting (Geetha et al., 2022; Ji et al., 2022) Many of these methods rely on traditional machine learning techniques, including linear regression, multiple linear regression, and support vector machines (Bamisile et al., 2022; Çelebi & Karaman, 2023) The integration of neural networks into time series analysis has prompted numerous researchers to explore these approaches for solar irradiance and energy production forecasting(Gasparin et al., 2022) Neural network-based models have been successfully applied to various time series problems, such as energy production, consumption, and wind speed prediction(Aslan, 2025; Aslan & Çelebi, 2022, 2024; Ifaei et al., 2023; Sunar & Khalid, 2024) Increasing the number of layers and optimizing model parameters can further enhance forecasting accuracy. Given the proven success of neural network-based models in time series forecasting, achieving high-accuracy predictions in the energy domain is feasible(Wang et al., 2019). However, determining optimal hyperparameter configurations remains a fundamental research challenge. In this context, identifying optimal hyperparameters for solar irradiance forecasting is critical for improving model performance. Proper hyperparameter tuning can significantly enhance prediction accuracy (Çalışkan, 2023).

This study aims to develop an artificial neural network (ANN) model with optimized hyperparameters for forecasting global horizontal irradiance (GHI) using high-quality data from the Solcast platform. The model was trained and evaluated using hourly data collected in Batman, Turkey, from January 1, 2022, to January 1, 2025. Through systematic hyperparameter optimization, the study seeks to achieve superior prediction accuracy, as measured by metrics such as mean absolute error (MAE), root mean square error (RMSE), and coefficient of determination (R^2).

RELATED STUDY

Accurate forecasting of GHI is critical for optimizing solar energy integration into power systems, yet challenges persist due to its variability and dependence on meteorological conditions (Chu et al., 2021). Recent advancements in machine learning and deep learning have enhanced predictive performance, with studies exploring numerical weather prediction post-processing, ensemble methods, and feature engineering to address these complexities (Castangia et al., 2021).

Recent studies show that applying machine learning post-processing to numerical weather prediction outputs, such as using an ANN for ECMWF day-ahead forecasts in Portugal, can reduce systematic bias and improve RMSE compared to baseline models. Over the Iberian Peninsula, a blended framework that fused satellite imagery, WRF-Solar, and several learners delivered the best short-term GHI estimates, although the expanded data flow increased

operational complexity (Huertas-Tato et al., 2020). Experiments that compared boosted trees, bagged trees, random forest, and generalized random forest found that ensemble learners provided more stable hourly forecasts than single models, yet the analysis still relied on moderate data spans and only limited blocked validation (Lee et al., 2020).

Deep-learning methods such as LSTM–CNN hybrids have outperformed single models in one-year experiments; however, these approaches often lack evaluation on multi-year datasets (Kumari & Toshniwal, 2021). Attention-based models have achieved high hourly prediction accuracy, though details on hyperparameter optimization are frequently omitted (Lai et al., 2021). Decomposing the signal with variational mode decomposition and predicting each mode with a CNN ensemble improved daily and hourly skill, though the workflow remained computationally intensive despite GPU acceleration (Cannizzaro et al., 2021). Input selection and systematic hyperparameter optimization are critical. Incorporating relevant exogenous variables in multivariate LSTM models significantly improves solar radiation forecasting compared to univariate models (Castangia et al., 2021). A bidirectional LSTM tuned by Bayesian optimisation in desert conditions reached $R^2 \approx 0.97$ for GHI while retaining a short training horizon(Elizabeth Michael et al., 2022). Proactive variable selection also curbed overfitting in deeper networks (Chen et al., 2023). However, the use of sine–cosine encoding for cyclical time features remains uncommon in current GHI forecasting studies.

Ensemble and decomposition strategies continue to expand. Multivariate empirical mode decomposition followed by lightweight regressors produced lower MAE than deeper baselines on sub-hourly data (Gupta & Singh, 2023). A two-level stacking ensemble trained on one-minute irradiance from South Africa trimmed RMSE by roughly one quarter versus a recurrent neural net, with larger gains reported against simpler baselines (Mugware et al., 2025). Weather-clustered CatBoost models that used three-year records from two continents cut RMSE by up to 39 % during cloudy periods (Ahmed et al., 2024). Adding large-scale GDAS predictors improved one-week to one-month horizons across Brazilian sites, though the authors performed only basic grid searches (Weyll et al., 2024). Important gaps persist. A decision-tree study that analyzed thirty-nine years of NASA POWER data reported $R^2 \approx 1.00$, implying potential leakage from random k-fold splits that ignore temporal order (Imam et al., 2024). No previous investigation combines multi-year training, sine–cosine encoding, random-search optimization, and strict TimeSeriesSplit validation.

Our proposed method addresses all four elements by training an ANN on three years of hourly Solcast data from Batman, Turkey, optimised with random search and evaluated with rolling, time-aware folds, thereby promoting seasonal generalisation and methodological transparency.

MATERIALS AND METHODS

This section summarizes the dataset, data preprocessing, model development, hyperparameter tuning, and evaluation methodology. Figure 1 provides a schematic of the overall workflow. The flowchart illustrates a cyclical process encompassing data preprocessing, definition of hyperparameter ranges, model training with varied parameters, evaluation using performance metrics such MAE, RMSE, and R^2, and selection of the optimal model through iterative updates. This comprehensive approach is designed to maximize model performance and ensure systematic evaluation during validation.

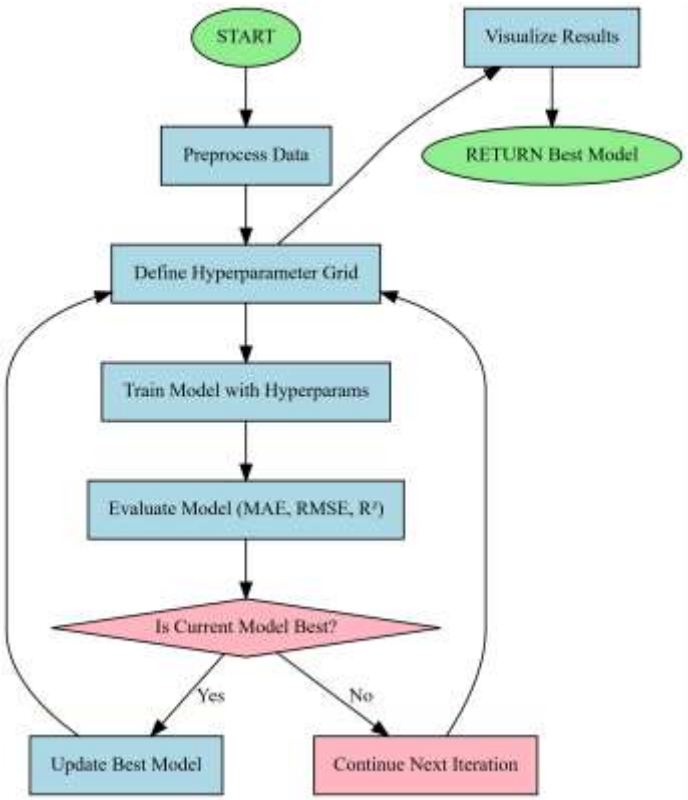

Figure 1. Workflow of the hyperparameter optimization and model selection process in solar irradiance prediction

Subsequent subsections will sequentially detail the study area and dataset, data preprocessing and feature engineering strategies, ANN model architecture and hyperparameter search methods, performance metrics used for model evaluation, and error analysis. This approach ensures the transparency, reproducibility, and contribution of the proposed method to the literature.

Study Area and Data Set

This study utilized a dataset of hourly GHI collected from January 1, 2022, 01:00 (UTC) to January 1, 2025, 00:00 (UTC). The data pertain to Batman, located in Turkey's Southeastern Anatolia Region (37.83625° N, 41.360574° E), and were obtained through the Solcast platform's API for non-commercial academic purposes, provided free of charge to public research institutions (Solcast, 2025). Data analysis facilitates the extraction of meaningful insights from complex datasets, supporting objective decision-making and enhancing model performance in scientific research. Figure 2 illustrates the diurnal variation of GHI, with color-coded morning, midday, and evening periods, revealing a rapid increase after sunrise, peaking at approximately 670 W m⁻ around noon, and symmetrically decreasing toward evening.



Figure 2. Hourly Profile of GHI

The dataset comprises GHI, air temperature, and temporal features. Its low error rate and high resolution are confirmed by independent studies (Det Norske Veritas-DNV, 2024; Subramanian et al., 2023) High-quality input data are crucial for enhancing the performance of machine learning-based solar irradiance forecasting models. Figure 3 shows that GHI distribution widens with increasing temperature, with values exceeding 800 W m^{-2} typically occurring at temperatures of 25 °C or higher. This finding indicates that high temperatures correspond to clear-sky conditions, supporting the physical consistency of model inputs.

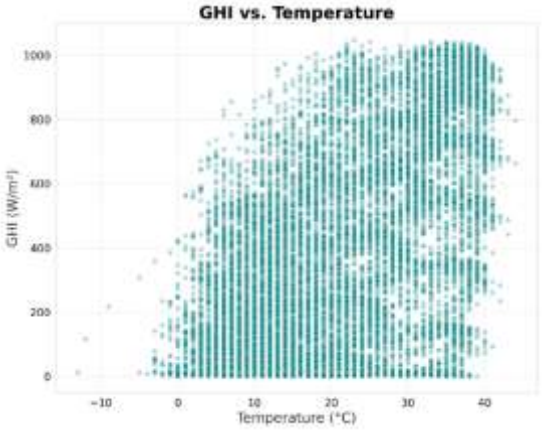

Figure 3. Scatter Plot of GHI versus Temperature

This distribution demonstrates that temperature serves as a significant predictor in GHI forecasting. The correlation between high temperatures and elevated radiation levels indicates that temperature is a critical input for enabling the model to produce physically consistent and reliable predictions.

Data Preprocessing and Feature Engineering

In this phase of the study, raw Solcast data underwent five sequential preprocessing steps: missing value imputation, statistical scaling, time-based feature extraction, cyclic encoding, and additional cleaning with synthetic variable generation. Each step was designed to enhance data quality and facilitate robust learning in the ANN model. Missing values in the hourly time series were addressed using the SimpleImputer with a median strategy (SimpleImputer(strategy="median")). The median was selected to mitigate sensitivity to outliers, ensuring stable results for climate data series, as supported by (Denhard et al., 2022)
Numerical features were subsequently standardized using StandardScaler, transforming them to a mean of zero and a variance of one. This approach balances gradient distributions in the ANN, accelerating training convergenc(Passalis et al., 2019). Time-based features were then extracted, including hour, day of the week, day of the year, month, and season. These features enable the model to capture diurnal and seasonal fluctuations effectively (Denhard et al., 2022). Cyclic encoding was applied to the hour and season variables, transforming them into sine-cosine pairs. This encoding ensures that cyclical transitions, such as from 23:00 to 00:00, are represented continuously, enhancing model interpretability(Sarmas et al., 2022). Finally, nighttime values (global horizontal irradiance, GHI ≤ 0) were removed to focus on meaningful solar data. A synthetic feature, solar energy, was generated using the formula solar_energy = GHI * 0.18, assuming a photovoltaic (PV) panel efficiency of $\eta = 0.18$ (Paoli et al., 2009). This comprehensive preprocessing pipeline preserved the physical significance of the data while optimizing the ANN's learning process, establishing a robust foundation for subsequent hyperparameter tuning.

Model Architecture and Hyperparameter Optimization

A feedforward ANN was constructed using the Sequential API, comprising an input layer, one to three hidden layers, and a linear output layer. The number of neurons in the hidden layers ranged from 16 to 128, while the input layer was varied between 32 and 256 neurons. Larger networks were avoided due to their potential instability with small datasets (Benish P & R, 2024; Birecikli et al., 2020). Hyperparameter optimization was performed using Keras Tuner's RandomSearch algorithm with five trials, employing TimeSeriesSplit with five folds for cross-validation (Benson et al., 2020). Time-sensitive validation was implemented to prevent data leakage into future time steps, following best practices for time-series modeling. Each trial was trained for a maximum of 50 epochs with a batch size of 32, incorporating EarlyStopping (patience = 5, restore_best_weights) to mitigate overfitting. The Adam optimizer was used across all hyperparameter trials, with the learning rate sampled from the set {1e-2, 1e-3, 1e-4}. The batch size was fixed at 32 to ensure consistent updates. These configurations aimed to achieve stable convergence for short-term solar irradiance forecasting. During the validation phase of hyperparameter tuning, TimeSeriesSplit divided the training set into five folds, further safeguarding against future data leakage (El-Shahat et al., 2024)

The proposed architecture and optimization strategy sought to identify the optimal parameter set while avoiding unnecessary complexity, ensuring robust validation tailored to time-series data.

Model Performance Metrics

Model accuracy was assessed using five complementary error metrics: MAE, RMSE, R^2, MAPE, and MdAE. MAE represents the average absolute difference between actual and predicted values. RMSE is calculated as the square root of the mean of squared errors, emphasizing larger deviations. R^2 indicates the proportion of variance in the target variable explained by the model. MAPE expresses the average absolute error as a percentage, facilitating comparisons across different locations. MdAE, defined as the median of absolute errors, provides a robust metric in the presence of outliers. These metrics collectively offer a comprehensive evaluation of model performance, as described in Eq. (1)–(5)(Çelebi & FiDan, 2024; Wen et al., 2022).

$$R^2 = 1 - \frac{\sum_{i-1}^{N}(x_i - x_i^*)^2}{\sum_{i-1}^{N}(x_i - \bar{x})^2} \quad (1)$$

$$\text{RMSE} = \sqrt{\frac{1}{N}\sum_{i-1}^{N}(x_i^* - x_i)^2} \quad (2)$$

$$MAPE = \frac{100}{N}\sum_{i=1}^{N}\left|\frac{x_i - x_i^*}{x_i}\right| \quad (3)$$

$$MAE = \frac{1}{N}\sum_{i=1}^{N}|x_i - x_i^*| \quad (4)$$

$$MdAE = \text{median}(|x_1 - x_1^*|, |x_2 - x_2^*|, \ldots, |x_i - x_i^*|) \quad (5)$$

Where N represents the number of observations, x_i denotes the actual GHI value for each hourly measurement, and x_i^* corresponds to the model-predicted GHI value at the same time point. The term $\bar{x}$ signifies the arithmetic mean of all actual GHI values, while $\bar{x}^*$ represents the arithmetic mean of the predicted GHI values

RESULTS AND DISCUSSION

Model Selection and Hyperparameter Results

The performance of the ANN model for solar irradiance forecasting was systematically evaluated by considering the effects of varying layer counts, neuron configurations, and learning rates. As presented in Table 1, the highest accuracy and lowest error metrics were achieved with a three-layer ANN comprising 192 input neurons, hidden layers with 96-96-16

neurons, and a learning rate of 0.001. This configuration yielded a MAE of 81.17 W/m², RMSE of 105.42 W/m², R² of 0.87, MAPE of 41.45%, and MdAE of 64.18 W/m².

Table 1. Accuracy and error metrics for ANN models across different hyperparameter combinations.

Input units	Hidden layer	Units 0	Learning rate	Hidden-2 units	MAE	RMSE	R²	MAPE (%)	MdAE	Hidden-3 units
32	2	64	0.01	16	82.24	108.22	0.86	64.72	58.85	
192	3	96	0.001	96	81.17	105.42	0.87	41.45	64.18	16
96	2	16	0.0001	64	170.43	205.48	0.51	73.61	160.16	
192	1	80	0.001	32	95.2	125.88	0.82	92.86	60.84	
32	1	80	0.01	48	75.45	101.33	0.88	87.23	45.78	

Models with either lower or higher learning rates, or insufficient neuron counts, exhibited significantly higher MAE and RMSE, alongside reduced R² values. Notably, models with inadequate parameters saw R² values drop as low as 0.51, with error metrics increasing by up to twofold. These findings underscore the necessity of carefully selecting the number of layers, neurons, and learning rate to achieve optimal ANN performance. The best hyperparameter combination was determined using the optimization algorithm described previously.

Test Set Prediction Performance

The predictive performance of the proposed ANN model was evaluated using the first 300 samples of the test set, spanning July 15 to August 4. As illustrated in Figure 4, the model's predicted GHI curve closely aligns with the observed GHI values across nearly all data points, successfully capturing both daily maximum and minimum points. This alignment provides visual evidence of the model's sensitivity to both short-term fluctuations and seasonal or periodic patterns.

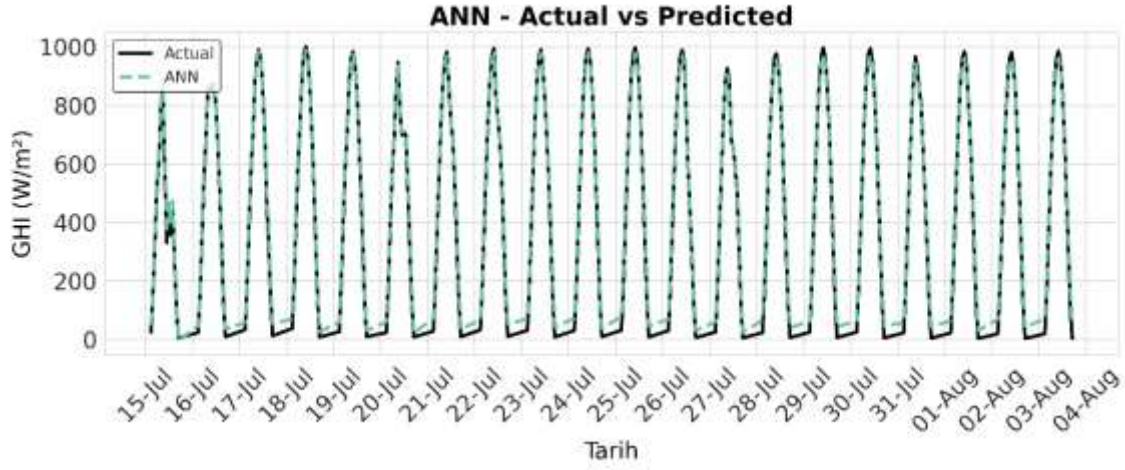

Figure 4. Time-series comparison of observed and ANN-predicted GHI values (W/m²).

The close match between observed and predicted GHI values demonstrates the model's ability to capture both short-term and periodic variations in solar irradiance. Notably, the model exhibits limited deviations even at low irradiance levels, with no evidence of systematic error trends. Analysis of the test period revealed no extreme deviations or discernible bias in the predictions. These results indicate that the ANN model possesses strong generalization capabilities on the test set, suggesting its reliability for practical applications. However, slight reductions in model accuracy may occur during extreme weather events or at very low irradiance levels, which warrants consideration in operational contexts.

Each point in Figure 5 represents an observation from the test set. The concentration of points along the diagonal line indicates that the model's predictions closely match the observed GHI

values. The model accurately captures low to moderate GHI levels, although slight deviations are observed at high irradiance levels in some instances.

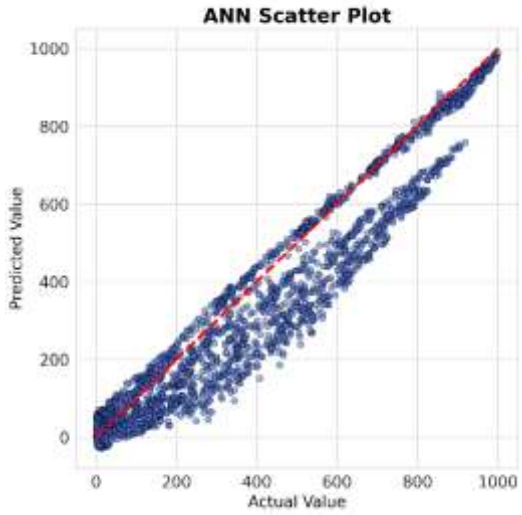

Figure 5. Scatter plot of ANN-predicted GHI (W/m²) values versus observed values.

The proximity of data points to the diagonal reference line in Figure 3 indicates that the ANN model generally produces stable and unbiased predictions. However, minor deviations from the diagonal indicate that model performance can decrease during extreme weather conditions or in the presence of sensor noise. Furthermore, at high GHI levels, some predictions fall below the diagonal, revealing a tendency for the model to underestimate actual values (negative bias) in these regions. This finding highlights the need for further refinement of the model to improve accuracy at high irradiance levels.

Error Behavior and Statistics

Figure 6 illustrates the temporal variation of prediction errors, defined as the difference between observed and ANN-predicted GHI values (W/m²). Analysis of the plot reveals that errors predominantly lie within a ±50 W/m² band and cluster near zero. However, a noticeable increase in error magnitude is observed starting from September 2024. This increase may stem from external factors, such as seasonal transitions or abrupt meteorological changes. Additionally, error distributions exhibit greater variability and amplitude during periods of fluctuating irradiance, particularly in autumn and winter months. Despite these variations, no consistent systematic bias or persistent positive/negative error trends are evident, with errors generally distributed symmetrically around zero.

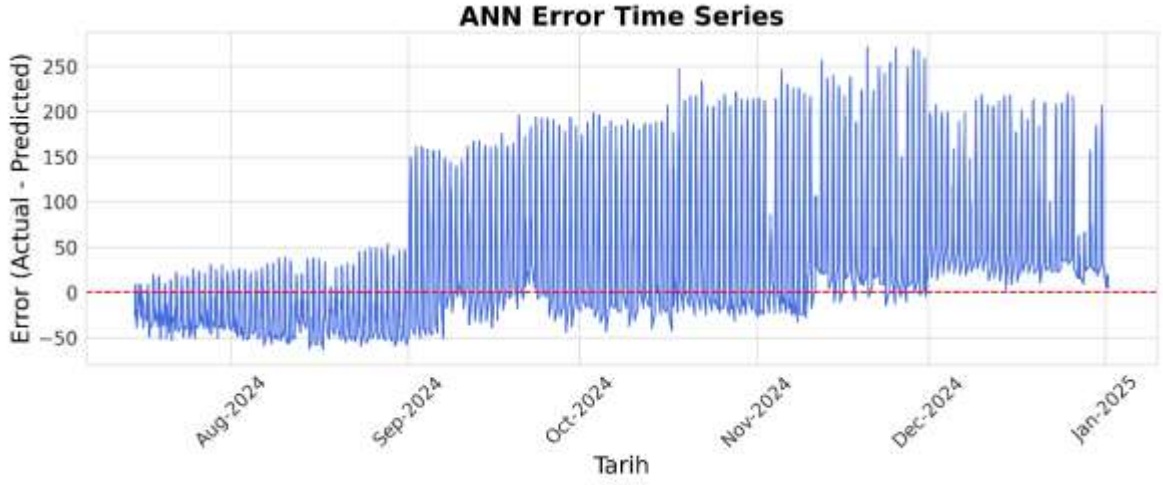

Figure 6. Time-series of prediction errors (observed – predicted GHI) for the ANN model on the test set.

The error behavior depicted in Figure 6 indicates that the ANN model produces highly stable predictions during summer months, when periodic variability is low. However, during transitional seasons, some positive error values reach up to 200 W/m², suggesting that the model may occasionally exhibit larger-than-expected deviations under sudden weather changes or extreme conditions. Figure 7 presents the histogram of prediction errors, showing that the majority cluster near zero, with both negative and positive small errors dominating. However, a pronounced spread in the right tail (positive errors) is observed, with occasional deviations exceeding 150 W/m².

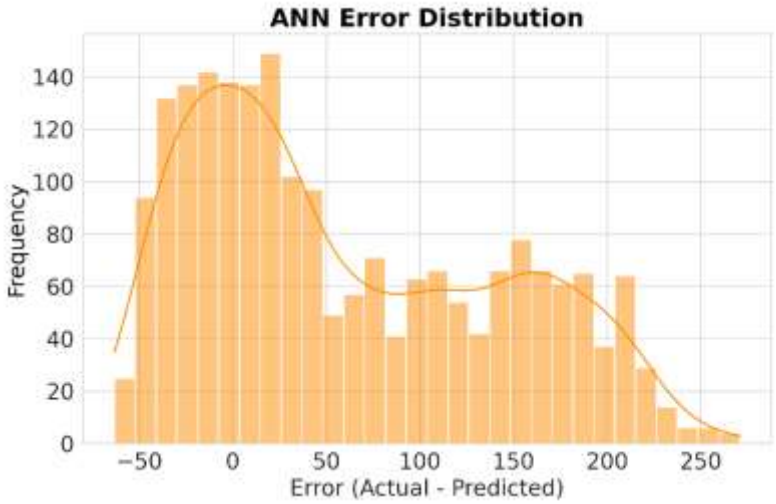

Figure 7. Histogram of the ANN model's prediction error distribution on the test set.

Physical Interpretability of The Model

Figure 8 presents the correlation matrix of meteorological and temporal variables employed in GHI prediction, offering valuable insights into the model's physical consistency and the predictive power of input variables. Strong positive or negative correlations are observed between GHI and key variables, including clearsky_ghi, air_temperature, cloud_opacity, and albedo. Notably, clearsky_ghi and air_temperature exhibit high positive correlations with GHI ($r > 0.9$), indicating their role as primary determinants of solar irradiance. Conversely, negative correlations with cloud_opacity and relative_humidity highlight the suppressive effect of increased cloudiness and humidity on GHI. Additionally, temporal synthetic variables, such as hour_sin and hour_cos, demonstrate significant relationships with GHI. These findings confirm that the ANN model generates statistically robust predictions. They also show physical consistency, aligning with the underlying solar-radiation processes

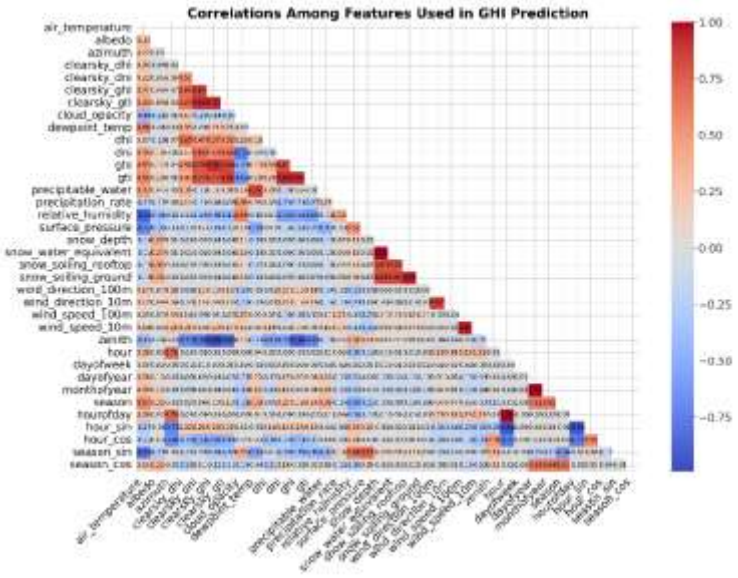

Figure 8. Correlation matrix of meteorological and temporal variables used in GHI prediction.

Discussion

This study proposes an ANN model for GHI prediction, leveraging multivariate meteorological and temporal data. The results were analyzed in detail, revealing that the optimal model architecture, configured with 192 input neurons, three hidden layers with 96-96-16 neurons, and a learning rate of 0.001, achieved competitive performance. The random search strategy minimized error variance across five trials. Test set accuracy metrics (MAE: 81.2 W/m², RMSE: 105.4 W/m², R^2: 0.87, MAPE: 41.5%) compare favorably with similar studies in the literatur(Al-Shourbaji & Alameen, 2025; Gürel et al., 2023)

Despite these strengths, the model exhibits limitations. Positive error deviations exceeding ±50 W/m² were observed during the August–December period, potentially due to seasonal variability or meteorological fluctuations. Recent studies emphasize the need for uncertainty analysis in machine learning (ML)-based GHI forecasting, highlighting performance variations across seasons and the importance of defining uncertainty bands(Gayathry et al., 2024). The correlation matrix further confirms the model's physical consistency, with strong positive correlations between GHI and clearsky_ghi and air_temperature, and negative correlations with cloud_opacity. However, the model lacks explainability, and integration of SHAP (SHapley Additive exPlanations) is recommended to enhance interpretability(Rajagukguk & Lee, 2025). This supports the inclusion of SHAP-based feature importance analysis in future work. Additionally, a systematic negative bias at high GHI levels was observed, which could be mitigated by incorporating more diverse training samples or hybrid ML models

CONCLUSION

This study developed an optimized ANN model for predicting GHI in Batman, Turkey. Hourly data from the Solcast platform, spanning January 1, 2022, to January 1, 2025, were utilized, with model hyperparameters optimized using Keras Tuner's RandomSearch algorithm. The optimal model, configured with three hidden layers (192 input neurons, 96-96-16 hidden neurons, and a learning rate of 0.001), achieved a test set performance of MAE: 81.17 W/m², RMSE: 105.42 W/m², and R^2: 0.87. These results demonstrate the model's ability to effectively capture daily and seasonal GHI patterns.

However, error magnitudes exceeding ±50 W/m² were observed during seasonal transitions (August–December), potentially due to meteorological variability. A negative bias at high GHI levels further indicates areas for improvement. C Correlation analysis demonstrates physical consistency, with GHI showing strong positive correlation with clearsky_ghi and air

temperature, and negative correlation with cloud_opacity. Future enhancements could include uncertainty quantification, hybrid machine learning models, and SHAP-based explainability to improve interpretability. This study underscores the potential of ANN-based models for GHI forecasting, offering a valuable tool for renewable energy systems.

ACKNOWLEDGEMENTS

Data Availability. The authors would like to thank Solcast for providing the global solar irradiance and PV system power output data used in this research. **The dataset is available for non-commercial research use from Solcast upon reasonable request and registration as an academic researcher or student at a public research institution. Access is granted free of charge for eligible researchers through the Solcast API Toolkit. For further information and data access, please visit** https://solcast.com/**.**

Code Availability. The complete implementation of the deep learning pipeline—including all steps of data preprocessing, feature engineering, model training, hyperparameter optimization, and performance evaluation—developed collaboratively by the authors, is publicly available on GitHub at: GitHub at: https://github.com/sbariscelebi/solar-irradiance-ann

Conflict of Interest. The authors declare that they have no conflict of interest regarding the publication of this paper.

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PROSTAT KANSERİNDE İLERİ RİSK SINIFLANDIRMASI İÇİN DCE-MRI VE PSA YOĞUNLUĞUNDAN YARARLANAN BÜTÜNLEŞTİRİCİ MAKİNE ÖĞRENME MODELİ

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ÖZET
Prostat kanseri, dünya çapında erkeklerde kansere bağlı ölümlerin önde gelen nedenlerinden biridir ve tedaviye ve risk sınıflandırmasına rehberlik edecek hassas tanı araçlarına duyulan ihtiyacı ön plana çıkarmaktadır. Dinamik Kontrastlı Manyetik Rezonans Görüntüleme (DCE-MRI) ve Prostat Spesifik Antijen (PSA) değerleri, tümör agresifliğini ve metastatik potansiyeli değerlendirmede kritik öneme sahiptir. Bu çalışma, prostat kanseri hastalarında Uluslararası Ürolojik Patoloji Derneği (ISUP) derece metastatik risk gruplarını tahmin etmek için DCE-MRI farmakokinetik parametrelerini PSA değerleriyle birleştiren bütünleştirici bir makine öğrenmesi modelini sunmaktadır. Histolojik olarak doğrulanmış prostat kanseri olan 102 hastanın retrospektif analizi, çok parametreli MRI verileri kullanılarak gerçekleştirilmiştir. DCE-MRI farmakokinetik parametreleri (Ktrans, Kep, Ve, CER, MaxSlope, IAUGC) çıkarılmış, standartlaştırılmış ve PSA değerleriyle birleştirilmiştir. Veri seti, Sentetik Azınlık Aşırı Örnekleme Tekniği ile dengelenmiş ve eğitim, doğrulama ve test setlerine ayrılmıştır. Random Forest, Destek Vektör Makineleri ve k-En Yakın Komşu gibi çoklu makine öğrenmesi modelleri eğitilmiş ve değerlendirilmiş; Random Forest sınıflandırıcısı, hem doğrulama hem de test setlerinde 0.92 AUC değeriyle en yüksek performansı göstermiştir. Hassasiyet-hatırlama analizi, yüksek risk grubu tanımlamasında duyarlılık ve özgüllüğü dengelemek için 0.3'lük optimal bir eşik belirlemiştir. SHAP analizi, toplam PSA, MaxSlope ve Kep'in en etkili öngörücüler olduğunu ortaya koymuştur. DCE-MRI ve PSA verilerini Random Forest modeliyle birleştiren bu bütünleştirici yaklaşım, metastatik risk sınıflandırmasının doğruluğunu önemli ölçüde artırarak klinik karar verme ve kişiselleştirilmiş tedavi stratejileri için potansiyel sunmakta, ancak yüksek riskli vakaların tespitindeki sınırlamaları ele almak için daha fazla doğrulama gerekmektedir.
Anahtar Kelimeler: Prostat kanseri, ISUP Derecesi, DCE-MRI, Makine Öğrenmesi, Random Forest

INTEGRATIVE MACHINE LEARNING MODEL LEVERAGING DCE-MRI AND PSA DENSITY FOR ADVANCED RISK STRATIFICATION IN PROSTATE CANCER

ABSTRACT
Prostate cancer is a leading cause of cancer-related mortality among men globally, emphasizing the need for precise diagnostic tools to guide treatment and risk stratification. Dynamic Contrast-Enhanced Magnetic Resonance Imaging (DCE-MRI) and Prostate-Specific Antigen (PSA) values are critical for assessing tumor aggressiveness and metastatic potential. This study presents an integrative machine learning model that combines DCE-MRI pharmacokinetic parameters with PSA values to predict International Society of Urological Pathology (ISUP) grade metastatic risk groups in prostate cancer patients. A retrospective analysis of 102 patients with histologically confirmed prostate cancer was conducted, utilizing

multiparametric MRI data. DCE-MRI pharmacokinetic parameters (Ktrans, Kep, Ve, CER, MaxSlope, IAUGC) were extracted, standardized, and combined with PSA values. The dataset was balanced using the Synthetic Minority Oversampling Technique and split into training, validation, and test sets. Multiple machine learning models, including Random Forest, Support Vector Machines, and k-Nearest Neighbors, were trained and evaluated, with the Random Forest classifier achieving the highest performance, yielding an AUC of 0.92 in both validation and test sets. Precision-recall analysis identified an optimal threshold of 0.3 for balancing sensitivity and specificity in high-risk group identification. SHAP analysis revealed total PSA, MaxSlope, and Kep as the most influential predictors. This integrative approach, combining DCE-MRI and PSA data with Random Forest modeling, significantly enhances the accuracy of metastatic risk stratification, offering potential for improved clinical decision-making and personalized treatment strategies, though further validation is needed to address limitations in detecting high-risk cases.
Keywords: Prostate cancer, ISUP Grade, DCE-MRI, Machine Learning, Random Forest

INTRODUCTION

Prostate cancer remains a global health concern due to its high incidence and potential lethality (Sung et al., 2021). Accurate grading is essential for treatment planning and outcome prediction. The International Society of Urological Pathology (ISUP) grading system, based on the Gleason score, offers a reliable framework for prostate cancer risk assessment. High ISUP grades (3–5) correlate with aggressive behavior and higher metastasis rates (Srigley et al., 2016).

Multiparametric MRI (mpMRI), particularly DCE-MRI, provides insights into tumor vascularity and permeability through pharmacokinetic parameters like Ktrans and Kep. Concurrently, PSA and PSA density are widely used biomarkers, although their specificity can be limited (Franiel et al., 2011; Hansford et al., 2015). Guidelines recommend bone scans for ISUP ≥3, underscoring the need for precise risk stratification tools (Rud et al., 2022). Machine learning offers potential for integrating imaging and clinical data to refine metastasis predictions, a gap this study seeks to address.

MATERIAL AND METHODS

Patient Cohort

The retrospective study included 102 biopsy-confirmed prostate cancer patients from April 2019 to December 2021. Exclusion criteria included artifacted MRI, delayed biopsy, or prior malignancy. Patients were classified into low (ISUP 1–2) and high (ISUP 3–5) metastatic risk groups.

Imaging Protocol

All patients underwent 3T mpMRI scans with sequences including T2-weighted, DWI/ADC, and DCE-MRI. The imaging parameters are shown in *table 1*. Gadolinium-based contrast was used, and parameters were extracted using the Tofts pharmacokinetic model.

Table 1: Multiparametric prostate MRI sequences and parameters

Parameter	T2	T2	T2	DWI/ADC	Focused DWI/ADC	DCE-MRI
Plane	Axial	Coronal	Sagittal	Axial	Axial	Axial
TR (ms)	3140	6852	3674	8156	4630	3400
TE (ms)	170	140	112	80	80	2.1-22
Flip angle	140	142	142	90	90	20
b value	-	-	-	50,400,800	50,800,1400	-
Slice thickness (mm)	3	3.5	3.5	5	3	2.2
FOV (cm)	18	22	22	28	30	30

Matrix	256	256	256	128	64	128
Acquisition time (min:s)	3.28	3.47	3.26	3.25	6.06	5.22

Feature Extraction

Pharmacokinetic features (Ktrans, Kep, Ve, CER, MaxSlope, IAUGC) and PSA metrics (total PSA, PSA density) were extracted. ROIs were placed in areas of lowest ADC values (Fig. 1).

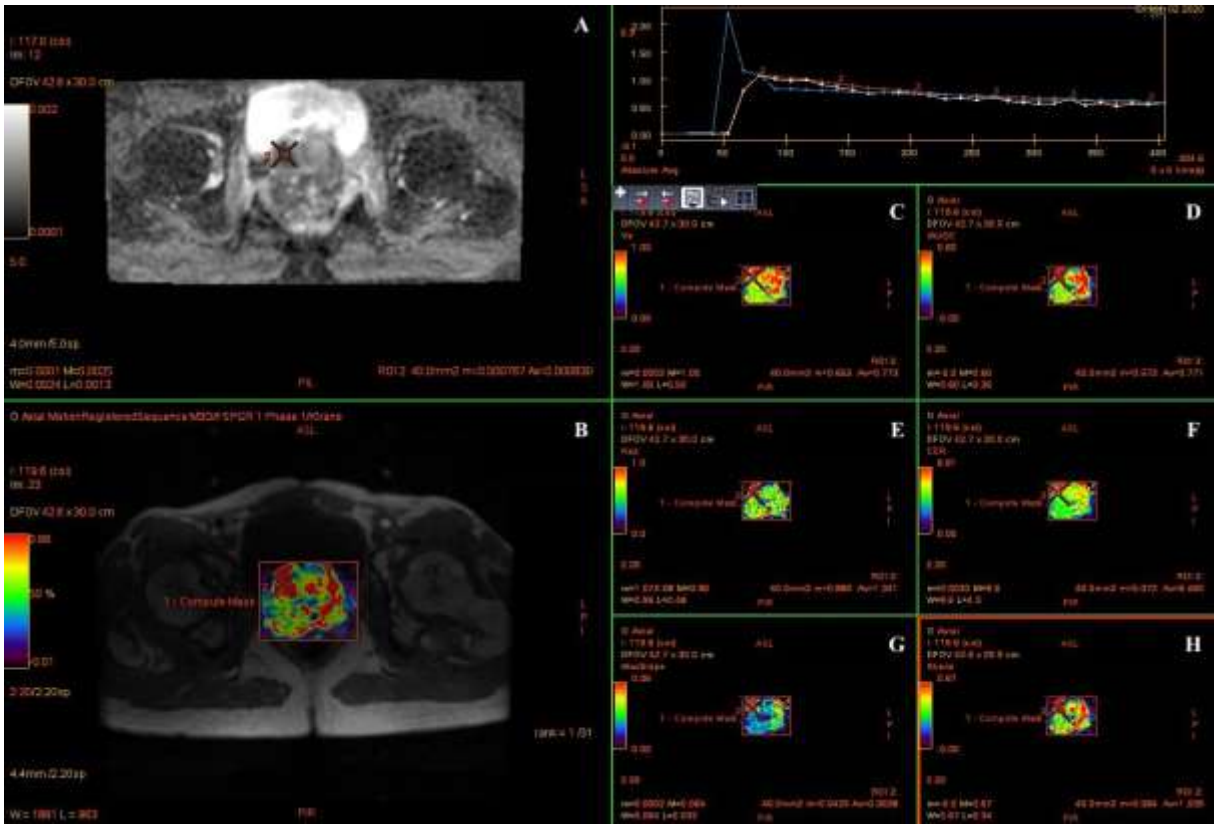

Figure 1: The Region of Interest (ROI) was initially selected on the ADC map at the lesion site with the lowest ADC values and subsequently applied to the corresponding perfusion maps (A:ADC mapping, B: DCE-MRI/Ktrans fusion image, C: V_e map, D: Initial area under the gadolinium curve map, E: K_{ep} map, F: Contrast enhancement ratio map, G: MaxSlope map, H: Ktrans map)

Prostate volume and PSA density were calculated following PI-RADS v2.1 standards.

Data Preprocessing

The dataset was standardized and balanced using the Synthetic Minority Oversampling Technique (SMOTE). The outcome variable was ISUP metastatic risk (binary). Data were split into training (60%), validation (20%), and test (20%) sets.

Machine Learning Models

Nine ML classifiers were trained: k-Nearest Neighbors, Support Vector Machines (SVM), Stochastic Gradient Descent (SGD), Random Forest, Naive Bayes, Logistic Regression, Gradient Boosting, XGBoost, and AdaBoost. GridSearchCV and 10-fold StratifiedKFold cross-validation were used for hyperparameter tuning. Models were evaluated using AUC, precision, recall, and F1 scores.

RESULTS

Clinical and Imaging Findings

The cohort had 62 patients in the low-risk and 40 in the high-risk group. High-risk patients were older (mean age 74.1 vs 70.6)(Table 2).

Table 2: ISUP grade distribution according to Gleason score

Group	ISUP Grade	Gleason score (*n*)
Low	1 (Low risk)	3+3 (40)
	2 (Intermediate favourable risk)	3+4 (22)
High	3 (Intermediate unfavourable risk)	4+3 (24)
	4 (High risk)	3+5 (1), 4+4 (7)
	5 (The highest risk)	4+5 (8)

PSA and PSA density were significantly higher in the high-risk group (mean PSA: 38.9 vs 8.6 ng/mL; $p < 0.001$). Kep also showed a significant difference ($p = 0.013$), while Ktrans, Ve, CER, MaxSlope, and IAUGC did not (Table 3).

Table 3: Comparison of DCE-MRI parameters and PSA values between low and high-risk ISUP grade groups

Parameters	**Low Risk**			**High Risk**			**p-value**
Bone metastasis (n)	6/62			15/40			**<0.001**
	Mean±SD	**Median (Range)**	**IQR (25%-75%)**	**Mean±SD**	**Median (Range)**	**IQR (25%-75%)**	
Ktrans (min^{-1})	0.233±0.099	0.221 (0.061-0.512)	0.168-0.274	0.267±0.181	0.214 (0.057-0.779)	0.142-0.355	0.134
Kep (min^{-1})	0.941±0.374	0.865 (0.334-1.983)	0.673-1.106	1.292±0.742	1.200 (0.212-3.407)	0.662-1.646	**0.013**
Ve	0.277±0.163	0.243 (0.039-0.888)	0.159-0.353	0.270±0.193	0.217 (0.060-0.992)	0.131-0.373	0.761
CER	2.291±0.692	2.282 (1.098-3.721)	1.671-2.872	2.290±1.002	2.014 (0.800-4.515)	1.519-3.076	0.699
MaxSlope	0.011±0.004	0.010 (0.005-0.030)	0.008-0.012	0.021±0.036	0.010 (0.002-0.203)	0.007-0.021	0.442
IAUGC	0.149±0.075	0.131 (0.033-0.379)	0.100-0.185	0.170±0.112	0.123 (0.027-0.437)	0.099-0.250	0.432
PSA (ng/mL)	8.633±6.088	6.800 (2.700-32.900)	4.902-8.893	38.910±32.568	31.350 (1.800-98.000)	12.287-54.150	**<0.001**

PSA density (ng/mL²)	0.219±0.174	0.153 (0.044-0.824)	0.099-0.277	0.970±0.832	0.806 (0.037-3.136)	0.237-1.451	**<0.001**

(SD = Standard deviation; IQR = Interquartile range; Ktrans = Transfer constant; Kep = Rate constant; Ve = Extracellular extravascular space volume; CER = Contrast enhancement ratio; IAUGC = Initial area under the gadolinium curve; PSA = Prostate-specific antigen)

Bone metastases were found in 15 high-risk versus 6 low-risk patients ($p < 0.001$), validating the risk stratification method.

Model Performance

The model performance evaluation revealed that among all the machine learning algorithms tested, the Random Forest classifier achieved the highest predictive accuracy in distinguishing between low and high ISUP grade metastatic risk groups. With an Area Under the Curve (AUC) of 0.92 on both the validation and test datasets, the Random Forest model demonstrated excellent generalizability and robustness. It also achieved an F1 score of 0.86, with balanced precision and recall values (0.86 each), indicating strong capability in minimizing both false positives and false negatives. While other models such as k-Nearest Neighbors (AUC = 0.90), Support Vector Machines (AUC = 0.83), and Stochastic Gradient Descent (AUC = 0.87) showed reasonable performance, they fell short of the Random Forest's consistent results across datasets (Table 4).

Table 4: Best hyperparameters and performance metrics of machine learning models

Model	Best Parameters	Validation AUC	Test AUC	F1 score	Precision	Recall
kNN	n_neighbors: 7	0.90	0.90	0.80	0.81	0.81
SVM	C: 1, kernel: linear	0.97	0.83	0.80	0.81	0.81
SGD	alpha: 0.01, penalty: L1	0.98	0.87	0.86	0.86	0.86
Random Forest	**max_depth: 12, n_estimators: 150**	**0.92**	**0.92**	**0.86**	**0.86**	**0.86**
Naive Bayes		0.90	0.91	0.86	0.86	0.86
Logistic Regression	C: 5, penalty: L2	0.96	0.85	0.80	0.81	0.81
Gradient Boosting	learning_rate: 0.1, n_estimators: 100	0.89	0.87	0.76	0.76	0.76
XGBoost	learning_rate: 0.2, n_estimators: 150	0.88	0.87	0.76	0.76	0.76
AdaBoost	n_estimators: 60	0.87	0.83	0.81	0.81	0.81

(kNN = k-Nearest Neighbors; SGD= Stochastic Gradient Descent; SVM = Support Vector Machines; XGBoost = Extreme Gradient Boosting; AdaBoost = Adaptive Boosting)

SHAP Analysis

SHAP plots indicated that total PSA, MaxSlope, and Kep were the top predictors in the Random Forest model (Fig. 2). These features capture tumor burden, vascular dynamics, and tissue permeability, reinforcing their clinical relevance.

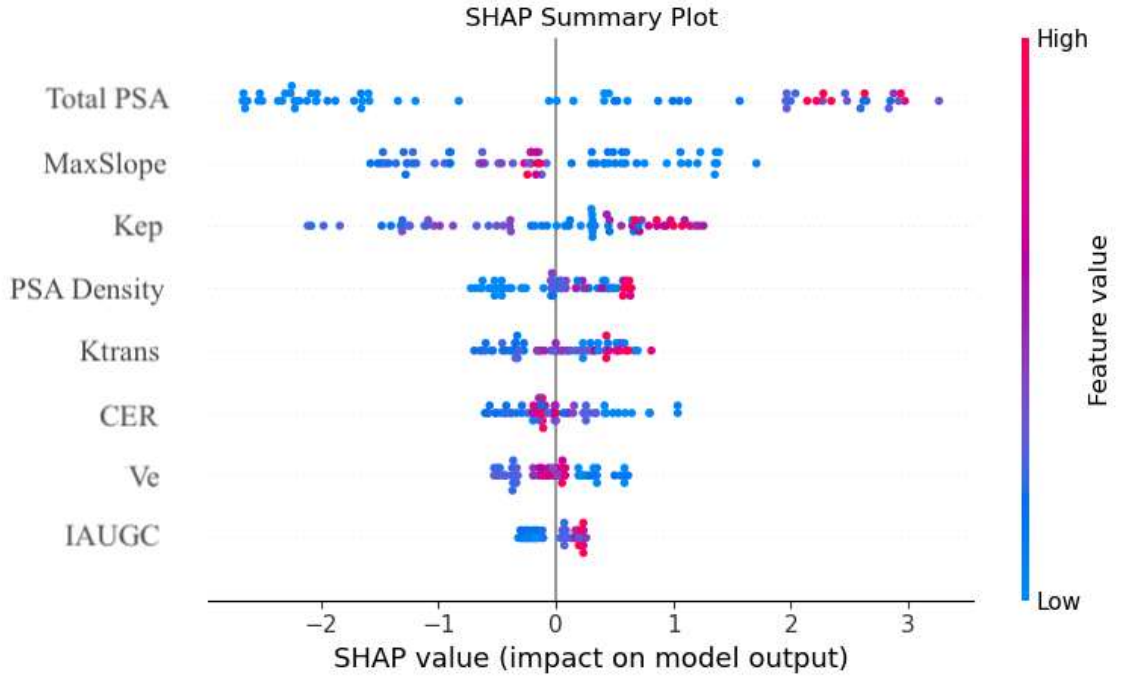

Figure 2: The SHAP summary plots show that the total PSA, MaxSlope and Kep features are the most significant contributors to the model. (PSA = Prostate-specific antigen; Kep = Rate constant; Ktrans = Transfer constant; CER = Contrast enhancement ratio; Ve = Extracellular extravascular space volume; IAUGC = Initial area under the gadolinium curve;)

DISCUSSION

This study confirms that integrating DCE-MRI pharmacokinetic parameters with PSA values improves metastatic risk prediction in prostate cancer. The Random Forest algorithm outperformed single-parameter approaches and other ML models, providing a robust and interpretable tool for clinical decision-making.

Compared to other biomarker-based models (e.g., microRNAs, BRCA2 mutations, SelectMDx, or deep learning-based PI-RADS integration), this study's model achieved a superior AUC of 0.92. Prior models reported AUCs ranging from 0.73 to 0.87 ;(Bryant et al., 2012; Kim et al., 2021; Wang et al., 2021; Nyberg et al., 2020; Pepe et al., 2020; Hiremath et al., 2021; Yang et al., 2023;Hong et al., 2022).

Notably, DCE-MRI parameters like Ktrans and Kep have previously been associated with tumor aggressiveness (Grading of Pancreatic Neuroendocrine Neoplasms Using Pharmacokinetic Parameters Derived from Dynamic Contrast-enhanced MRI, n.d.; Huang et al., 2019; Fennessy et al., 2014). This study builds on those findings by demonstrating that their integration into a composite model provides superior performance.

The use of Random Forest is justified due to its robustness with non-linear, high-dimensional data and its interpretability through SHAP. The model could be embedded into clinical decision-support systems to prioritize patients for bone scans and reduce unnecessary imaging.

This study has several limitations. Its retrospective design may introduce selection bias, and reliance on biopsy rather than prostatectomy specimens could underestimate ISUP grades due to sampling errors. The small sample size, especially in the high-risk group, limits generalizability. Additionally, the lack of external validation and potential variability in DCE-

MRI protocols across institutions may affect the reproducibility of results. Future prospective, multi-center studies with standardized imaging are needed to confirm the model's clinical utility.

Future directions include integrating PSMA PET/CT metrics to further enhance prediction, particularly for intermediate-risk patients.

CONCLUSIONS

An integrative ML model using DCE-MRI parameters and PSA values—particularly via Random Forest—demonstrates excellent predictive power for ISUP-based metastatic risk in prostate cancer. This tool could guide personalized screening and management, supporting a more efficient, accurate, and cost-effective approach to prostate cancer care.

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İNOVATİF ÇEVRE DOSTU TEKNOLOJİLER VE EKOLOJİK AYAK İZİ: SÜRDÜRÜLEBİLİR BİR GELECEK İÇİN UYUMLU YAKLAŞIMLAR

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ÖZET
Çevre dostu teknolojiler, doğal kaynakların korunması, enerji verimliliğinin artırılması ve çevresel etkilerin en aza indirilmesi amacıyla geliştirilen yenilikçi sistem ve ürünleri ifade etmektedir. Bu teknolojiler, sürdürülebilir kalkınmayı destekleyerek hem bugünün hem de gelecek nesillerin ihtiyaçlarını gözeten teknolojiler olarak karşımıza çıkmaktadır. Günümüzde küresel iklim değişikliği, hava ve su kirliliği gibi çevresel tehditler karşısında, çevre dostu teknolojilerin önemi giderek artmaktadır.

Çevre dostu teknolojilerin yaygınlaşması, sadece çevresel değil, aynı zamanda ekonomik ve toplumsal faydalar da sunmaktadır. Enerji maliyetlerini düşürmek, istihdam yaratmak ve ekolojik dengeyi korumak bu faydalardan bazılarıdır. Ancak bu teknolojilere geçiş sürecinde yeterli finansman, politika desteği ve kamu bilincinin oluşturulması büyük önem taşımaktadır. Özellikle iklim değişikliği, su kirliliği ve biyolojik çeşitlilik kaybı gibi küresel çevre sorunları karşısında, çevre dostu teknolojilerin rolü her geçen gün daha da önemli hale gelmektedir. Bu bağlamda, ekolojik ayak izi kavramı, çevre dostu teknolojilerin çevresel etkisini ölçmede temel bir araç olarak öne çıkmaktadır. Ekolojik ayak izi, bir bireyin, toplumun veya ülkenin tükettiği doğal kaynakların, dünya üzerinde ne kadar alan kapladığını ifade etmektedir. Bu ölçüm, insan faaliyetlerinin gezegen üzerindeki baskısını anlamak ve azaltmak için önemli bir göstergedir. Ekolojik ayak izinin azaltılması, sadece mevcut teknolojilerin kullanılmasıyla değil, aynı zamanda inovasyon yoluyla geliştirilen yeni çözümlerle mümkündür. Enerji üretiminde güneş panellerinin verimliliğini artıran nano-teknolojiler, geri dönüşüm süreçlerini optimize eden yapay zekâ sistemleri ve karbon yakalama teknolojileri inovatif çevre dostu teknolojilerine örnek olarak verilebilmektedir. Bu teknolojiler, bireylerin ve toplumların ekolojik ayak izini küçültmede kritik rol oynamaktadır.

Bu bağlamda bu bildiride çevre dostu teknolojilerin günümüzde geldiği durum ekolojik ayak izi kapsamında ele alınmaya çalışılacaktır. Bu ele alınış için veriler literatür taraması ile toplanacaktır. Bildiride, kavramsal çerçevede çevre dostu teknolojiler, sürdürülebilirlik ile ekolojik ayak izi kavramları ele alındıktan sonra dünyadan ve Türkiye'den örnekler verilerek sürdürülebilir bir gelecek için uygulanması gereken politikalar ortaya konulacaktır.

Anahtar Kelimeler: Çevre, Çevre Dostu, Sürdürülebilir, Ekolojik Ayak İzi

INNOVATIVE ECO-FRIENDLY TECHNOLOGIES AND ECOLOGICAL FOOTPRINT: HARMONIOUS APPROACHES FOR A SUSTAINABLE FUTURE

ABSTRACT

Environmentally friendly technologies refer to innovative systems and products developed for the purpose of protecting natural resources, increasing energy efficiency and minimizing environmental impacts. These technologies stand out as technologies that support sustainable development and take into account the needs of both today and future generations. Today, the importance of environmentally friendly technologies is increasing in the face of environmental threats such as global climate change, air and water pollution. The spread of environmentally friendly technologies offers not only environmental but also economic and social benefits. Reducing energy costs, creating employment and protecting the ecological balance are some of these benefits. However, sufficient financing, policy support and creating public awareness are of great importance in the transition process to these technologies. The role of environmentally friendly technologies is becoming more and more important every day, especially in the face of global environmental problems such as climate change, water pollution and loss of biodiversity. In this context, the concept of ecological footprint stands out as a basic tool for measuring the environmental impact of environmentally friendly technologies. Ecological footprint expresses how much space an individual, society or country consumes on the earth's surface. This measurement is an important indicator for understanding and reducing the pressure of human activities on the planet. Reducing the ecological footprint is possible not only by using existing technologies but also by developing new solutions through innovation. Nanotechnologies that increase the efficiency of solar panels in energy production, artificial intelligence systems that optimize recycling processes, and carbon capture technologies can be given as examples of innovative environmentally friendly technologies. These technologies play a critical role in reducing the ecological footprint of individuals and societies. In this context, this report will attempt to address the current state of environmentally friendly technologies within the scope of ecological footprint. Data for this discussion will be collected through a literature review. In the report, after addressing the concepts of environmentally friendly technologies, sustainability, and ecological footprint within the conceptual framework, the policies that need to be implemented for a sustainable future will be presented by giving examples from the world and Turkey.

Keywords: Environment, Eco-Friendly, Sustainable, Ecological Footprint

MEME ULTRASONU LEZYON SINIFLANDIRMASI İÇİN MULTİ-CNN DERİN ÖZELLİK FÜZYONU VE YIĞINLAMA TOPLULUK SINIFLANDIRICISI

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ÖZET
Meme kanseri, dünya genelinde en yaygın kanser türlerinden biri olup, doğru ve zamanında tanı araçlarının önemini vurgulamaktadır. Meme ultrasonografisi, benign ve malign lezyonları ayırt etme yeteneğiyle değer verilen, yaygın kullanılan, non-invaziv bir görüntüleme tekniğidir. Bu çalışma, meme ultrason görüntülerini benign, malign ve normal kategorilere sınıflandırmak için gelişmiş özellik çıkarma ve topluluk öğrenmesi tekniklerini kullanarak tanısal doğruluğu artırmayı amaçlayan güçlü bir makine öğrenmesi modelini sunmaktadır. Beş halka açık veri setinden oluşan 2233 görüntülük bir veri seti kullanılarak, ilgili bölgeler maskelenmiş ve önceden eğitilmiş VGG16, ResNet50V2 ve EfficientNetB3 modellerinden derin özellikler çıkarılıp birleştirilmiştir. Temel Bileşen Analizi, LightGBM ile Özyinelemeli Özellik Eleme ve Kısmi En Küçük Kareler Ayırt Edici Analizi içeren kapsamlı bir özellik seçme süreci uygulanmıştır. LightGBM, XGBoost, CatBoost ve Random Forest modellerini lojistik regresyon meta-öğrenicisiyle birleştiren bir yığınlama topluluk sınıflandırıcısı, sentetik azınlık fazla örnekleme ile dengelenmiş %75'lik eğitim seti üzerinde 5 katlı çapraz doğrulama ile eğitilmiş ve %25'lik test seti üzerinde değerlendirilmiştir. Model, 0.956 makro ortalama Eğrisi Altındaki Alan değeri ve 0.88 F1 skoru ile özellikle benign ve normal vakalarda otomatik meme ultrason sınıflandırması için önemli bir potansiyel sergilemiştir. Bununla birlikte, malign lezyonlara yönelik daha düşük duyarlılık, klinik karar desteği için modelin daha fazla geliştirilmesi gerektiğini göstermektedir.
Anahtar Kelimeler: Meme Ultrasonu, Derin Öğrenme, Bilgisayar Destekli Tanı, Topluluk Öğrenmesi, Görüntü Sınıflandırma

MULTI-CNN DEEP FEATURE FUSION AND STACKING ENSEMBLE CLASSIFIER FOR BREAST ULTRASOUND LESION CLASSIFICATION

ABSTRACT
Breast cancer remains one of the most prevalent cancers worldwide, underscoring the critical need for accurate and timely diagnostic tools. Breast ultrasonography is a widely used, non-invasive imaging technique valued for its ability to differentiate between benign and malignant lesions. This study introduces a robust machine learning model designed to classify breast ultrasound images into benign, malignant, and normal categories, aiming to enhance diagnostic accuracy through advanced feature extraction and ensemble learning techniques. Using a dataset of 2233 images from five publicly available sources, regions of interest were masked, and deep features were extracted from pre-trained VGG16, ResNet50V2, and EfficientNetB3 models, which were subsequently combined. A comprehensive feature selection process was employed, incorporating Principal Component Analysis, Recursive Feature Elimination with LightGBM, and Partial Least Squares Discriminant Analysis. A stacking ensemble classifier, combining LightGBM, XGBoost, CatBoost, and Random Forest with a logistic regression

meta-learner, was trained using 5-fold cross-validation on a balanced 75% training set, enhanced by synthetic minority oversampling, and evaluated on a 25% test set. The model achieved a macro-average AUC-ROC of 0.956 and an F1-score of 0.88, demonstrating strong potential for automated breast ultrasound classification, particularly for benign and normal cases. However, its lower sensitivity for malignant lesions highlights the need for further refinement to enhance its utility in clinical decision support.
Keywords: Breast Ultrasound, Deep Learning, Computer-Aided Diagnosis, Ensemble Learning, Image Classification

INTRODUCTION

Breast cancer remains a leading cause of cancer-related mortality among women globally, with early detection being critical for improving survival rates and treatment efficacy(Zhang et al., 2020). Ultrasonography is a vital imaging modality due to its accessibility, cost-effectiveness, lack of ionizing radiation, and real-time visualization capabilities. However, its operator-dependent nature and challenges in image interpretation lead to diagnostic variability (Yap et al., 2018). Deep learning, particularly convolutional neural networks (CNNs), offers a promising solution for automated lesion classification, reducing variability and enhancing diagnostic consistency. Previous studies, such as Cao et al., have demonstrated CNNs' ability to delineate lesion boundaries more consistently than manual methods, while Vigil et al. showed the potential of integrated detection and diagnosis models (Cao et al., 2019; Vigil et al., 2022). Yu et al. highlighted improved accuracy through deep feature extraction, and Kalafi et al. emphasized attention mechanisms to focus on diagnostically relevant image regions (Kalafi et al., 2021; Yu et al., 2021). Automated CNN-based approaches, as noted by Yap et al., provide scalable solutions for rapid, reliable lesion detection, potentially improving patient outcomes. This study aims to develop and validate a machine learning model for classifying breast ultrasound images as benign, malignant, or normal, supporting radiologists and enhancing diagnostic accuracy.

MATERIAL AND METHODS

The study utilized five publicly available, anonymized breast ultrasound datasets: BUS-UCLM, BUSI, QAMEBI, BUSC, and BrEaST, totaling 2233 images (1005 benign, 672 malignant, 556 normal). Ethical approval was waived due to the use of non-identifiable data. Images were preprocessed using Python 3.8 and OpenCV, applying masks to isolate regions of interest, resizing to 224x224 pixels, and converting to RGB for compatibility with pre-trained CNNs. Feature extraction was performed using three pre-trained CNNs—VGG16, ResNet50V2, and EfficientNetB3—trained on ImageNet, with final classification layers removed to access hierarchical feature representations. Features from all models were concatenated into a 200,704-dimensional vector per image. Feature selection involved StandardScaler for uniform scaling, followed by Principal Component Analysis (PCA) to retain 95% variance and Partial Least Squares Discriminant Analysis (PLS-DA) for class-discriminative reduction. A stacking ensemble classifier was developed, integrating four base models (LightGBM, XGBoost, CatBoost, Random Forest) with logistic regression as the meta-learner, using 5-fold cross-validation. Performance was evaluated using metrics like AUC-ROC, AUC-PR, F1-score, precision, recall, PPV, and NPV, with ROC and precision-recall curves plotted. The model pipeline is summarized in Figure 1, with hyperparameters detailed in Table 1.

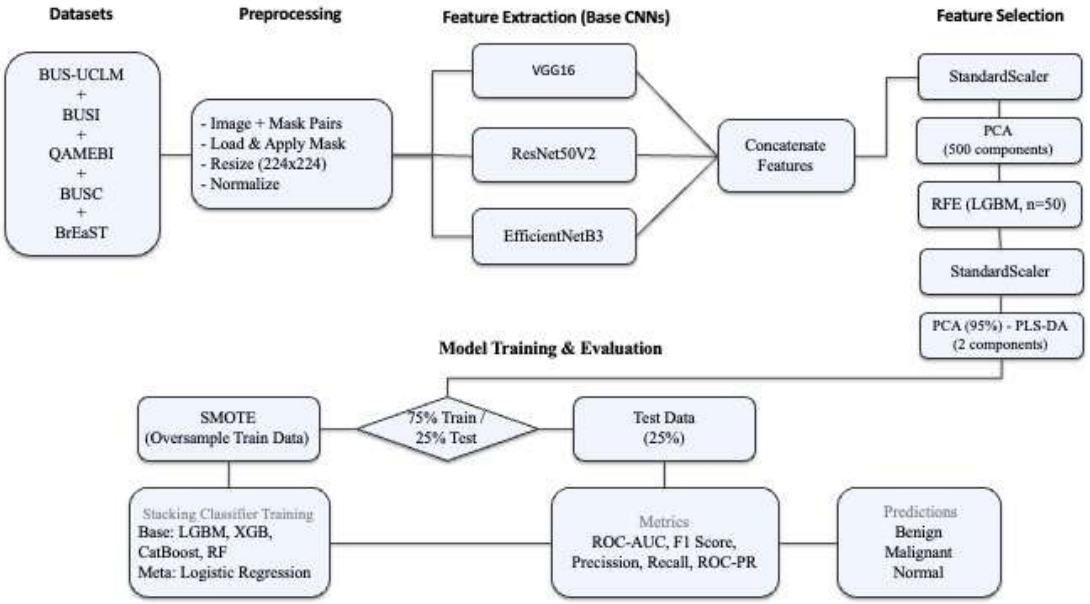

Figure 1: Summary of the model pipeline

Table 1: Hyperparameters of the base models

Model	Key Parameters
LightGBM	num_leaves=63, max_depth=15, n_estimators=50
Random Forest	max_depth=20, n_estimators=200
XGBoost	eval_metric='logloss'
CatBoost	verbose=0
Stacking	cv=5, final_estimator=LogisticRegression(max_iter=1000)

RESULTS

The dataset comprised 2233 ultrasound images, successfully processed with features extracted from masked regions using VGG16, ResNet50V2, and EfficientNetB3. Concatenated features formed a 200,704-dimensional vector per image, reduced via PCA to retain 95% variance, followed by PLS-DA (Fig. 2).

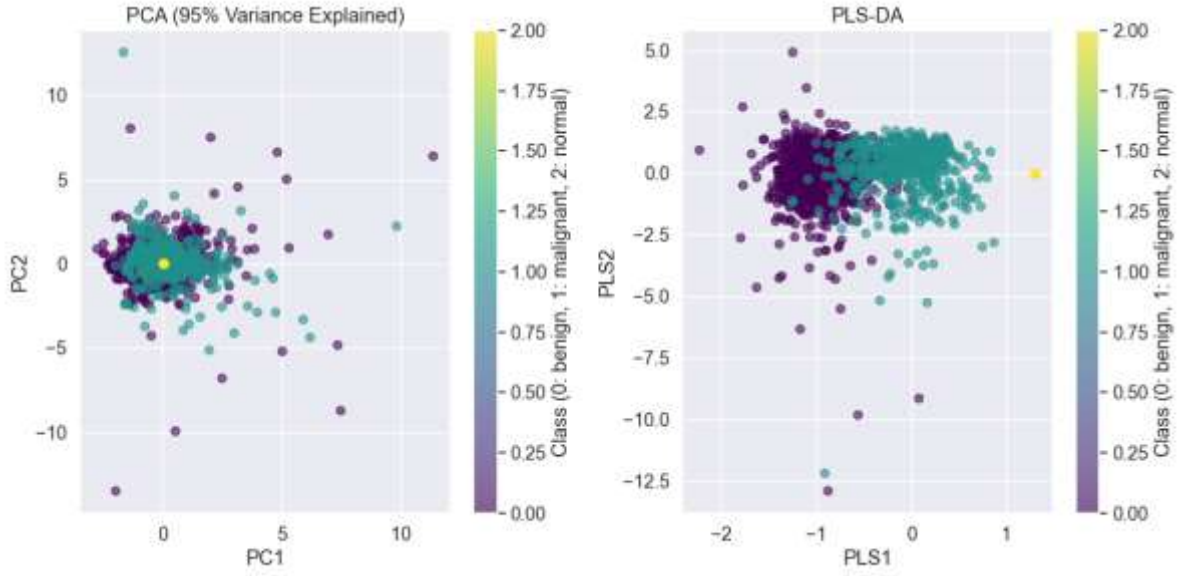

Figure 2: Comparison of dimensionality reduction techniques applied to the selected and scaled image features. (Left) Principal Component Analysis (PCA) projection onto the first two principal components (PC1, PC2), capturing 95% of the total variance in the features used for classification. (Right) Partial Least Squares Discriminant Analysis (PLS-DA) projection onto the first two latent variables (PLS1, PLS2), derived specifically to maximize the separation between classes based on the same feature set.

The stacking ensemble classifier achieved strong performance on the test set, with a macro average AUC-ROC of 0.956 and F1-score of 0.88. Class-specific results were: benign (AUC-ROC 0.984, F1 0.93, precision 0.92, recall 0.93, PPV 0.924, NPV 0.949), normal (AUC-ROC 0.969, F1 0.92, precision 0.86, recall 1.00, PPV 0.863, NPV 1.000), and malignant (AUC-ROC 0.916, F1 0.79, precision 0.87, recall 0.71, PPV 0.875, NPV 0.899). ROC curves (Fig. 3) showed excellent sensitivity-specificity for benign and normal classes, with a more gradual curve for malignant, indicating a higher trade-off.

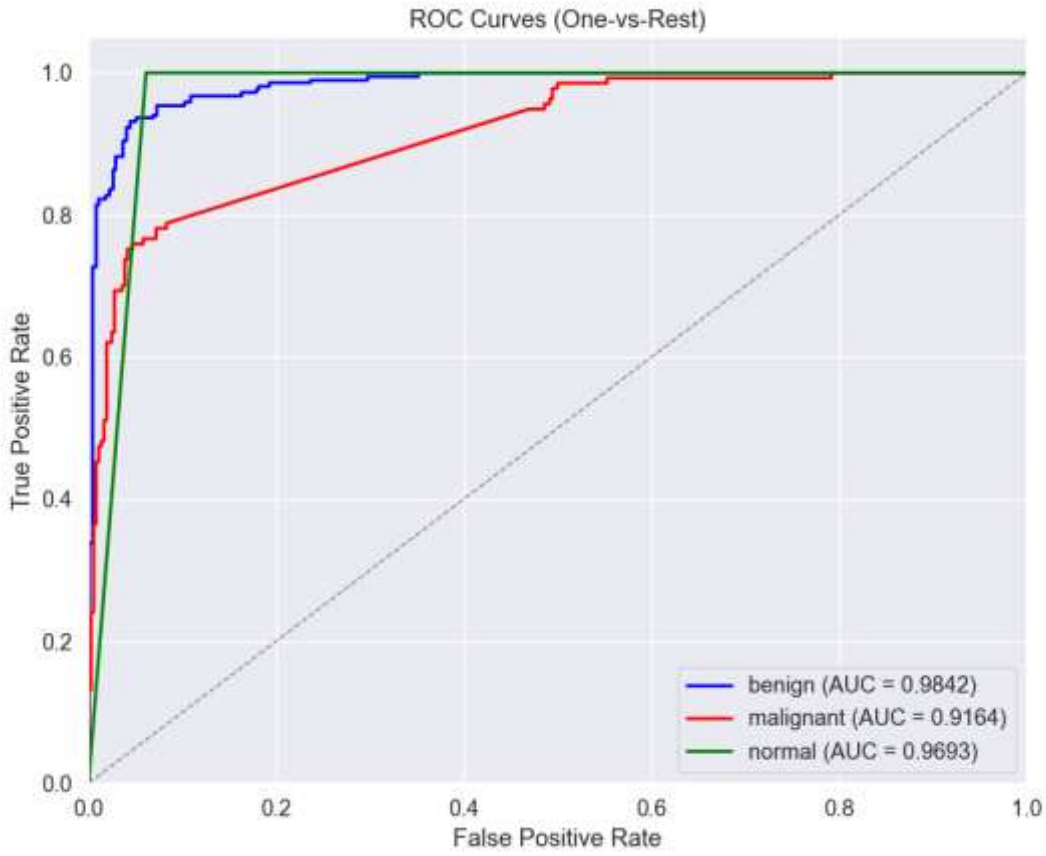

Figure 3: Receiver Operating Characteristic (ROC) curves for benign (AUC = 0.9842), malignant (AUC = 0.9164), and normal (AUC = 0.9693) classes on the test set.

Precision-recall curves (Fig. 4) yielded AP scores of 0.9803 (benign), 0.8634 (normal), and 0.8305 (malignant), reflecting challenges in maintaining precision at high recall for malignant cases.

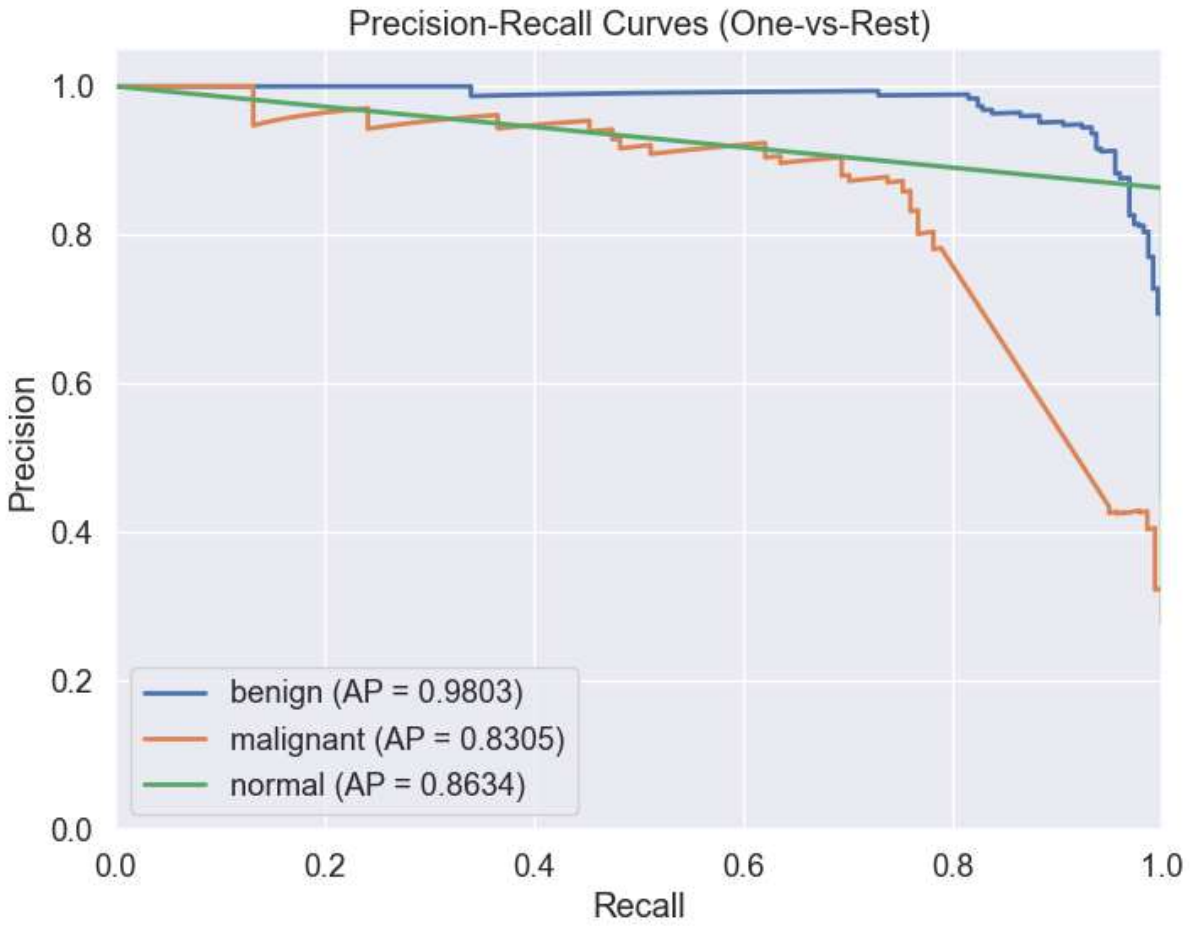

Figure 4: Precision-Recall curves for benign (AP = 0.9803), malignant (AP = 0.8305), and normal (AP = 0.8634) classes on the test set.

Feature importance analysis (Fig. 5) ranked ResNet50V2 highest (18 features, total importance 3,467, avg. 192.61), followed by VGG16 (18 features, 3,103, avg. 172.39) and EfficientNetB3 (14 features, 2,395, avg. 171.07).

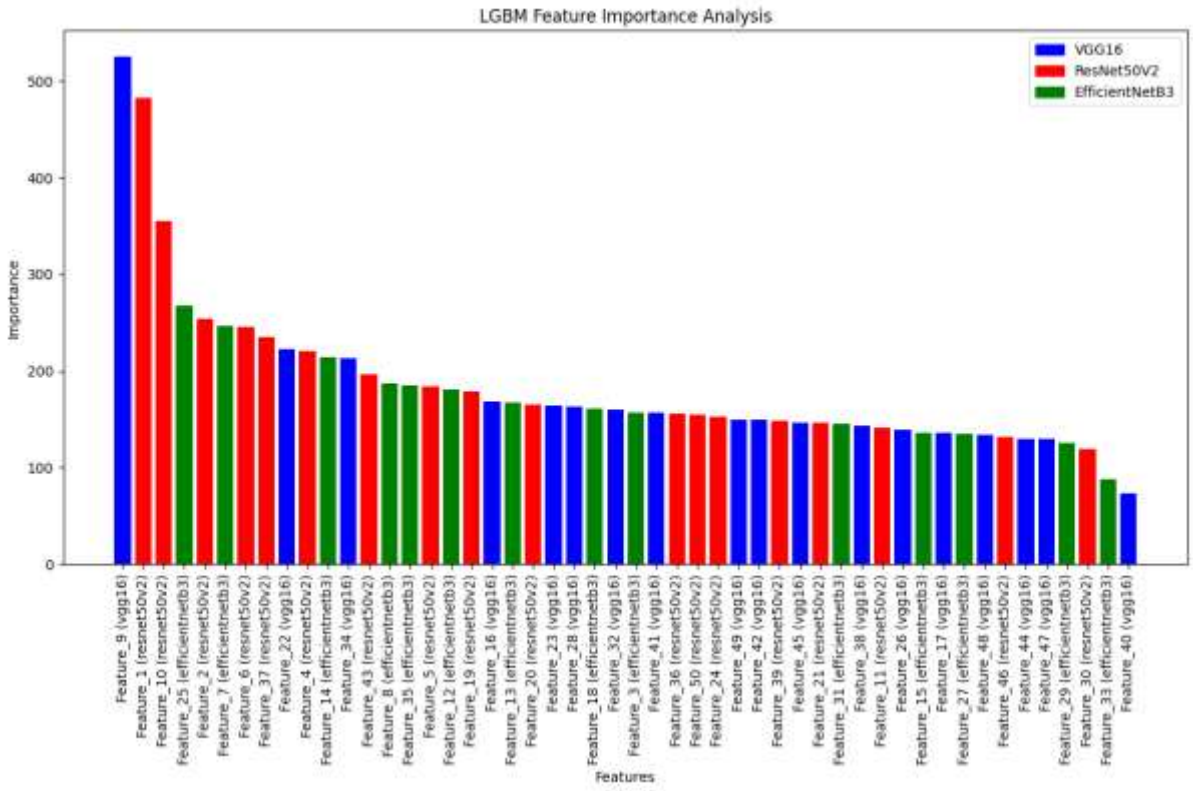

Figure 5: Feature importance analysis of the top 50 selected features from ResNet50V2, VGG16, and EfficientNetB3 models.

DISCUSSION

The model demonstrated robust performance (AUC-ROC 0.956, F1 0.88) on a diverse, multi-center dataset, excelling in benign (AUC 0.984, F1 0.93) and normal (AUC 0.969, F1 0.92) classifications. Success factors include multi-CNN feature fusion, capturing diverse patterns, and the stacking ensemble, leveraging multiple algorithms' strengths, as supported by Ragab et al.'s high-accuracy ensemble. SMOTE mitigated class imbalance, boosting benign and normal performance. However, malignant recall (0.71) was lower than desired, with 28-29% false negatives, a clinical concern compared to Yadav et al.(Yadav et al., 2024) (90.32%) and Kalafi et al.(Kalafi et al., 2021) (96% sensitivity). This may stem from malignant lesion complexity, SMOTE limitations, or aggressive feature selection discarding subtle features. The model's performance is competitive with Gu et al.(Gu et al., 2022) (AUC 0.91) and Cao et al.(Cao et al., 2019) (87.5% accuracy), surpassing Vigil et al.(Vigil et al., 2022) (78.5% accuracy). Limitations include potential information loss from feature selection and lack of external validation. Future improvements could involve cost-sensitive learning, advanced oversampling (e.g., ADASYN), or attention mechanisms, as suggested by Kalafi et al., to enhance malignant detection.

CONCLUSIONS

This study developed a robust model for breast ultrasound classification using multi-CNN feature fusion and a stacking ensemble, achieving high accuracy (AUC-ROC 0.956, F1 0.88), particularly for benign and normal cases. It shows promise as a clinical decision support tool, reducing operator variability and potentially minimizing unnecessary biopsies. However, lower malignant recall (0.71) requires refinement to reduce false negatives. Future work should focus on enhancing malignant detection via cost-sensitive learning, attention mechanisms, or advanced oversampling, and validating on independent datasets for generalizability. With

improvements, this model could enhance early breast cancer detection and support improved patient outcomes.

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AKUT PANKREATİTTE HASTALIK ŞİDDETİNİN BELİRLEYİCİLERİ OLARAK KARACİĞER VE PANKREAS YAĞ FRAKSİYONLARI: MR İDEAL-IQ ÇALIŞMASI

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ÖZET
Akut pankreatit, obezite ve hiperlipidemi gibi metabolik faktörlerden etkilenen, değişken şiddette önemli bir inflamatuar durumdur ve bu faktörler aynı zamanda metabolik disfonksiyonla ilişkili steatotik karaciğer hastalığı (MASLD) ve non-alkolik yağlı pankreas hastalığı (NAFPD) ile ilişkilidir. Bu çalışma, IDEAL MRI ile ölçülen karaciğer ve pankreas yağ fraksiyonlarının akut pankreatit hastalığının şiddetini öngörmedeki rolünü incelemektedir. 127 hastanın retrospektif analizinde, akut pankreatitin şiddeti, revize Atlanta sınıflandırması (RAC), bilgisayarlı tomografi şiddet indeksi (CTSI) ve modifiye CTSI (mCTSI) kullanılarak değerlendirilmiştir. Karaciğer ve pankreasın proton yoğunluğu yağ fraksiyonu (PDFF) seviyeleri IDEAL MRI ile ölçülmüş ve hastalar biliyer ve biliyer olmayan pankreatit gruplarına ayrılmıştır. MASLD hastaların %40.9'unda, NAFPD ise %30'unda saptanmıştır. Karaciğer PDFF, biliyer olmayan pankreatitte anlamlı derecede daha yüksek bulunmuştur (p=0.040) ve MASLD'li hastalar daha yüksek CTSI ve mCTSI skorları göstermiştir (sırasıyla p=0.009 ve p=0.033). NAFPD olan ve olmayan hastalar arasında şiddette anlamlı bir fark gözlenmemiştir. Karaciğer PDFF, biliyer pankreatitte CTSI ve mCTSI ile pozitif korelasyon göstermiştir. ROC analizi, karaciğer PDFF >%3.9 ve pankreas korpus PDFF >%12.1'in ciddi pankreatiti öngördüğünü, karaciğer PDFF <%4.5'in ise biliyer etiyolojiyi işaret ettiğini belirlemiştir. Bu bulgular, IDEAL MRI ile ölçülen karaciğer ve pankreas PDFF seviyelerinin, özellikle MASLD'li hastalarda, ciddi akut pankreatiti öngörmek ve etiyolojilerini ayırt etmek için umut verici biyobelirteçler olduğunu göstermektedir, ancak klinik faydasını artırmak için daha fazla çalışmaya ihtiyaç vardır.
Anahtar Kelimeler: Metabolik disfonksiyonla ilişkili yağlı karaciğer hastalığı, alkolik olmayan yağlı pankreas hastalığı, akut pankreatit, IDEAL, proton yoğunluğu yağ fraksiyonu

ABSTRACT
Acute pancreatitis is a significant inflammatory condition with varying severity, often influenced by metabolic factors such as obesity and hyperlipidemia, which are also linked to metabolic dysfunction–associated steatotic liver disease (MASLD) and non-alcoholic fatty pancreatic disease (NAFPD). This study explores the role of liver and pancreatic fat fractions, measured using IDEAL MRI, in predicting disease severity in acute pancreatitis. In a retrospective analysis of 127 patients, the severity of acute pancreatitis was assessed using the

revised Atlanta classification (RAC), computed tomography severity index (CTSI), and modified CTSI (mCTSI). Proton density fat fraction (PDFF) levels of the liver and pancreas were quantified via IDEAL MRI, with patients categorized into biliary and non-biliary pancreatitis groups. MASLD was identified in 40.9% of patients and NAFPD in 30%. Liver PDFF was significantly higher in non-biliary pancreatitis (p=0.040), and patients with MASLD showed higher CTSI and mCTSI scores (p=0.009 and p=0.033, respectively). No significant differences in severity were observed between patients with and without NAFPD. Liver PDFF positively correlated with CTSI and mCTSI in biliary pancreatitis. ROC analysis identified liver PDFF >3.9% and pancreatic corpus PDFF >12.1% as predictors of severe pancreatitis, while liver PDFF <4.5% indicated biliary etiology. These findings suggest that IDEAL MRI-derived liver and pancreatic PDFF levels are promising biomarkers for predicting severe acute pancreatitis and distinguishing its etiologies, particularly in patients with MASLD, though further studies are needed to enhance their clinical utility.
Keywords: Metabolic dysfunction–associated steatotic liver disease, non-alcoholic fatty pancreatic disease, acute pancreatitis, IDEAL, proton density fat fraction

INTRODUCTION

Acute pancreatitis (AP) is an inflammatory condition of the pancreas, primarily caused by gallstones or alcohol consumption, characterized by acinar cell destruction, abdominal pain, and elevated pancreatic enzyme levels (Lankisch et al., 2015). Metabolic dysfunction–associated steatotic liver disease (MASLD) and non-alcoholic fatty pancreatic disease (NAFPD) share risk factors with AP, such as obesity and metabolic syndrome, and may worsen its severity through proinflammatory cytokine production and pancreatic fat-related tissue damage (Wu et al., 2019; Xu et al., 2015). Traditional diagnostic methods like liver biopsy and magnetic resonance spectroscopy have limitations in assessing fat content regions (Longo et al., 1995).. The IDEAL MRI technique, developed by Reeder et al., offers accurate fat quantification by addressing confounding factors in earlier imaging methods (Reeder et al., 2005). This study aims to evaluate the effectiveness of IDEAL MRI in quantifying liver and pancreatic PDFF and to determine the correlation between these fat fractions and the clinical severity of acute pancreatitis based on Computed Tomography Severity Index (CTSI), modified CTSI (mCTSI), and the revised Atlanta classification.

MATERIAL AND METHODS

Study Design and Patient Selection

This retrospective study, approved by the local ethics committee (2022/142), included 127 patients diagnosed with AP between November 2020 and December 2022. Inclusion criteria were age ≥18 years, contrast-enhanced abdominal CT within 24 hours of admission, and IDEAL MRI/MRCP within 48–72 hours. Exclusion criteria included malignancy, pregnancy, hepatitis, alcoholic pancreatitis, missing data, or poor-quality imaging. AP diagnosis required two of three criteria: typical abdominal pain, elevated amylase/lipase levels, or imaging findings (Toouli J, Brooke-Smith M, Bassi C, 2002). Patients were classified into biliary (gallstones or elevated liver enzymes) or non-biliary pancreatitis groups. Laboratory data and comorbidities were recorded.

Imaging Protocol

Contrast-enhanced CT was performed using a 16-slice scanner with a pancreatic phase acquisition at 35-40 seconds post-contrast injection. Iodinated contrast medium was administered intravenously at a dose of 1 mL/kg body weight, with an injection rate of 4 mL/s.

Contrast-enhanced MRI/MRCP scans of the abdomen were performed on a 3-tesla MR unit (3T GE Discovery MR750w, GE Healthcare, Waukesha, Wisconsin, USA) using a 16-channel

phased-array body coil. The imaging protocol comprised axial and coronal T2, axial T2 fat suppressed, diffusion-weighted imaging, coronal 3D MRCP, axial T1 LAVA with pre- and post-contrast dynamic images, as well as axial IDEAL IQ sequences for fat fraction mapping. Parameters for the IDEAL IQ sequence were set with TR of 6.9 msec, TE of 2.9 msec, ETL of 3, FOV ranging between 35-40 cm, matrix resolution of 160x160, bandwidth of 127 kHz, 8 mm slice thickness, and a 3-degree flip angle. As a gadolinium-based contrast agent, gadobutrol (Gadovist; Bayer Healthcare) was used at a standard dose of 0.1 mmol/kg.

Image Analysis

Two radiologists with 5 and 10 years of experience analyzed images. CTSI and mCTSI scores were calculated from CT, categorizing AP severity as mild, moderate, or severe. RAC classified AP based on organ failure and complications.

Pancreatic PDFF was measured by placing regions of interest (ROIs) in the pancreas head, neck, body, and tail, avoiding necrotic areas, with a 10.4% threshold for NAFPD (Wong et al., 2014) (Fig. 1).

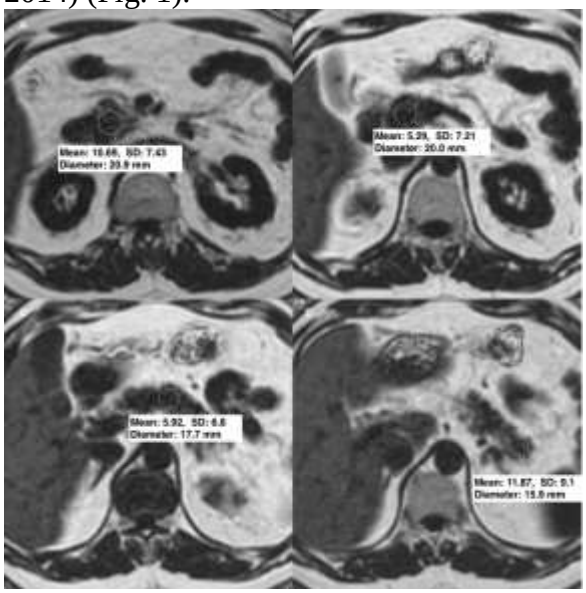

Figure 1: In a patient with a mean pancreatic PDFF level of 8.4%, placement of ROIs of appropriate size so as not to overflow from the parenchyma; A) Head, B) Neck, C) Body, D) Tail.

To measure liver PDFF, ROIs of approximately 3 cm^2 were placed in segments 2, 5, 6, 7, and 8 on the same sequence, avoiding bile ducts and major hepatic vessels (Fig. 2). The averaged liver PDFF values used a threshold of 5% for diagnosing MASLD (Starekova et al., 2021).

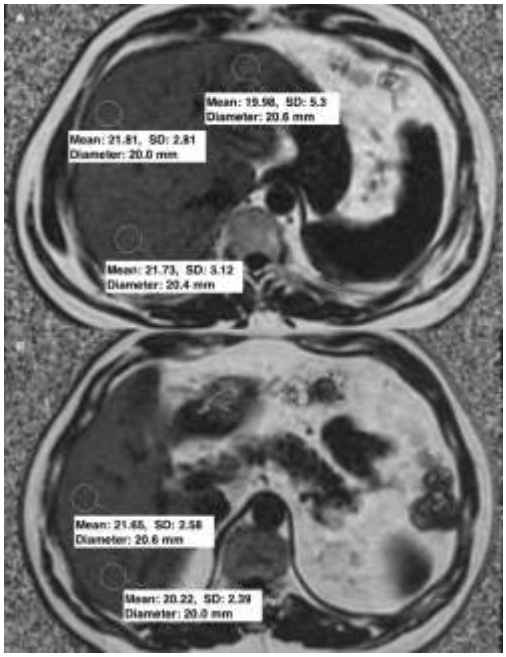

Figure 2: In a patient with a mean liver PDFF level of 21%, A) ROIs of approximately 3 cm2 placed in segments 2, 7 and 8, B) ROIs of similar size placed in segments 5 and 6.

Statistical Analysis

Statistical analyses used IBM SPSS Statistics (version 22.0). Descriptive statistics, normality tests, t-tests, ANOVA, Mann-Whitney U, Kruskal-Wallis, Chi-square, and Fisher's exact tests were applied. Correlations used Pearson's or Spearman's methods. ROC analysis evaluated PDFF's diagnostic performance for severe AP, with $p<0.05$ indicating significance. Post-hoc power analyses assessed statistical robustness.

RESULTS

Descriptive Statistics

Of 252 patients, 127 were included (mean age 61.7 ± 17.0 years, 48% male). Biliary pancreatitis comprised 79.5% of cases. CTSI classified 79.5% as mild, 19.7% moderate, and 0.8% severe; mCTSI classified 60.6% mild, 37.8% moderate, and 1.6% severe. RAC identified 63.8% mild, 31.5% moderately severe, and 4.7% severe AP. Mean pancreatic PDFF was 9.0% ± 8.5, and liver PDFF was 5.9% ± 5.3. MASLD was present in 40.9% and NAFPD in 30% of patients.

Post-Hoc Power Analysis

Power analysis confirmed adequate power for comparisons between biliary/non-biliary pancreatitis and MASLD/non-MASLD groups, but lower power (~0.68) for mild vs. moderately severe/severe AP comparisons.

Comparisons Between Groups

Liver PDFF was significantly higher in non-biliary pancreatitis ($p=0.040$) and patients with comorbidities ($p=0.025$). Pancreatic PDFF was higher in patients with comorbidities ($p=0.001$) and hypertension ($p=0.002$) (Table 1).

Table 1: Distribution and analysis of pancreatic and liver PDFF levels based on the descriptive characteristics of the cases

Feature	Pancreas PDFF	p-value	Liver PDFF	p-value
	Median (min-max)		Median (min-max)	
Gender		0.447		0.567
Male	7.2 (0.9-44.6)		4.0 (1.0-27.0)	
Female	6.6 (0.8-50.2)		4.1 (0.9-22.5)	
Etiology		0.601		***0.040***
Non-biliary	6.4 (0.9-28.3)		5.6 (2.0-26.0)	
Biliary	7.0 (0.8-50.2)		3.9 (0.9-27.0)	
Comorbid disease		***0.001***		***0.025***
(+)	8.3 (1.7-50.2)		4.5 (0.9-27.0)	
(-)	4.0 (0.8-18.2)		3.4 (1.0-22.5)	
HT		***0.002***		0.117
(+)	8.1 (1.9-50.2)		4.5 (0.9-27.0)	
(-)	4.2 (0.8-27.0)		3.5 (1.0-22.5)	
DM		0.613		0.265
(+)	6.4 (1.7-22.8)		5.0 (1.5-26.0)	
(-)	7.2 (0.8-50.2)		4.0 (0.9-27.0)	
CAD		0.429		0.419
(+)	6.5 (2.6-44.6)		4.0 (1.0-22.5)	
(-)	7.2 (0.8-50.2)		4.0 (0.9-27.0)	
Pleural effusion		0.674		0.124
(+)	8.4 (1.9-18.2)		6.0 (2.0-26.0)	
(-)	6.7 (0.8-50.2)		4.0 (0.9-27.0)	

**HT; Hypertension, DM; Diabetes Mellitus, CAD; Coronary Artery Disease, PDFF; Proton Density Fat Fraction*

*** The Mann-Whitney U test was used in all analyses.*

Patients with MASLD had higher CTSI (p=0.009) and mCTSI (p=0.033) scores. Compared to patients without MASLD, those with MASLD exhibited a higher proportion of non-biliary etiologies (28.8% vs. 14.7%), although this difference was not statistically significant (p = 0.051) (Table 2).

Table 2: Comparison of AP severity and etiology in patients with and without MASLD

	Liver PDFF ≤5 (n=75)	Liver PDFF >5 (n=52)	p-value
	Mean ± SD	Mean ± SD	
CTSI	2.1 ± 1.3	2.7 ± 1.2	***0.009***†
mCTSI	2.5 ± 1.4	3.1 ± 1.3	***0.033***†
Atlanta*			0.118††
MAP	52 (69.3)	29 (55.8)	
MSAP-SAP	23 (30.7)	23 (44.2)	
Etiology*			0.051††
Non-biliary	11 (14.7)	15 (28.8)	
Biliary	64 (85.3)	37 (71.2)	

†Independent samples t-test, ††Chi-square test, †††Mann-Whitney U test
*N (%)

No significant differences in severity were found between NAFPD and non-NAFPD groups.

Correlation Analyses

Liver PDFF positively correlated with CTSI (p=0.002) and mCTSI (p=0.003) in biliary pancreatitis, but not in non-biliary cases. Pancreatic PDFF correlated with age (p<0.001) but not with severity scores (Table 3)

Table 3: Correlation between pancreatic and liver PDFF levels and age, CTSI and mCTSI

Total (n=127)		**Pancreas PDFF**	**Liver PDFF**
Age	rho	***0.457***	0.056
	p-value	***<0.001***	0.533
CTSI	rho	0.098	***0.278***
	p-value	0.271	***0.002***
mCTSI	rho	0.010	***0.258***
	p-value	0.915	***0.003***
Biliary pancreatitis (n=101)			
Age	rho	***0.482***	0.086
	p-value	***<0.001***	0.394
CTSI	rho	0.174	***0.296***
	p-value	0.082	***0.003***
mCTSI	rho	0.091	***0.263***
	p-value	0.365	***0.008***
Non-biliary pancreatitis (n=26)			
Age	rho	***0.399***	0.166
	p-value	***0.044***	0.417
CTSI	rho	-0.125	0.100
	p-value	0.541	0.627
mCTSI	rho	-0.252	0.150
	p-value	0.215	0.464

**PDFF; Proton density fat fraction, CTSI; CT severity index, mCTSI; modified CT severity index, rho; Correlation coefficient*

*** Spearman correlation test was used in all analyses*

ROC Analyses

Liver PDFF >3.9% (AUC=0.74, p=0.002) and pancreatic corpus PDFF >12.1% (AUC=0.73, p=0.028) predicted severe AP with high sensitivity and negative predictive values (Table 4). Liver PDFF <4.5% indicated biliary pancreatitis (AUC=0.63, p=0.042).

Table 4: ROC analyses of pancreatic and liver PDFF levels in severe pancreatitis

	AUC	**%95 CI**	**p-value**
Pancreas PDFF	0.66	0.575-0.745	0.228
Head PDFF	0.65	0.563-0.735	0.207
Neck PDFF	0.56	0.471-0.650	0.657
Corpus PDFF	0.73	0.640-0.801	***0.028***
Tail PDFF	0.64	0.547-0.720	0.403
Liver PDFF	0.74	0.655-0.814	***0.002***

**PDFF; Proton density fat fraction, AUC; Area under the curve, CI; Confidence interval*

*** Severe pancreatitis was determined according to the RAC.*

DISCUSSION

This study confirms that metabolic dysfunction–associated steatotic liver disease (MASLD) is associated with increased acute pancreatitis (AP) severity, as evidenced by higher CTSI (p=0.009) and mCTSI (p=0.033) scores in MASLD patients. The positive correlation between liver PDFF and severity scores in biliary pancreatitis (CTSI, p=0.002; mCTSI, p=0.003) suggests that hepatic fat accumulation may amplify inflammatory responses, particularly in gallstone-related cases (Petrov MS, Taylor R, 2021). A liver PDFF threshold of >3.9% predicted severe AP with high sensitivity (100%) and negative predictive value (100%), indicating its potential as a non-invasive biomarker for identifying high-risk patients, even in those without MASLD.

Acute pancreatitis often has a mild and self-limiting course, but in 10–20% of cases, it is observed to be severe, and mortality is increased in this patient group (Sarri et al., 2019). The accumulation of neutral fat in the liver cells accompanied by progressive liver inflammation is considered a hepatic metabolic disorder (Wang et al., 2022). Our findings indicate that acute pancreatitis is more severe in patients with MASLD. Liver PDFF **levels** were higher in cases of non-biliary pancreatitis, and although non-biliary causes were more commonly observed among patients with MASLD, a statistically borderline but not significant relationship was found (p = 0.051). Regarding NAFPD, no significant relationship or correlation was found between disease severity and diverse etiologies.

Yoon et al. (Yoon et al., 2017) investigated the effect of steatotic liver disease (SLD) on the severity of acute pancreatitis using non-contrast CT in 200 patients. They found that the prevalence of SLD was significantly higher in patients with moderate and severe AP. Wu et al. (Wu et al., 2019) evaluated the effect of MASLD on the severity of AP using the revised Atlanta classification in a study with 656 patients. They reported that the severity of disease was higher in the moderate-severe MASLD group than in the mild group. Liu et al. (Liu et al., 2022) investigated the effect of SLD on AP severity in 189 patients and found that Acute Physiology and Chronic Health Evaluation II (APACHE-II) and mCTSI scores were higher in patients with SLD. Also, SLD was observed more frequently in cases of non-biliary pancreatitis. Our findings are consistent with previous studies regarding the impact of MASLD and AP severity. In addition, a liver PDFF value above 3.9% has a diagnostic role in the diagnosis of severe pancreatitis. This cut-off value indicates that severe pancreatitis may also develop in patients without MASLD.

Huifang et al. (FAN et al., 2022) evaluated pancreatic steatosis with the IDEAL MRI method and reported that there was no significant difference in pancreatic PDFF **levels** between mild and moderate-severe pancreatitis groups according to the MR severity index (p > 0.050). Xie et al. (Xie et al., 2019) compared pancreas CT Hounsfield Unit (HU) **levels** with AP severity and found that systemic inflammatory response syndrome, APACHE-II, and Ranson scores increased correlatively as HU **levels** decreased due to pancreatic steatosis. However, the modified CT Severity Index (mCTSI) score did not show a significant correlation. In our study, no significant pancreatic PDFF correlation was found between mild, moderate, and severe AP groups. Furthermore, there were no differences in RAC, CTSI, or mCTSI scores between the groups with and without NAFPD. NAFPD is a newly recognised entity and may be a component of metabolic syndrome. Research indicates that NAFPD may adversely affect the prognosis of acute pancreatitis, particularly in patients with comorbidities. Methods and threshold values for measuring pancreatic steatosis vary across studies, potentially contributing to inconsistent results. In this study, we employed the IDEAL-IQ MRI sequence and established a threshold value of 10.4% for diagnosing NAFPD. This variation in methodology and thresholds likely contributes to differences in study results. Additionally, variations in patient populations and genetic and metabolic factors may influence findings.

Also, Huifang et al. (FAN et al., 2022) included 72 AP patients and 82 healthy control groups in their study and reported that 5.1% pancreatic PDFF **level** had 100% sensitivity and 90.2% specificity in diagnosing AP. As there was no healthy control group in our study, we cannot evaluate the diagnostic performance of IDEAL PDFF. However, our ROC analysis demonstrated that a liver PDFF **level** of less than 4.5% supported the diagnosis of biliary pancreatitis when differentiating between biliary and non-biliary pancreatitis. The presence of hypertriglyceridemic patients in non-biliary pancreatitis and the primary role of MASLD in the etiology may have contributed to the observed differences in liver PDFF levels. In addition, in patients with high liver PDFF but also gallstones, diagnosing non-biliary pancreatitis may be misleading, and vice versa. In this case, it may be appropriate to use PDFF levels as a supportive finding.

However, several limitations must be acknowledged. The low statistical power (~0.68) for comparisons between mild and moderately severe/severe AP groups increases the risk of Type II errors, particularly for NAFPD-related findings. The small number of severe AP cases (n=6) limited subgroup analyses, as these patients were often too unstable for MRI/MRCP, introducing selection bias. Motion artifacts in MRI further complicated measurements, potentially affecting PDFF accuracy. The absence of baseline pancreatic PDFF data before AP onset precludes understanding whether inflammation alters fat measurements. Additionally, as a single-center retrospective study, the findings may not generalize to diverse populations with varying genetic and metabolic profiles.

CONCLUSIONS

MASLD increases the risk of severe AP, and IDEAL MRI-derived liver and pancreatic PDFF levels are valuable for predicting severity and differentiating etiologies. Larger studies are needed to validate these findings and enhance clinical applicability.

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PROSTAT KANSERİNDE KEMİK METASTAZI TAHMİNİNİN KANTİTATİF MPMRI ÖZELLİKLERİ, ISUP DERECESİ VE PSA YOĞUNLUĞU KULLANILARAK GELİŞTİRİLMESİ: BİR MAKİNE ÖĞRENİMİ YAKLAŞIMI

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ÖZET
Prostat kanserinde kemik metastazı, hayatta kalma ve yaşam kalitesini olumsuz etkileyen ciddi bir komplikasyon olup, erken tespit ve tedavi planlaması için doğru tahmin araçlarına ihtiyaç duyar. Bu çalışma, kantitatif multiparametrik MRI (mpMRI) özelliklerini, Uluslararası Ürolojik Patoloji Derneği (ISUP) derecesini ve prostat spesifik antijen (PSA) yoğunluğunu entegre ederek kemik metastazı tahminini iyileştirmek için makine öğrenimini kullanmaktadır. Histolojik olarak doğrulanmış prostat kanserli 122 hastanın retrospektif analizi yapılmış, dinamik kontrastlı MRI (DCE-MRI) perfüzyon parametreleri (IAUGC, MaxSlope), PSA yoğunluğu ve ISUP dereceleri çıkarılmıştır. Tanı anında hastaların %21.3'ünde kemik metastazı saptanmıştır. Veri seti, fazla örnekleme ile dengelenmiş ve %70 eğitim, %30 test setlerine ayrılmıştır. Çoklu makine öğrenimi modelleri değerlendirilmiş, XGBoost modeli %91.5 doğrulama ve %92.6 test AUC'si ile en yüksek performansı göstermiş, %93.3 hassasiyet ve %93.1 duyarlılık elde etmiştir. IAUGC ve MaxSlope kemik metastazı ile anlamlı şekilde ilişkili bulunmuş (p=0.035 ve p=0.050), 0.24 PSA yoğunluğu eşik değeri %88 duyarlılık ve %60 özgüllük sağlamıştır (AUC=0.77). SHAP analizi, PSA yoğunluğu ve MaxSlope'u ana tahmin ediciler olarak vurgulamıştır. MpMRI özellikleri, ISUP derecesi ve PSA yoğunluğunu birleştiren bu makine öğrenimi yaklaşımı, kemik metastazı tahmin doğruluğunu önemli ölçüde artırarak ek görüntüleme ve radyasyon maruziyetine bağımlılığı azaltabilir, ancak daha geniş klinik kabul için çok merkezli doğrulama gereklidir.
Anahtar Kelimeler: Prostat kanseri, Kemik metastazı, Makine öğrenmesi, PSA yoğunluğu, ISUP derecesi

ENHANCING BONE METASTASIS PREDICTION IN PROSTATE CANCER USING QUANTITATIVE MPMRI FEATURES, ISUP GRADE, AND PSA DENSITY: A MACHINE LEARNING APPROACH

ABSTRACT
Bone metastasis in prostate cancer is a severe complication that adversely affects survival and quality of life, necessitating accurate predictive tools for early detection and treatment planning. This study leverages machine learning to improve bone metastasis prediction by integrating quantitative multiparametric MRI (mpMRI) features, International Society of Urological Pathology (ISUP) grade, and prostate-specific antigen (PSA) density. A retrospective analysis of 122 patients with histologically confirmed prostate cancer was performed, extracting dynamic contrast-enhanced MRI (DCE-MRI) perfusion parameters (IAUGC, MaxSlope), PSA density, and ISUP grades. Bone metastases were identified in

21.3% of patients at diagnosis. The dataset was balanced using oversampling and split into 70% training and 30% test sets. Multiple machine learning models were evaluated, with the XGBoost model achieving the highest performance, demonstrating validation and test AUCs of 91.5% and 92.6%, respectively, alongside 93.3% precision and 93.1% recall. IAUGC and MaxSlope were significantly associated with bone metastasis (p=0.035 and p=0.050), and a PSA density cut-off of 0.24 yielded 88% sensitivity and 60% specificity (AUC=0.77). SHAP analysis highlighted PSA density and MaxSlope as key predictors. This machine learning approach, combining mpMRI features, ISUP grade, and PSA density, significantly enhances bone metastasis prediction accuracy, potentially reducing reliance on additional imaging and radiation exposure, though multi-center validation is required for broader clinical adoption.
Keywords: Prostate cancer, Bone metastasis, Machine learning, PSA density, ISUP grade

INTRODUCTION

Prostate cancer is the second most common cancer in men globally and a leading cause of cancer-related mortality (Sung et al., 2021). Bone metastasis, a severe complication, significantly reduces survival rates and quality of life, necessitating early detection for optimized treatment. Multiparametric MRI (mpMRI), incorporating T2-weighted imaging, diffusion-weighted imaging (DWI), and dynamic contrast-enhanced (DCE) MRI, is a standard for evaluating clinically significant prostate cancer (csPCa) (Breit et al., 2021). DCE-MRI provides perfusion data critical for assessing tumor aggressiveness (Berman et al., 2016). Current guidelines recommend bone scans for high-risk patients based on PSA levels or Gleason scores, but these have variable predictive accuracy (Schaeffer et al., 2024). Machine learning (ML) offers a promising approach to integrate quantitative mpMRI features, ISUP grade, and PSA density for improved bone metastasis prediction (Li et al., 2022). This study addresses the literature gap by developing ML models to predict bone metastasis using these

MATERIAL AND METHODS

Study Design and Patient Selection

This retrospective study, approved by the local ethics committee (2022/227), included 122 patients with histopathologically confirmed prostate cancer from January 2018 to December 2020. Inclusion criteria required mpMRI, while exclusion criteria included artifacted images or non-prostate malignancies. Informed consent was waived due to the retrospective design and anonymized data.

Multiparametric MRI Protocol

MpMRI was performed on a 3T GE Discovery MR750w scanner using a pelvic phased-array coil. The protocol included T2-weighted images, DWI (b-values 0-800-1400), and DCE-MRI with gadolinium contrast (0.1 mmol/kg, 2 mL/sec)(Table 1). Perfusion parameters (Ktrans, Kep, Ve, CER, MaxSlope, IAUGC) were processed using AW Server 2.0 software based on the Tofts model.

Table 1: Multiparametric prostate MRI sequences and parameters

Parameter	T2	T2	T2	DWI/ADC	Focused DWI/ADC	DCE-MRI
Plane	Axial	Coronal	Sagittal	Axial	Axial	Axial
TR (ms)	3140	6852	3674	8156	4630	3400
TE (ms)	170	140	112	80	80	2,1-22
Flip angle	140	142	142	90	90	20
b value	-	-	-	50,400,800	50,800,1400	-
Slice thickness (mm)	3	3,5	3,5	5	3	2,2
FOV (cm)	18	22	22	28	30	30
Matrix	256	256	256	128	64	128
Acquisition time (min:s)	3,28	3,47	3,26	3,25	6,06	5,22

Data Extraction

Prostate cancer was confirmed via 12-quadrant transrectal biopsy, with Gleason scores classified per ISUP grading (Srigley et al., 2016)(Table 2).

Table 2: ISUP Grading System

ISUP Grade	Gleason score	Description
1	3+3	Low risk; the cancer is usually slow growing and less likely to spread
2	3+4	Intermediate favorable risk; the cancer can be spread with slightly increased risk
3	4+3	Intermediate unfavorable risk; the cancer can be spread with moderately increased risk
4	3+5 4+4 5+3	High risk; the cancer can be fast growing and more likely to spread
5	4+5 5+5	Very high risk; the cancer can be fast growing and most likely to spread

All measurements were performed by two radiologists, who reached a consensus, with 5 and 10 years of experience, respectively. MpMR images of patients diagnosed with prostate cancer obtained before biopsy were investigated to create the dataset. Dynamic contrast-enhanced images were processed with AW Server 2.0 (GE Healthcare, Chicago, Illinois, USA) software. The volume of interest area (VOI) was placed manually to include the prostate and seminal vesicles. Images in the VOI area were processed according to the Tofts model to obtain Ktrans, Kep, Ve, contrast enhancement ratio (CER), MaxSlope, and initial area under the gadolinium curve (IAUGC) perfusion maps. A circular region of interest (ROI), measuring 35-45 mm², was placed on a single MRI slice in the area of the lesion confirmed by biopsy, specifically targeting the spot with the lowest ADC values identified in the ADC mapping. If more than one lesion was present, the lesion with the highest PI-RADS score was selected. The placed ROI was copied to perfusion maps and pharmacokinetic data of the lesion were obtained (Fig. 1).

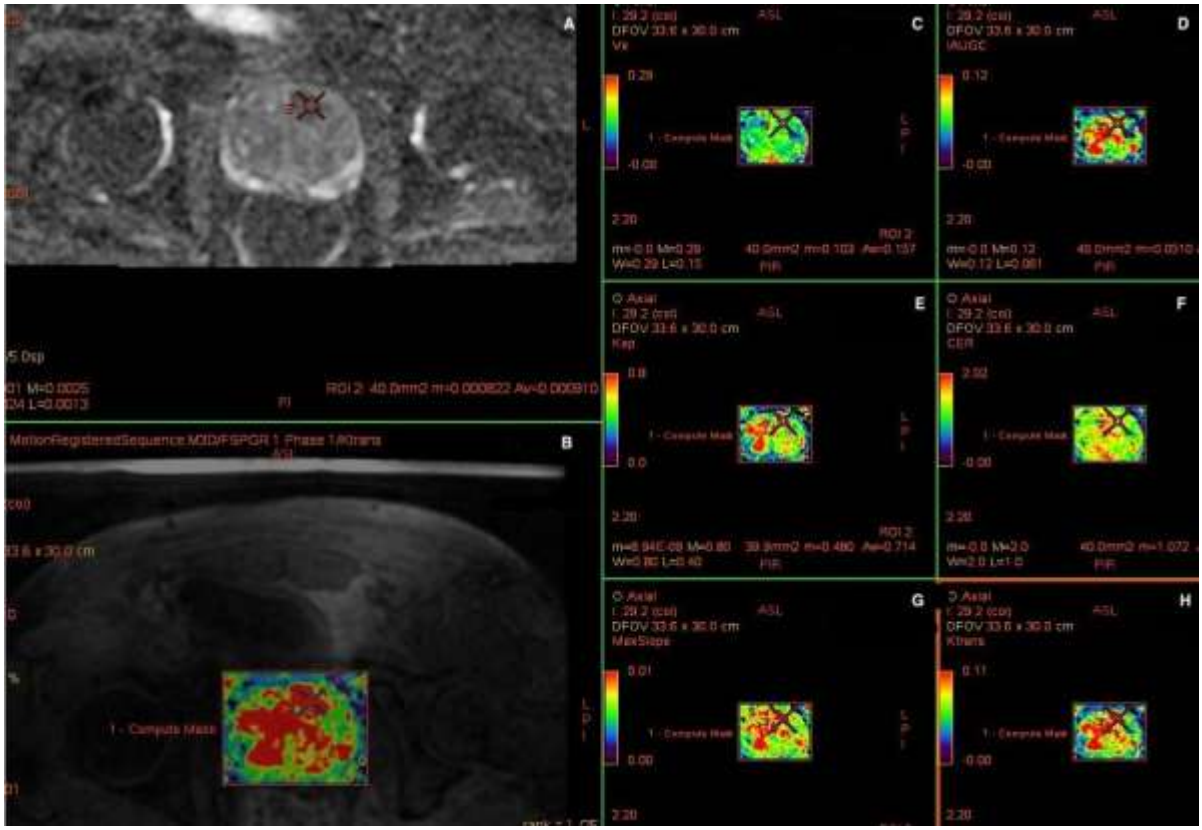

Figure 1: In ADC mapping, the ROI (Region of interest) was placed in the region of the lesion with the lowest ADC values and copied to the perfusion maps (A:ADC mapping, B: DCE-MRI/ K_{trans} fusion image, C: V_e map, D: Initial area under the gadolinium curve map, E: K_{ep} map, F: Contrast enhancement ratio map, G: MaxSlope map, H: K_{trans} map)

Prostate volume was calculated from T2-weighted images, and PSA density was derived by dividing total PSA by volume.

Screening for Bone Metastases

Bone metastases were assessed using bone scintigraphy, supplemented by 68Ga-PSMA PET/CT or MRI when needed. Two oncologic radiologists confirmed findings, identifying metastases via increased uptake or abnormal MRI signal patterns.

Data Preprocessing

Orange data mining software v3.34 was used to build the machine learning model. The dataset was created based on statistical results of pharmacokinetic data, PSA density, and ISUP grade values. Data were normalized to a range of 0-1 to create a common scale. The ratio of individuals without bone metastasis to those with bone metastasis was 3.7. To minimize distribution imbalance among groups in the dataset, the group with bone metastases was subjected to 100% oversampling using the same data. This approach increased the representation of the minority group in the dataset while preserving the overall data structure.

Data Sampling and Model Construction

The dataset consisted of pharmacokinetic features, ISUP grade, and PSA density that were significantly associated with bone metastasis. The dataset was divided into training and test sets with a fixed ratio of 70% and 30%. Training sets were used to create ML algorithms and test sets were used to evaluate the accuracy of the models. To create the ML algorithm, k-nearest neighbors (kNN), support vector machine (SVM), stochastic gradient descent (SGD), random forest (RF), neural network (ANN), naive bayes, logistic regression (LR), gradient boosting, extreme gradient boosting (XGBoost) and AdaBoost models were used. Table 3 summarizes the parameters used for each algorithm.

Table 3: Parameter settings of machine learning algorithms

Machine learning algorithms/Parameters	Parameter value
k-Nearest Neighbors	
Number of neighbors	5
Metrics	Eucledian
Weight	Uniform
Support Vector Machine	
Kernel	Sigmoid
İteration Limit	100
Random Forest	
Number of trees	20
Minimum limit for split	5
Stochastic Gradient Descent	
Loss Function	Hinge
Regularization	Lasso (L1)
Learning rate	Constant
İnitial learning rate	0.01
Neural Network	
Neurons in hidden layers	100
Activation	Logistic
Solver	SGD
Maximum number of iterations	200
Naive Bayes	
Prior probability estimation	Relative frequency
Logistic Regression	
Regularization	Lasso (L1)
Adaptive Boosting	
Number of estimators	50
Classification algorithm	SAMME.R
Regression loss function	Linear
Learning rate	0,1
Gradient Boosting	
Number of trees	100
Learning rate	0,1
Fraction of training instances	1
XGBoost	
Number of trees	100
Learning rate	0,1
Fraction of training instances	1
Regularization lambda	1

The training set was divided into 10 subgroups with the 10-fold cross-validation method, trained with 9 different subgroups, and tested with 1 subgroup each time. This process was repeated 10 times and the validation score was obtained by averaging the results. Once the models were trained with the 10-fold cross-validation method, they were tested with the test set. To avoid overfitting and underfitting, the acceptable gap between validation and test results was set at 3%, even though this is not a standard value. The accuracy of the models was assessed by the area under the curve (AUC). The methodology of our study is summarized in figure 2.

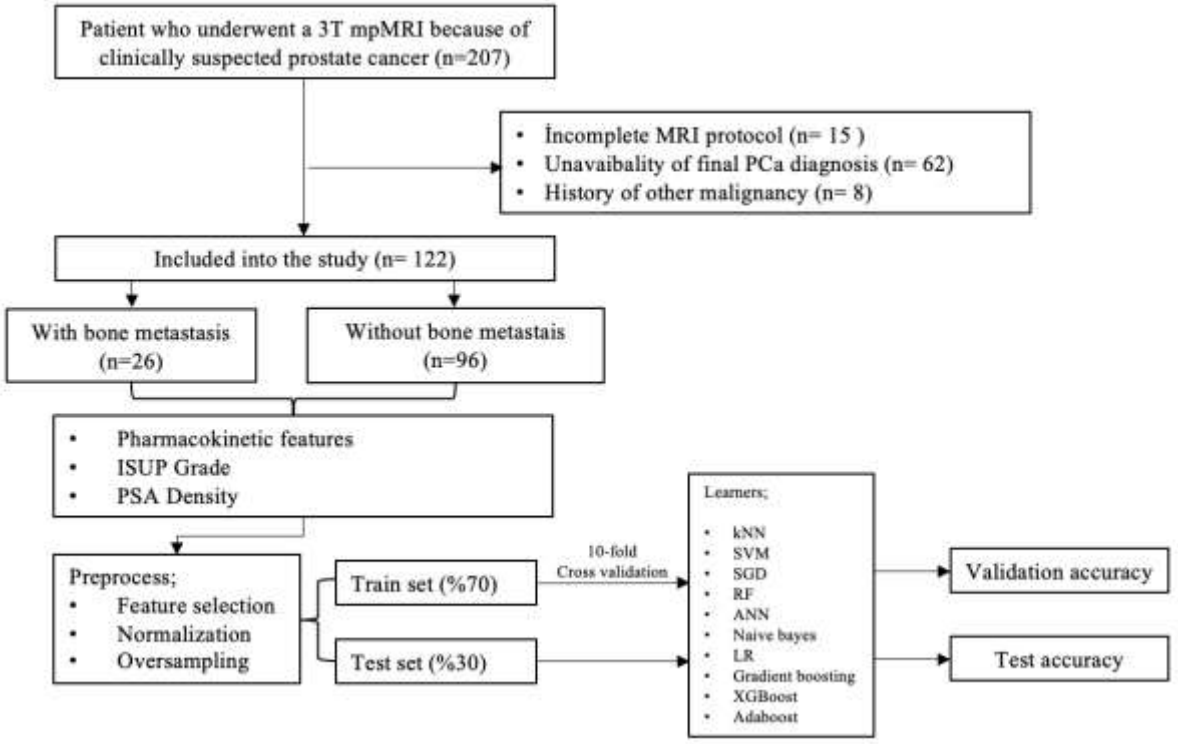

Figure 2: Data acquisition process

Statistical Analysis

SPSS v26 was used for statistical analysis. Non-normal data were compared using the Mann-Whitney U test, and ISUP grades were grouped into low (1-2) and high (3-5) risk per EAU guidelines. Chi-square tests assessed risk group-metastasis associations. ROC analysis determined optimal PSA density cut-offs, and SHAP analysis quantified feature contributions. A p-value <0.05 was significant.

RESULTS

Demographic and Pathological Features

The study included 122 patients, with 26 (21.3%) having bone metastases at diagnosis and 96 (78.6%) without. Mean ages were 71.3±8.5 (non-metastasis) and 72.9±8.6 (metastasis), with no significant age difference. High-risk ISUP grades (3-5) showed a strong correlation with bone metastasis ($p<0.001$), with 80% of metastasis cases having ISUP grades 3-5, underscoring the prognostic value of histopathological grading.

Biochemical and Perfusion Parameters

Median PSA density was significantly higher in the metastasis group (1.04 ng/mL³, range 0.07-3.59) compared to the non-metastasis group (0.18 ng/mL³, range 0.04-3.14; $p<0.001$). ROC analysis identified a PSA density cut-off of 0.24, yielding a sensitivity of 0.88, specificity of 0.60, and AUC of 0.77, indicating moderate discriminatory power. Among DCE-MRI parameters, IAUGC ($p=0.035$) and MaxSlope ($p=0.050$) were significantly associated with bone metastasis, reflecting increased vascular permeability in aggressive tumors. Ktrans showed a near-significant trend ($p=0.070$), while Ve, Kep, and CER were not significant ($p>0.05$), suggesting selective relevance of perfusion metrics (Table 4).

Table 4: Statistic results

Dataset features, *median (min-max)*	Bone metastasis		p-value
	(-)	(+)	
$K_{trans,}$	0,2135 (0,0217-0,8390)	0,2725 (0,0940-0,6370)	0,07
V_e	0,2285 (0,0596-0,8880)	0,2425 (0,0390-0,9920)	0,486
IAUGC	0,1220 (0,0268-0,4370)	0,1515 (0,0672-0,5010)	0,035
Kep	0,9010 (0,1750-3,5730)	1,0260 (0,3670-3,1720)	0,279
CER	2,2505 (0,4460-6,33)	2,5995 (0,8-5,34)	0,226
MaxSlope	0,0099 (0,0023-0,2030)	0,1500 (0,0021-0,1119)	0,05
PSA density	0,18 (0,04-3,14)	1,04 (0,07-3,59)	<0,001
ISUP Grade	2 (1-5)	3 (1-5)	<0,001

Machine Learning Model Performance

The dataset, incorporating IAUGC, MaxSlope, ISUP grade, and PSA density, was used to train multiple ML models. XGBoost outperformed others, achieving a validation AUC of 91.5% and test AUC of 92.6%, with a precision of 93.3%, recall of 93.1%, and F1 score of 93.2%. Gradient Boosting was the second-best model (test AUC 89.1%, F1 score 91.2%), while Random Forest showed overfitting due to a wider validation-test gap (Table 5).

Table 5: Machine learning models results, *AUC*

Models	Validation	Test
k-Nearest Neighbors	0,74	0,80
Support Vector Machine	0,67	0,64
Random Forest	0,88	0,92
Stochastic Gradient Descent	0,78	0,82
Neural Network	0,76	0,83
Naive Bayes	0,79	0,84
Logistic Regression	0,77	0,80
Adaptive Boosting	0,90	0,83
Gradient Boosting	0,89	0,89
XGBoost	0,91	0,92

SHAP analysis highlighted PSA density as the primary contributor to predictions, followed by MaxSlope, emphasizing their roles in identifying metastatic risk (Fig.3).

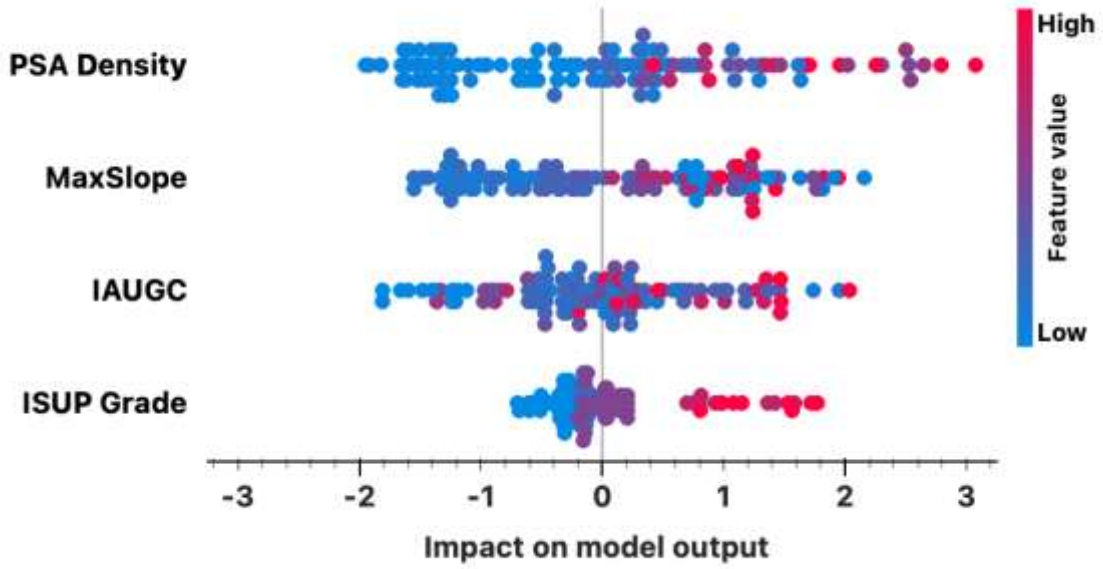

Figure 3: The SHAP summary plots show that the PSA Density and MaxSlope features are the most significant contributors to the model.

DISCUSSION

This study demonstrates that integrating DCE-MRI perfusion features (IAUGC, MaxSlope), ISUP grade, and PSA density via machine learning, particularly XGBoost, significantly enhances bone metastasis prediction in prostate cancer, achieving a test AUC of 92.6% compared to 77% for PSA density alone. The significant associations of IAUGC (p=0.035) and MaxSlope (p=0.050) with metastasis align with studies linking these parameters to tumor vascularity and aggressiveness, as reported by Kamrava et al. and Chung et al (Chung et al., 2014; Kamrava et al., 2013). The near-significant Ktrans trend (p=0.070) contrasts with Aytekin et al.'s findings, possibly due to differences in sample size or tumor characteristics (Oto et al., 2012). High PSA density (≥0.24) and ISUP grades 3-5 were critical predictors, consistent with NCCN and EAU guidelines for high-risk stratification (Wu et al., 2018).. XGBoost's superior performance, with high precision (93.3%) and recall (93.1%), mirrors Liu et al.'s 96.2% accuracy in SEER-based metastasis prediction, highlighting its robustness in handling complex datasets (Liu et al., 2021). Unlike Random Forest, which exhibited overfitting, XGBoost maintained consistency across validation and test sets, supported by a narrow 1.1% AUC gap. SHAP analysis underscored PSA density's dominant role, suggesting it captures systemic disease burden, while MaxSlope reflects local tumor biology. This approach could reduce reliance on bone scans, minimizing radiation exposure and costs. Limitations include the retrospective single-center design, small sample size (n=122), and class imbalance despite oversampling, which may affect model robustness. The lack of external validation and potential overfitting in some models (e.g., Random Forest) necessitate caution. Future multicenter studies with larger, diverse cohorts and external validation are essential to confirm generalizability and facilitate clinical integration.

CONCLUSIONS

ML models, particularly XGBoost, integrating quantitative mpMRI features, ISUP grade, and PSA density, offer high accuracy in predicting bone metastasis in prostate cancer, potentially reducing reliance on additional imaging. Multicenter prospective studies are needed for clinical adoption.

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GECİKME FAİZİ İLE AKDİ FAİZ ARASINDAKİ FARKLAR VE UYGULAMA SONUÇLARI: KREDİ KARTI BORÇLARI ÜZERİNE BİR İNCELEME

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ÖZET
Kredi kartı, bankaların mali gücü yeterli ve gerekli kriterleri taşıyan müşterilerine, belirli bir harcama limiti kapsamında alışveriş yapma, nakit avans kullanma ve taksitli ödeme olanağı sunduğu ödeme araçlarından biridir. Müşterilerin hesap dönemi içinde yaptığı harcamalar ile önceki aylardan yansıyan taksitli harcamaların toplamı, dönem sonunda banka tarafından bildirilir. Bu dönem genellikle 30 günü kapsamaktadır. Kredi kartlarında hesap kesim tarihi, banka ve müşteri tarafından birlikte belirlenmekte olup genellikle müşterinin ödeme yapabileceği zamana denk getirilmektedir. Hesap kesim tarihinden itibaren yasal olarak en az 10 gün içerisinde döneme yansıyan borcun ödenmesi beklenmektedir. Son ödeme gününe kadar ödenmeyen borçlar için banka gecikme faizi uygular ve bu durum kredi notunu olumsuz etkiler. Asgari ödeme dâhil hiç ödeme yapılmaması, kredi notu raporuna "geç ödeme" olarak yansır. Kredi kartı ödemelerindeki gecikmeler, kredibiliteyi düşürür ve ödenmeyen tutara faiz uygulanmasına yol açar. Uygulanacak faiz türleri, çeşitli faktörlere bağlı olarak değişmektedir. Kredi kartı müşterisinin asgari ödeme tutarının tamamını ya da bir kısmını ödememesi durumunda ödenmeyen asgari tutar üzerinden gecikme faizi alınmaktadır. Bu tür faizlerde borç arttıkça faiz yükü artmaktadır. Asgari tutarın ödenmemesi ya da olması gerekenden daha az ödenmesi durumunda gecikme faizi işlemeye başlayacaktır. Kredi kartı borcunun sadece asgari ödeme tutarı ödendiği durumda, kalan borç için işletilen faiz türü akdi faizdir. Toplam borcun ödenmeyen kısmı için hesap kesim tarihinden son ödeme tarihine kadar akdi faiz, son ödeme tarihinden itibaren asgari tutarın ödenmeyen kısmı için gecikme faizi, kalan hesap bakiyesinin asgari tutarı aşan ödenmeyen kısmı için ise ayrıca akdi faiz hesaplanmaktadır. Akdi faiz ve gecikme faizi azami oranları, Türkiye Cumhuriyeti Merkez Bankası tarafından belirlenmekte ve belirli periyotlarla güncellenmektedir. Kredi kartı müşterisinin hiç ödeme yapmaması, yalnızca asgari tutarın kısmen ya da tamamen ödenmesi gibi durumlarda uygulanacak faiz tutarları farklılık gösterecektir. Bu çalışmada kredi kartı ödemelerinde oluşabilecek farklı senaryolara yönelik faiz uygulamaları açıklanmıştır.
Anahtar Kelimeler: kredi kartı, gecikme faizi, akdi faiz, asgari ödeme,kredi notu

DIFFERENCES BETWEEN LATE PAYMENT INTEREST AND CONTRACTUAL INTEREST AND THEIR PRACTICAL IMPLICATIONS: AN ANALYSIS ON CREDIT CARD DEBT

ABSTRACT
A credit card is a financial instrument provided by banks to customers who meet certain criteria and possess sufficient financial standing. It allows them to make purchases, access cash advances, and perform installment-based transactions within a specified credit limit. The total amount spent by the customer during the billing period, along with any installment payments carried over from previous months, is reported by the bank at the end of the period, which typically lasts 30 days. The billing date is jointly determined by the bank and the customer and

is usually aligned with the customer's expected ability to repay. From the billing date, customers are legally required to pay their due balance within a minimum period of ten days. If the outstanding debt is not paid by the due date, the bank applies a late payment interest, which adversely affects the customer's credit score. When no payment is made, including the minimum required amount, this is recorded in the credit report as a "late payment." Such delays lower the customer's creditworthiness and result in additional interest charges. The type of interest applied may vary depending on several factors. If the customer fails to pay the full or partial minimum amount, late payment interest is charged on the unpaid portion. As the outstanding debt grows, the interest burden increases proportionally. In cases where the minimum payment is not made, or if a lower amount is paid, the late payment interest begins to accrue. If only the minimum amount is paid, contractual interest is applied to the remaining balance. For the unpaid portion of the total debt, contractual interest is charged from the billing date to the due date; following the due date, late payment interest is applied to the unpaid part of the minimum amount, while contractual interest continues to be charged on the remaining unpaid balance exceeding the minimum. The maximum rates for both contractual and late payment interest are determined by the Central Bank of the Republic of Türkiye and updated quarterly. The amount of interest to be charged differs depending on whether no payment is made, only part of the minimum payment is made, or the full minimum payment is made. This study explains the interest practices applied under various scenarios related to credit card payments.
Keywords: credit card, late payment interest, contractual interest, minimum payment, credit score

GİRİŞ

Kredi kartları, modern bankacılık sisteminin en yaygın kullanılan ödeme araçlarından biri haline gelmiştir. Taksitli alışverişten nakit çekime kadar uzanan çeşitli finansal işlemleri mümkün kılan bu araçlar, tüketicilere kısa vadeli likidite sağlarken, bankalar için de önemli bir faiz geliri kaynağı oluşturmaktadır. Ancak kredi kartı kullanımına ilişkin ödeme disiplininin bozulması, kullanıcılar açısından borçların katlanarak artmasına, bankalar açısından ise riskli alacakların büyümesine neden olmaktadır.

Özellikle ödeme sürecinde yer alan "akdi faiz" ve "gecikme faizi" gibi faiz türleri, tüketici davranışlarını doğrudan etkileyen ve çoğu zaman yeterince anlaşılmayan kavramlardır. Bu faiz türlerinin hesaplanma biçimi, yasal dayanakları ve uygulamadaki yansımaları, kredi kartı borç yönetiminin temel yapı taşlarını oluşturur. Bu bağlamda, söz konusu faiz türleri arasındaki farkların açıklığa kavuşturulması, tüketici bilincinin artırılması açısından önem taşımaktadır.

Bu çalışmada, kredi kartı ödemelerinde farklı ödeme senaryoları çerçevesinde akdi ve gecikme faizlerinin nasıl uygulandığı incelenmekte, bu uygulamaların kredi notuna ve borç yüküne olan etkileri tartışılmaktadır. Ayrıca çalışmada Türkiye Cumhuriyet Merkez Bankası tarafından belirlenen yasal faiz oranları ve güncel düzenlemeler de dikkate alınarak, konuya ilişkin somut örneklemeler sunulmaktadır.

ARAŞTIRMA VE BULGULAR

Çalışma hazırlanırken yöntem olarak literatür incelemesi ve nitel analiz benimsenmiştir. Veriler güncel sektör faiz oranları ve örnek faiz hesaplamalarıyla detaylandırılarak açıklanmıştır.

Kredi Kartı Sistematiği ve İşleyişi

Kredi kartları, banka müşterilerinin belirli bir limit çerçevesinde mal ve hizmet alımı yapabilmelerine, nakit avans çekebilmelerine ve taksitli ödeme seçeneklerinden yararlanabilmelerine olanak sağlayan ödeme araçlarıdır (Ataman, Yıldırım, 2022). Hesap kesim tarihinden sonra başlayan ödeme süreci, tüketicilere borçlarını kapatma veya yapılandırma fırsatı verir. Bu süreç, genellikle 30 günlük bir dönem sonunda başlar ve son

ödeme tarihine kadar en az 10 gün sürer. Bu süre içinde borcun tamamı ya da asgari ödeme tutarı ödenmediği takdirde çeşitli faiz uygulamaları devreye girer (BDDK, 2023).

Kredi Kartlarında Faiz Türleri: Akdi Faiz ve Gecikme Faizi

Bankalar tarafından kredi kartı borçlarına uygulanan iki temel faiz türü bulunmaktadır: akdi faiz ve gecikme faizi (Eren, 2021). Akdi faiz, müşterinin kredi kartı borcunun tamamını ödememesi ancak asgari tutarı ödemesi durumunda kalan bakiye üzerinden uygulanan faiz türüdür. Hesap kesim tarihi ile son ödeme tarihi arasında kalan süreye ilişkin olarak uygulanır (TCMB, 2025). Gecikme faizi ise, asgari ödeme tutarının kısmen ya da tamamen ödenmemesi durumunda devreye girer.

Kredi kartı işlemlerinde uygulanacak azami faiz oranları, Kredi Kartı İşlemlerinde Uygulanacak Azami Faiz Oranları Hakkında Tebliğ (Sayı: 2020/16) ile belirlenen yöntem kapsamında hesaplanmakta olup her ayın sondan beşinci iş günü TCMB tarafından ilan edilmektedir.

Bankalar tarafından kredi kartı işlemlerinde uygulanabilecek en yüksek faiz oranlarının hesaplanmasında gereken referans oran, Bankalarca Ticari Müşterilerden Alınabilecek Ücretlere İlişkin Usul ve Esaslar Hakkında Tebliğ (Sayı: 2020/4) kapsamında belirlenen yöntemle hesaplandıktan sonra ilan edilmektedir. (TCMB, 2025).

Belirtilen faiz oranları ilgili dönemler için geçerli olan azami oranlardır. Bankalar Türkiye Cumhuriyet Merkez Bankası'nın belirlemiş olduğu oranları aşmamak koşuluyla kredi kartı işlemlerinde uygulayacakları faiz oranlarını serbestçe belirlemektedir.

İlgili tarihler için değerlendirdiğimizde; kredi kartı asgari ödeme hesaplama işlemi Bankacılık Düzenleme ve Denetleme Kurumu (BDDK) kararı doğrultusunda %20 ile %40 arasında belirlenmiş olup kart limiti 25.000 TL altında olan kredi kartları için asgari oran %20, limiti 25.000 TL üzerinde olan kartlar için de asgari oran %40'tır.

Tablo 1. Güncel Kredi Kartı Azami Faiz Oranları

Geçerlilik Tarihi	Referans Oran (%)	Türk Lirası								Yabancı Para	
		Kredi Kartı İşlemlerinde Uygulanacak Dönem Borcu						Nakit Çekim veya Kullanım İşlemlerinde Uygulanacak** **Kredili mevduat hesapları için de geçerlidir.		Kredi Kartı İşlemlerinde Uygulanacak	
		25.000 TL altında		25.000-150.000 TL arasında		150.000 TL üzerinde* *Dönem borcuna bakılmaksızın kurumsal kredi kartları için de geçerlidir.					
		Azami Akdi Faiz Oranı (%)	Azami Gecikme Faiz Oranı (%)	Azami Akdi Faiz Oranı (%)	Azami Gecikme Faiz Oranı (%)	Azami Akdi Faiz Oranı (%)	Azami Gecikme Faiz Oranı (%)	Azami Akdi Faiz Oranı (%)	Azami Gecikme Faiz Oranı (%)	Azami Akdi Faiz Oranı (%)	Azami Gecikme Faiz Oranı (%)
1/7/2025	3,11	3,50	3,80	4,25	4,55	4,75	5,05	5,00	5,30	3,50	3,80
1/6/2025	3,11	3,50	3,80	4,25	4,55	4,75	5,05	5,00	5,30	3,50	3,80
1/5/2025	3,11	3,50	3,80	4,25	4,55	4,75	5,05	5,00	5,30	3,50	3,80
1/4/2025	3,11	3,50	3,80	4,25	4,55	4,75	5,05	5,00	5,30	3,50	3,80
1/3/2025	3,11	3,50	3,80	4,25	4,55	4,75	5,05	5,00	5,30	3,50	3,80
1/2/2025	3,11	3,50	3,80	4,25	4,55	4,75	5,05	5,00	5,30	3,50	3,80
1/1/2025	3,11	3,50	3,80	4,25	4,55	4,75	5,05	5,00	5,30	3,50	3,80
1/12/2024	3,11	3,50	3,80	4,25	4,55	4,75	5,05	5,00	5,30	3,50	3,80
1/11/2024	3,11	3,50	3,80	4,25	4,55	4,75	5,05	5,00	5,30	3,50	3,80

Kaynak: TCMB

Farklı Senaryolarda Kredi Kartı Faiz Uygulamaları

Kredi kartı kullanıcılarının ödeme davranışlarına göre farklı faiz senaryoları ortaya çıkmaktadır (Ayla, Dilek, Pilatin, 2020).

Tablo 2 Kredi kartı faiz uygulamaları

Senaryo 1	Borcun tamamının ödenmesi	Faiz uygulanmaz.
Senaryo 2	Sadece asgari tutarın ödenmesi	Kalan tutara sadece akdi faiz uygulanır.
Senaryo 3	Sadece asgari tutarın bir kısmının ödenmesi	Ödenmeyen asgari kısma gecikme faizi, kalan bakiye için akdi faiz uygulanır.
Senaryo 4	Hiç ödeme yapılmaması	Asgari tutara gecikme faizi ve tüm tutara akdi faiz uygulanır.

Kredi kartı ödemelerinde gecikme yaşanması durumunda bu durum, kredi kayıt büroları tarafından kredi notuna "geç ödeme" olarak yansıtılmaktadır (Findeks, 2023). Tekrar eden gecikmeler, tüketicinin kredibilitesini düşürmekte ve ileride banka kredilerine erişimi zorlaştırmaktadır (Yüksel, Özsarı, 2017). Bu yönüyle faiz türlerinin sadece mali sonuçları değil, aynı zamanda tüketicinin finansal itibarı üzerindeki etkileri de bulunmaktadır.

Farklı Senaryoların Örneklerle Açıklanması

Aşağıdaki örnekler hesap kesim tarihi ile son ödeme tarihinin arasında 10 gün, son ödeme tarihi ile bir sonraki hesap kesim tarihinin arasında 20 gün olduğu durumlar için oluşturulmuş olup tarih aralıkları hesaplanırken, gerçek gün aralıkları dikkate alınmıştır.

İncelenen örneklerde kullanıcının kart limitinii 100.000 TL olduğu varsayımına dayanılarak TCMB 2025 Haziran ayı verilerine göre azami akdi faiz ve gecikme faiz oranları uygulanmıştır. Bu doğrultuda hesaplamalar asgari ödeme oranının %40 olduğu duruma göre yapılmıştır. TCMB azami oranı olan faiz oranları uygulanmış olup akdi faiz oranı: %4,25 Gecikme Faiz Oranı: %4,55 olarak dikkate alınmıştır.

Örnek 1: Kredi kartı Limitinden 10.000 TL tutarında kullanım olduğu ve son ödeme tarihinde 4.000 TL asgari tutarın tamamının ödendiği durumda örnek faiz hesaplaması aşağıdaki yer alan Tablo.3 'te yer almaktadır:

Tablo.3 Kredi Kartı Kullanıcısının Sadece Asgari Tutarı Ödemesi Örneği

Kullanım Tutarı	Asgari Ödeme Tutar Oranı	Asgari Ödeme Tutarı	Ödeme Tutarı	Toplam Ödenmeyen Tutar	Asgari Ödeme Tutarının Ödenmeyen Kısmı	Akdi Faiz Oranı	Gecikme Faiz Oranı	Akdi Faiz Tutarı*	Gecikme Faiz Tutarı	Akdi Faiz Tutarı**	Toplam Faiz Tutarı
10.000 TL	%40	4.000 TL	4.000 TL	6.000 TL	Asgari tutarın tamamı ödendi.	%4,25	%4,55	85 TL	Uygulanmadı.	170 TL	255 TL

Örnek 1'de müşteri asgari tutarın tamamını ödediği için asgari tutara gecikme faizi uygulanmaz. Hesap kesim tarihinden bir sonraki hesap kesim tarihine kadar kalan bakiye olan 6.000 TL'ye akdi faiz işler. Örnekteki verilere göre ödenmeyen tutara hesap kesim tarihi ile son ödeme tarihi arasındaki 10 günlük süreç için 85 TL akdi faiz hesaplanmaktadır. Ayrıca

ödenmeyen tutara son ödeme tarihinden bir sonraki hesap kesim tarihine kadar olan 20 günlük süreç için de 170 TL akdi faiz tahakkuk edecektir.
Verilere dayanarak müşterinin dönem sonunda toplam ödemesi gereken faiz tutarı 255 TL olacaktır.

Örnek 2: Kredi Kartı Limitinden 10.000 TL tutarında kullanım olduğu ve son ödeme tarihinde 4.000 TL asgari tutarın yarısı olan 2.000 TL'nin ödendiği durumda örnek faiz hesaplaması Tablo 4'te yer almaktadır.

Tablo 4. Kredi kartı kullanıcısının asgari tutarın bir kısmını ödemesi örneği

Kullanım Tutarı	Asgari Ödeme Tutar Oranı	Asgari Ödeme Tutarı	Ödeme Tutarı	Toplam Ödenmeyen Tutar	Asgari Ödeme Tutarının Ödenmeyen Kısmı	Akdi Faiz Oranı	Gecikme Faiz Oranı	Akdi Faiz Tutarı*	Gecikme Faiz Tutarı	Akdi Faiz Tutarı**	Toplam Faiz Tutarı
10.000 TL	%40	4.000 TL	2.000 TL	8.000 TL	2.000 TL	%4,25	%4,55	113,33TL	60,67 TL	170 TL	344 TL

Örnek 2'de müşteri 4000 TL olarak hesaplanan asgari tutarın sadece yarısını ödediği için asgari tutardan kalan 2000 TL'lik kısım için gecikme faizi uygulanacaktır. Ödenmeyen toplam tutar olan 8000 TL üzerinden hesap kesim tarihinden son ödeme tarihine kadar 113,33 TL akdi faiz tahakkuk ettirilecektir. Asgari ödeme tutarın ödenmeyen kısmına son ödeme tarihinden bir sonraki hesap kesim tarihine kadar olan 20 günlük süreç için 60,67 TL gecikme faizi tahakkuk edecektir. Ayrıca gecikme faizi uygulanan tutar dışında kalan 6.000 TL için son ödeme tarihinde bir sonraki hesap kesim tarihine kadar 170 TL akdi faizi tahakkuk ettirilecektir. Faiz toplamları incelendiğinde ikinci örnekte ödenecek toplam faiz 344 TL olacaktır.

Örnek 3: Müşteri 4000 TL olarak hesaplanan asgari dahil olmak üzere hiç ödeme yapmamıştır.

Tablo 5. Kredi kartı kullanıcısının asgari tutar dahil hiç ödeme yapmaması örneği

Kullanım Tutarı	Asgari Ödeme Tutar Oranı	Asgari Ödeme Tutarı	Ödeme Tutarı	Toplam Ödenmeyen Tutar	Asgari Ödeme Tutarının Ödenmeyen Kısmı	Akdi Faiz Oranı	Gecikme Faiz Oranı	Akdi Faiz Tutarı*	Gecikme Faiz Tutarı	Akdi Faiz Tutarı**	Toplam Faiz Tutarı
10.000 TL	%40	4.000 TL	0 TL	10.000 TL	4.000 TL	%4,25	%4,55	141,67 TL	121,33 TL	170 TL	433 TL

Toplam borcun ödenmeyen kısmı için hesap kesim tarihinden son ödeme tarihine kadar akdi faiz, son ödeme tarihinden itibaren asgari tutarın ödenmeyen kısmı için gecikme faizi, kalan hesap bakiyesinin asgari tutarı aşan ödenmeyen kısmı için ise akdi faizi uygulanmıştır.
Asgari tutar olan 4000 TL'lik kısım için son ödeme tarihinden bir sonraki hesap kesim tarihine kadar olan 20 günlük süre için 121,33 TL gecikme faizi tahakkuk ettirilmiştir. Kalan tutar olan 6000 TL için ise son ödeme tarihinden bir sonraki hesap kesim tarihine kadar olan 20 günlük süre için 170 TL akdi akdi faiz uygulanmıştır. Ödenmeyen tutara hesap kesim tarihinden son ödeme tarihine kadar olan 10 gün için ise toplam ödenmeyen tutar olan 10.000 TL üzerinden 141,67 TL akdi faiz yansıtılmış olup toplamda 433 TL faiz ödemesi tahakkuk ettirilmiştir.

SONUÇ

Bu çalışma, kredi kartı kullanıcılarının ödeme davranışlarına göre farklı faiz türlerinin nasıl devreye girdiğini ve bu durumun bireysel finansal denge ile kredi notu üzerindeki etkilerini ortaya koymuştur. Akdi faiz ve gecikme faizi kavramları, genellikle tüketiciler tarafından yeterince anlaşılmamakta ve ödeme stratejileri bu farklar dikkate alınmadan şekillenmektedir. Oysa her iki faiz türü hem hukuki hem de mali sonuçlar doğuran kritik unsurlar olup, borcun büyüme hızını ve tüketicinin finansal güvenilirliğini doğrudan etkilemektedir. Araştırmada ele alınan senaryolar, küçük miktardaki ödeme gecikmelerinin bile zamanla yüksek faiz yüküne ve kredi notunda olumsuz yansımalarla sonuçlanabilecek düşüşlere yol açabileceğini göstermiştir. Bu durum, tüketicilerin ödeme planlamalarını sadece asgari tutar

üzerinden değil, toplam borcun kapatılmasına odaklı yapmalarının gerekliliğini ortaya koymaktadır. Aynı zamanda, bankaların kredi kartı kullanıcılarını faiz türleri konusunda daha şeffaf biçimde bilgilendirmeleri, finansal okuryazarlığın artırılmasına katkı sağlayacaktır. Sonuç olarak, kredi kartı borçlarının yönetimi yalnızca bireysel bir tercih değil, aynı zamanda sistematik bir mali disiplin gerektirir. Akdi ve gecikme faizi oranlarının düzenli olarak güncellenmesi ve bu güncellemelerin açık biçimde duyurulması, tüketicinin bilinçli tercihler yapabilmesi açısından önem taşımaktadır. Bu bağlamda tüketicilerin, yalnızca borcun miktarına değil, faiz türlerinin işleyişine ve yasal dayanaklarına da hakim olmaları, sürdürülebilir bir kredi kartı kullanımının temel koşuludur.

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TASARRUFLARIN KORUNMASINDA KAMUSAL GÜVENCE: TASARRUF MEVDUATI SİGORTA FONU'NUN STRATEJİK ROLÜ

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ÖZET
Düzenleyici ve denetleyici kuruluşlar, finansal sistemin güven ve istikrar temelinde işlemesini sağlamaktadır. Finansal piyasalarda fon fazlası olan birimlerle fon ihtiyacı olan birimler arasında kaynak aktarımı sağlanırken, yatırımcıların korunması ve finansal piyasalara güvenin oluşturulması finansal sistemin etkinliği için gereklidir. Sistemin önemli aktörlerinden olan bankaların, bireysel müşterilerden mevduat veya katılım fonu adı altında topladığı fonlar sistemin önemli halkalarındandır. Bireysel tasarruf sahiplerin bankacılık sistemine bu fonları emanet etmesi ancak gerekli güvenin sağlanmasıyla mümkündür. Türkiye'de gerçek kişilere ait bankalarda bulunan tasarrufların güvenliğinin sağlanması işlevini üstlenen ve mevduat sahiplerinin haklarını korumak amacıyla oluşturulan kurumsal yapı, 1983 yılında Türkiye Cumhuriyet Merkez Bankası bünyesinde kurulan Tasarruf Mevduatı Sigorta Fonu'dur. Tasarruf Mevduatı Sigorta Fonu'nun görev ve yetkilerinin yasal dayanağı 5411 sayılı Bankacılık Kanunu'dur. Kurum; belirli limitler kapsamında tasarruf mevduatının sigortalanması, Bankacılık Düzenleme ve Denetleme Kurumu tarafından verilen kararlar doğrultusunda mali bünyesi zayıflayan veya iflas eden bankalara el koyma, yönetme, tasfiye etme ve devretme yetkileriyle finansal piyasalarda aktif bir rol üstlenmiştir. Türkiye'nin yaşadığı bankacılık krizleriyle birlikte kurumun işlevsel açıdan daha etkin hale getirildiği görülmektedir. Özellikle 1990'lı yıllarda ve sonrasında yaşanan 2001 krizinde çok sayıda bankanın iflas etmesiyle birlikte, bu bankalara el koyulması, tasfiye edilmesi ve bazı bankaların yeniden yapılandırılarak sektöre kazandırılmasında Tasarruf Mevduatı Sigorta Fonu'nun etkisi büyüktür. Kriz dönemlerinde, yalnızca tasarruf sahiplerinin zararları telafi edilmekle kalmamış, aynı zamanda sistemik risklerin yayılması da engellemiştir. Türkiye'nin finansal yapısı içinde yer alan kritik kurum, tasarruf sahiplerinin haklarını koruması ve kriz anlarında güvenlik ağı oluşturması açısından işlevini etkin olarak yerine getirmektedir. Bu çalışmada, güven unsurunun tasarruf mevduatlarına etkisi ve bu durumun yasal zemini incelenmiştir.
Anahtar Kelimeler: Tasarruf mevduatı, bireysel bankacılık, finansal piyasa, finansal istikrar

PUBLIC GUARANTEE IN THE PROTECTION OF SAVINGS: THE STRATEGIC ROLE OF THE SAVINGS DEPOSIT INSURANCE FUND

ABSTRACT
Regulatory and supervisory institutions ensure that the financial system operates on the basis of trust and stability. While transferring funds from surplus units to deficit units in financial markets, protecting investors and fostering trust in the financial system are essential for the system's effectiveness. One of the critical components of the system is banks, which collect funds from individual customers in the form of deposits or participation accounts. The willingness of individual savers to entrust their funds to the banking system is only possible when sufficient confidence is established. In Türkiye, the institutional body responsible for securing the savings of natural persons held in banks and for protecting the rights of deposit holders is the Savings Deposit Insurance Fund, established in 1983 under the Central Bank of

the Republic of Türkiye. The legal basis for the duties and powers of the Savings Deposit Insurance Fund is set out in the Banking Law No. 5411. Within the limits defined by law, the institution insures savings deposits and plays an active role in financial markets by taking over, managing, liquidating, or transferring banks whose financial structure has weakened or that have gone bankrupt, based on decisions made by the Banking Regulation and Supervision Agency. Following Türkiye's banking crises, the institution has become more functionally effective. Especially during the 1990s and the 2001 crisis, when numerous banks collapsed, the Savings Deposit Insurance Fund played a significant role in seizing, liquidating, and in some cases restructuring and reintegrating these banks into the sector. During times of crisis, not only were the losses of depositors compensated, but systemic risks were also mitigated. As a critical institution within Türkiye's financial architecture, the Savings Deposit Insurance Fund has effectively fulfilled its role in protecting savers' rights and acting as a safety net during periods of instability. This study examines the impact of trust on savings deposits and analyzes the legal framework that supports this mechanism.
Keywords: Savings deposits, retail banking, financial market, financial stability

GİRİŞ

Finansal sistemin sağlıklı işlemesi, yalnızca ekonomik faaliyetlerin devamlılığı açısından değil, aynı zamanda toplumsal güven duygusunun tesisi bakımından da büyük önem taşımaktadır. Özellikle bireysel tasarrufların bankacılık sistemine yönlendirilmesi, ekonomik kalkınmanın ve finansal sürdürülebilirliğin temel taşlarından biridir. Ancak bireylerin birikimlerini yasal haklarının korunduğunu bilerek bankalara emanet edebilmesi, bu sistemin şeffaflık, güven ve denetim esaslarına dayanmasıyla mümkün olmaktadır. Finansal piyasalarda geçmişte yaşanan krizler, mevduat sahiplerinin zarar görmesine neden olmuş, bu da sistemin genel güvenilirliğini sorgulanır hâle getirmiştir. Bu tür dönemlerde finansal kurumlara duyulan güvenin azalması, sermaye kaçışı, banka iflasları ve sistemik risklerin artması gibi olumsuz sonuçlar doğurmuştur. Bu bağlamda, tasarrufların korunmasına yönelik kamusal güvencelerin önemi daha da belirginleşmiştir. Türkiye'de bu ihtiyaca karşılık gelen kurumsal yapı, 1983 yılında Türkiye Cumhuriyet Merkez Bankası bünyesinde kurulan ve sonrasında bağımsız bir yapıya kavuşan Tasarruf Mevduatı Sigorta Fonu (TMSF)'dur. Fonun temel görevi; mevduat sahiplerinin belirli sınırlar dâhilinde korunmasını sağlamak ve mali yapısı bozulan bankaların tasfiye süreçlerini yöneterek sistemik riski en aza indirmektir. TMSF'nin varlığı, yalnızca bireylerin haklarını korumakla kalmayıp, aynı zamanda finansal sistemin bütünlüğünü de gözeten bir güvenlik ağı işlevi görmektedir. Bu çalışmanın amacı, bireylerin bankacılık sistemine duyduğu güvenin tesisi sürecinde kamusal güvencelerin özellikle de TMSF'nin üstlendiği stratejik rolü analiz etmektir. Çalışmada, Türkiye'nin yaşadığı finansal kriz dönemleri incelenerek TMSF'nin müdahaleleri değerlendirilmekte ve mevduat sigorta sisteminin finansal istikrar üzerindeki etkileri tartışılmaktadır. Aynı zamanda, bireysel tasarrufların korunması konusunda kamu müdahalesinin yasal ve yapısal boyutları da ele alınacaktır.

ARAŞTIRMA VE BULGULAR

Çalışma hazırlanırken yöntem olarak literatür incelemesi ve nitel analiz benimsenmiştir.

Tasarruf Mevduatı Sigorta Fonu'nun Kurumsal Gelişimi

Tasarruf Mevduatı Sigorta Fonu (TMSF), 1983 yılında Türkiye Cumhuriyet Merkez Bankası bünyesinde kurularak, başlangıçta sınırlı bir mevduat güvencesi sağlama işleviyle görev yapmaya başlamıştır. 1994 krizi sonrası sistemin zayıflıkları ortaya çıkmış ve TMSF'nin işlevsel yapısı yeniden düzenlenmiştir (Görgülü, Gökçen 2025). 2001 yılına gelindiğinde, yaşanan finansal kriz ile birlikte birçok bankanın iflası sonucu TMSF, finansal sistem içerisinde

çok daha aktif ve kapsamlı bir aktör hâline gelmiştir (Akyol, 2018). 2003 yılında çıkarılan 5020 sayılı Kanun ile Fon, özerk bir tüzel kişilik kazanarak Bankacılık Düzenleme ve Denetleme Kurumu (BDDK) ile eşgüdüm halinde çalışmaya başlamıştır. TMSF'nin kamu kurumu olarak özerk faaliyetlerini yerine getirebilmesi için hukuki yetkileri ise 2005 tarihli 5411 sayılı Bankacılık Kanunu ile sistematik biçimde tanımlanmıştır (Resmî Gazete, 2005).

Şekil 1 TMSF görev ve amaçları

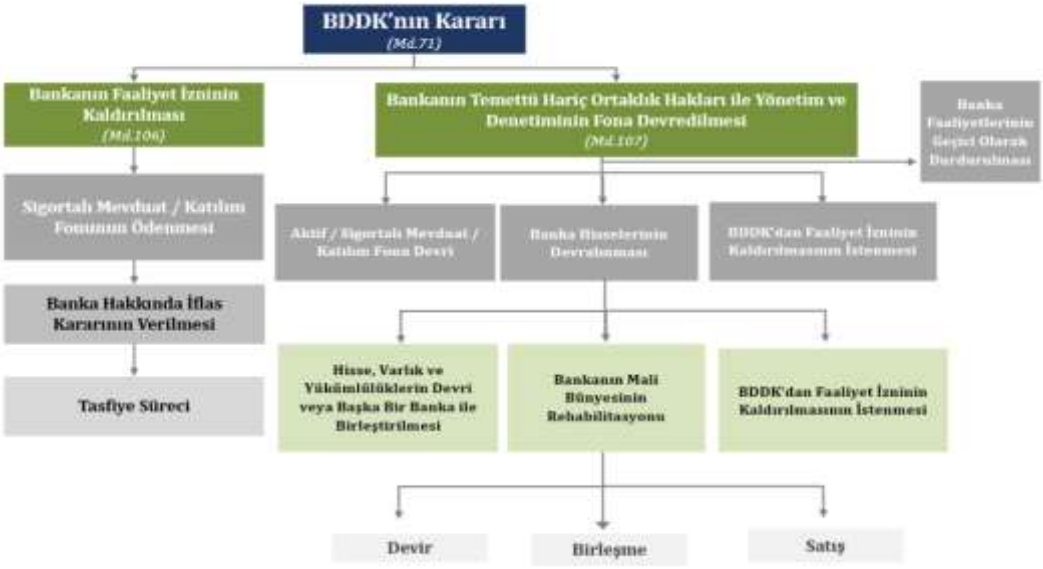


Kaynak: TMSF

Resmi kuruluşlar, kredi kuruluşları ve finansal kuruluşlara ait olanlar dışında kalan, gerçek kişilere ait, Türk Lirası, döviz ve kıymetli maden cinsinden mevduatlar veya fonlar, her bir mevduat ya da katılım bankasında her bir kişi için, 2025 yılında 950 Bin TL'ye kadar sigorta kapsamındadır. Bu tutar tekrardan, her takvim yılı başından geçerli olacak şekilde güncellenmektedir. Tasarruf mevduatları için yapılan bu sigorta dahilinde yapılacak ödemeler, katılım bankası veya mevduat bankasının faaliyet izninin kaldırılması halinde Türk lirası olarak yapılmaktadır. Sigorta dahilinde ödenecek tutar değerlendirilirken mevduat hesaplarının anapara ve faiz reeskontları toplamı da dikkate alınmaktadır. Döviz ve altın cinsinden mevduat veya katılım hesaplarının Türk lirası karşılıkları, bankanın faaliyet izninin kaldırıldığı tarihte mevcut olan Merkez Bankası Döviz Alış Kurları ve İstanbul Altın Borsası seans kapanış fiyatı (altın cinsinden hesaplar için) dikkate alınarak belirlenmektedir. Kıyı bankacılığı (off-shore) işlemleri sigorta kapsamında değerlendirilmemektedir (Türkiye İş Bankası, 2025)

TMSF'nin kriz dönemlerinde önemi giderek artan yetkilerinden biri banka çözümleme ve geri kazanım süreçlerini yürütmesidir. Bankacılık Kanunu'nun 71'inci maddesi hükümleri çerçevesinde Bankacılık Düzenleme ve Denetleme Kurulu (BDDK), sorunlu bir bankanın faaliyet iznini kaldırabilmekte veya bankanın temettü hariç ortaklık hakları ile yönetim ve denetimini Fona devredebilmektedir.

Şekil 2 Banka Çözümleme veya Tasfiye Süreci



Kaynak : TMSF

Faaliyet izni kaldırılarak ve iflas tasfiyesi yöntemiyle çözümlenen bankalar fona devredildiği yıl itibariyle TYT Bank (1994), Marmara Bank (1994), İmpexbank (1994), Kıbrıs Kredi Bankası (2000), İmar Bankası (2003) Bank Asya (2016) olarak sıralanmıştır (TMSF, 2025).

Doğrudan satışı yapılarak çözümlenen bankalar fona devredildiği yıllarla birlikte TÜRK Ticaret Bankası (1997), Bank Ekspres (1998), Demirbank (2000), Sitebank (2001) ve Tarişbank (2001)'tır.

Birleştirildikten Sonra Satılan Bankaları incelendiğinde; Egebank, Yurtbank ve Yaşarbank'ın 1999 yılında fona devredildiği, 2000 yılında Bank Kapital ve 2001 yılında Ulusal Bank'ın da fona devredilmesinden sonra bu bankalar tüm aktif ve pasifleriyle Sümerbank çatışı altında birleştirilmiştir. Birleşme neticesinde Oyak Grubu, Sümerbank'ı devralmış ve bankanın unvanı 2008 yılında ING Bank A.Ş. olmuştur.

Başka bir bankaya devredilerek çözümlenen bankalara bakıldığında Pamukbank karşımıza çıkmaktadır. 2002'de fona devredilen bankanın 2004 yılında Halk Bankası'na devri gerçekleşmiştir.

Birleştirilerek çözümlenen bankalar incelendiğinde fona devredilme yılları itibariyle İnterbank (1999), Esbank (1999), Etibank (2000), İktisat Bankası (2001), Kentbank (2001), EGS Bank (2001) ve Toprakbank (2001) olup Birleşik Fon Bankası (Bayındırbank) çatısı altında toplanmışlardır. Birleşik Fon Bankası (Bayındırbank) 2001 yılı itibariyle halen TMSF bünyesinde yer almaktadır.

Kriz Dönemlerinde TMSF Müdahaleleri ve Sistemik Etkileri

Türkiye'de 1994 ve 2001 yıllarında yaşanan krizlerinde birçok banka iflas etmiş, tasarruf sahipleri ciddi zararlar görmüştür. 1997–2002 yılları arasında TMSF, toplam 25 bankaya el koymuş ve bunların büyük kısmını tasfiye ederek, kalan birkaçını ise yeniden yapılandırarak sektöre kazandırmıştır (Fedai, 2019). Bu süreçte, krizin sistematik etkilerini azaltmak ve kamuoyunun sisteme duyduğu güvenin devamlılığı için mevduat sigorta limitleri artırılmış, geçici olarak tam mevduat güvencesi sistemi uygulanmıştır (BDDK, 2004). TMSF'nin yürüttüğü bu operasyonlar yalnızca bireysel hakların korunmasını değil, aynı zamanda sistemik riskin yayılmasının önlenmesini hedeflemiştir. 2001 yılında yaşanan krizde, toplam mevduatların %40'ından fazlası TMSF kapsamında güvence altına alınmıştır (TMSF, 2002).

Tasarruf Mevduatı Sigorta Fonu'nun kuruluşundan bu yana geçirdiği yapısal dönüşümler, hem yasal altyapı açısından hem de operasyonel etkinlik bakımından önemlidir. Özellikle 2001

krizinden sonra TMSF'nin sadece mevduat sigortacısı değil, aynı zamanda aktif bir kriz yöneticisi rolü üstlenmesi, Türkiye finansal sisteminde kurumsal kapasitenin geliştiğini göstermektedir (Orhan, Dinçer, Çelik 2009). Ayrıca, TMSF bünyesinde oluşturulan varlık yönetim birimleri, el konulan bankalardaki sorunlu varlıkların profesyonel şekilde yönetilmesine katkı sağlamıştır.

SONUÇ

Bu dönemde uygulanan geçici tam mevduat güvencesi, güvenin hızla tesisi açısından kritik bir politika aracı olmuştur. Fon, yalnızca bankalara el koymakla kalmamış, aynı zamanda yeniden yapılandırma, satış ve birleşme gibi yöntemlerle finansal sisteme yeniden kazandırma işlevini de yerine getirmiştir. Ayrıca, bu dönemde TMSF'nin denetim, değerleme ve varlık yönetimi gibi operasyonel süreçlerinde ciddi iyileştirmeler yapıldığı gözlemlenmiştir.

Finansal sistemin sürdürülebilirliği için güven unsurunun tesis edilmesi, bireysel yatırımcıların sisteme olan katılımını teşvik eden temel faktörlerden biridir. Türkiye örneğinde, finansal krizler sırasında yaşanan olumsuzluklara karşın kamu müdahalesi ile oluşturulan güvenlik ağları, sistemik çöküşlerin önlenmesinde kilit rol oynamıştır.

Tasarruf Mevduatı Sigorta Fonu'nun kriz dönemlerinde üstlendiği görevler, yalnızca mevduat sahiplerinin haklarının korunması açısından değil, aynı zamanda finansal sistemin geneline yayılabilecek dalga etkilerin sınırlanması bakımından da oldukça değerlidir. Fonun hukuki ve kurumsal çerçevesi, zaman içinde yaşanan deneyimlerle güçlendirilmiş, fonun fonksiyonelliği artırılmıştır.

Ancak uzun vadeli bir istikrar ortamı için yalnızca sigorta mekanizmaları yeterli değildir. Şeffaflık, bağımsız denetim ve hesap verebilirlik ilkeleriyle desteklenen bir mevduat güvencesi sistemi, halkın tasarruflarını finansal sistemde tutma eğilimini artıracaktır. Bu doğrultuda, TMSF'nin teknolojik altyapısının geliştirilmesi, politika şeffaflığına öncelik verilmesi ve bağımsızlığının güçlendirilmesi gibi stratejik adımlar atılması gerekmektedir.

Sonuç olarak, TMSF örneği, kamusal güvencenin bireysel tasarruflar üzerindeki olumlu etkisini açık biçimde ortaya koymakta ve kriz dönemlerinde güven temelli müdahalenin gerekliliğini desteklemektedir.

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KEVLAR 29 KUMAŞLA KAPLANMIŞ BOR KARBÜR SERAMİK VÜCUT ZIRHININ BALİSTİK PERFORMANSININ SONLU ELEMANLARLA İNCELENMESİ

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ÖZET
Silah ve mermi sanayisi geliştikçe zırh sistemleri de aynı doğrultuda ilerleme kaydetmiştir. Vücut zırhı, sahadaki personeli ölümcül kurşunlardan ve vücudun çeşitli kısımlarını yaralanmalarından korur. Kullanılan zırhın hafif olması, personelin hareket olanağını ve güvenliğini olumlu yönde etkilemektedir. İmalat maliyetlerinin artışıyla birlikte, üretimden önce ürünlerin tasarımı, analizi ve simülasyonları önemli hale gelmiştir.
Bu kapsamda, bu çalışmada kompozit kumaşlar ve seramik malzeme kullanılarak hibrit kompozit-seramik zırh tasarımı yapılmış ve modellemesi yapılan zırhların balistik performansları sonlu elemanları yöntemiyle incelenmiştir. Bor karbür (B_4C), modellenen zırhlarda seramik malzeme olarak tercih edilmiştir. Zırh modellerinin yapısında kullanılan seramik malzemenin balistik performansını yükseltmek için aramid kökenli, örgülü yapıdaki epoksi takviyeli kevlar 29 kumaş, bor karbürün ön ve arka yüzeyinde kullanılmıştır. Tek yönlü ultra yüksek moleküler ağırlıklı polietilen kumaş (UHMWPE), zırh model yapısında destek plaka olarak kullanılmış ve zırh modelleri Ansys paket programının Acp-pre kısmında yapılmıştır. Kalınlıkları farklı, katmanlı 5 zırh modellenmiş ve zırhların balistik koruma performansları, sonlu elemanlar metoduna göre çalışan Ansys programının Explicit Dynamic bölümünde incelenmiştir. Analizlerde, 7.62 x 51 mm AP mermi çekirdeği kullanılmıştır. Ulusal Adalet Enstitüsünün (National Institute of Justice) yayınladığı NIJ-SV-01.01.06 standardı referans alınarak çarpışma analizlerinde mermi çekirdeği hızı 960 m/s olarak belirlenmiştir. İncelemeler neticesinde zırh yapısındaki seramik malzemenin kevlar kumaşlarla kaplanması, malzeme üzerindeki hasarlanmayı azaltmış, diğer yandan seramik malzeme ve destek plaka ultra yüksek moleküler ağırlıklı polietilen kumaş arasında kevlar kumaşın varlığı destek plakaya doğrudan darbe ve enerjiyi iletmemiş bununla birlikte polietilen kumaşın balistik performansı artmış bu sayede polietilen kumaş, zırh üzerinde oluşan deformasyon ve toplam enerjiyi düşürmüştür. Ölümlü yaralanmalara olanak veren arka yüz deforme limitlerinin altında deformasyonlar değerleri elde edilmiştir.
Anahtar Kelimeler: Bor karbür, Balistik koruma, Kompozit kumaş

FINITE ELEMENT INVESTIGATION OF THE BALLISTIC PERFORMANCE OF BORON CARBIDE CERAMIC BODY ARMOR COVERED WITH KEVLAR 29 FABRIC

ABSTRACT

As the arms and ammunition industry has developed, armor systems have also advanced in the same direction. Body armor protects personnel in the field from lethal bullets and injuries to various parts of the body. The lightness of the armor used has a positive effect on the mobility and safety of personnel. With the increase in production costs, the design, analysis, and simulation of pre-production products have gained importance.

In this context, a hybrid composite-ceramic armor design was created using composite fabrics and ceramic materials, and the ballistic performance of the modeled armor was examined using the finite element method. Boron carbide (B4C) was chosen as the ceramic material for the modeled armor. To enhance the ballistic performance of the ceramic material used in the armor models, aramid-based woven epoxy-reinforced Kevlar 29 woven fabric was used on the front and back surfaces of the boron carbide. A unidirectional ultra-high molecular weight polyethylene (UHMWPE) fabric was used as the support plate in the armor model structure, and the armor models were created in the Acp-pre section of the Ansys software package. Five armor models with different thicknesses were designed, and their ballistic protection performance was analyzed in the Explicit Dynamic section of the Ansys program, which operates based on the finite element method. In the analyses, 7.62 x 51 mm AP bullet core was used. According to the NIJ-SV-01.01.06 standard published by the National Institute of Justice (NIJ), the bullet core velocity was set to 960 m/s in the impact analyses. The results of the studies showed that covering the ceramic material in the armor structure with Kevlar fabric reduced the damage inflicted on the material. On the other hand, the presence of Kevlar fabric between the ceramic material and the support plate blocked the direct impact and energy transfer to the support plate, thereby enhancing the ballistic performance of the polyethylene fabric. As a result, the polyethylene fabric reduced deformation and total energy on the armor. Deformation values were obtained below the limits that could cause fatal injuries on the rear surface.

Keywords: Boron carbide, Ballistic protection, Composite fabric

GİRİŞ

Küresel çapta bölgesel çatışmaların artışıyla birlikte, savunma amaçlı kullanılan zırhların önemi giderek artmıştır. Savaş alanında kullanılan zırhlar, patlayıcılar ve mühimmat atışlarından dolayı oluşabilecek yaralanmaların ve kullanılan ekipmanların maddi hasarlarını azaltma amacıyla kullanılır (Moss et al., n.d.). Eski Japon zırhları ipekten, Yunan zırhları deriden ve Orta çağ Avrupa zırhları metalden yapılırdı. Ancak silah teknolojisinin gelişmesiyle birlikte, geleneksel malzemelerden yapılan zırhların balistik koruma seviyeleri azalmıştır. Bu nedenle, zırhlar sürekli olarak geliştirilmekte ve modern silah tehditlerine karşı daha etkili koruma sağlamak için yeni malzemeler ve tasarımlar kullanılmaktadır(Işık et al., 2013). Kompozit malzeme teknolojisinin gelişimiyle birlikte yüksek dayanıma sahip ve hafiflik bakımında etkili performans gösteren aramid ve karbon kumaşların, zırhlarda kullanımı artmıştır (Eken, 2017). Kompozit kumaşlara göre daha düşük alansal yoğunluğa, kopma değerine sahip olan ultra yüksek moleküler ağırlıklı polietilen (UHMWPE) kumaşların da zırh sistemlerinde kullanımı giderek yaygınlaşmaktadır(Alarçin, 2020; Aslantas et al., n.d.; Cavallaro, 2011). Kompozit malzemelerin yanı sıra zırhın balistik direncini artırma maksadıyla seramik malzemelerin de oldukça kullanımı yaygınlaşmıştır. Bor karbür, silisyum karbür ve alümina oksit, zırh kullanımı için tercih edilen başlıca seramik malzemelerdir. Ancak bor

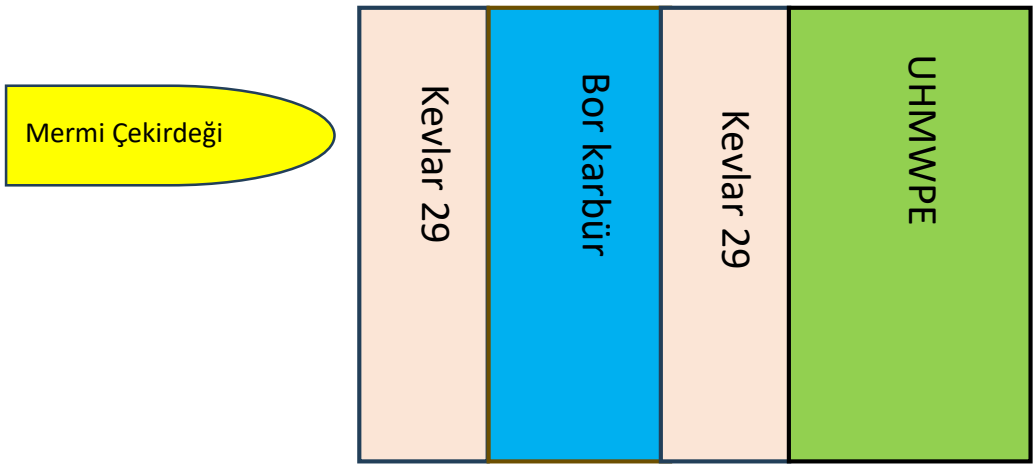
karbürün diğer seramik malzemelerden biraz daha hafif olmasından dolayı ağırlığın önemli olduğu uygulamalarda kullanımı avantajlı hale gelmiştir (Gooch, 2011; Garcia-Avila et al., 2015; Normandia et al., n.d.; Rui et al., 2021; Heim et al., 2023).

Taşdemirci ve arkadaşları, zırh modellerinde kullandıkları ara katmanın zırh bütününde enerjiyi sönümlediğini, seramik katmandaki hasarlanmayı azalttığını değerlendirmişlerdir (Tasdemirci et al., 2012). Bandaru, Ahmed ve Bhatnagar, kevlar, bazalt, ultra yüksek moleküler ağırlıklı polietilen (UHMWPE) kumaşların zırh sistemlerinde kullanımının, yüksek hızda mermi atışlarında zırhta oluşan deformasyonu azalttığını bildirmişlerdir (Bandaru et al., 2017). Hongfei ve diğerleri, ultra yüksek moleküler ağırlıklı polietilen (UHMWPE) ve bor karbürü kombine kullanarak tasarımını gerçekleştirdikleri entegre zırhı farklı mermi hızı ve açısında deneysel ve simülasyon testlerde incelemişlerdir. Test sonuçlarına göre mühimmat çarpma hızının balistik değerleri geçtiğinde kompozit-seramik zırhın hasarlanmasını azalttığını ve açının artmasıyla da hibrit zırhın koruma seviyesinin arttığını sonucuna varmışlardır (Wang et al., 2021). Saleem ve diğerleri, silisyum karbür, epoksi aramid kumaş ve tek yönlü ultra yüksek moleküler ağırlıklı polietilen kumaşla birlikte seramik -kompozit zırh elde etmişlerdir. Deneysel testler ve Ansys programında yaptıkları analizlerin sonucunda 9 mm tabanca mermisine karşı modelledikleri zırhta, merminin birçok katmanda hasar bırakmadığını ve takviyeli ultra yüksek moleküler ağırlıklı polietilen kumaşın aramid kumaşa göre enerjiyi daha çok emdiğini bildirmişlerdir (Saleem et al., 2022). Signetti ve arkadaşları katmanlı zırh sistemleri üzerine çalışmışlardır. Tabakalı kompozit zırh sistemlerindeki dizilim çeşitliliğinin mermideki kırılma dayanımı düşürerek tabakalara teması sonucunda zırh sisteminin tokluk sağladığını ortaya koymuşlardır(Signetti et al., 2022). Guo ve diğerleri, ultra yüksek moleküler ağırlıklı polietilen ve kevlar kumaşları da kullanarak seramik-kompozit zırhı 7,62 mm zırh delici mermiyle teorik ve sayısal yöntemlerle incelemişlerdir. Ön tabakada kayma direnci iyi olan malzemenin çekme-kopma hasarlarında çekme-kopma hasarlanmalarında azaltıcı etkide olduğunu söylemişlerdir (Guo et al., 2022). Lin, Li, Liu ve Fan, köpük, kil ve ultra yüksek moleküler ağırlıklı polietilen kumaş içeren hafif zırhı incelemişlerdir. Polietilen kumaşın temas yüzeyini genişlettiğini ve oluşabilecek arka yüzey deformasyonunu azalttığını belirtmişlerdir (Lin et al., 2023). Lu, Wu ve diğerleri alümina oksit ve ultra yüksek moleküler ağırlıklı polietilen kumaş içeren seramik-kompozit zırh tasarımını nümerik ve teorik olarak inceleyerek, en iyi kalınlıkta kombine malzeme kullanımı sonucu polietilen kumaşın enerji emme kabiliyetinin artacağını ve sistemde üzerinde pozitif etki bırakacağını belirtmişlerdir(Lu et al., 2024) . Küçük ve Çelik, AISI 304 paslanmaz çeliğin arka yüzeyine kevlar kumaş kullanarak balistik performansı üzerine çalışmışlardır, modeldeki malzemelerin balistik koruma düzeyini artırdıklarını bildirmişlerdir(Küçük et al., 2023).

Bu çalışma kapsamında, bor karbür, kevlar 29 ve ultra yüksek moleküler ağırlıklı polietilen kullanarak, tabakalı 5 farklı kompozit-seramik zırh, Ansys paket programının ACP-pre kısmında modellenmiştir. Zırh modellerinin deformasyon ve enerji sonuçları, 7,62 x 51 mm zırh delici merminin çekirdeğiyle 960 m/s hızda sonlu elemanlar yöntemi kullanılarak çarpışma analizi yapılmıştır.

MATERYAL VE METOT

Zırh modellerinde kevlar 29, ultra yüksek moleküler ağırlıklı polietilen (UHMWPE) kompozit kumaş ve seramik malzeme olarak ise bor karbür (B_4C) kullanılmıştır. Zırh modeli boyutları 200 x 200 mm ve model kalınlıkları kullanılan malzemelere göre değişkenlik göstermektedir. Şekil 1'de zırh modelinin şema görünümü verilmiştir.



Şekil 1. Mermi çekirdeği ve zırh modelinin şematik görünümü

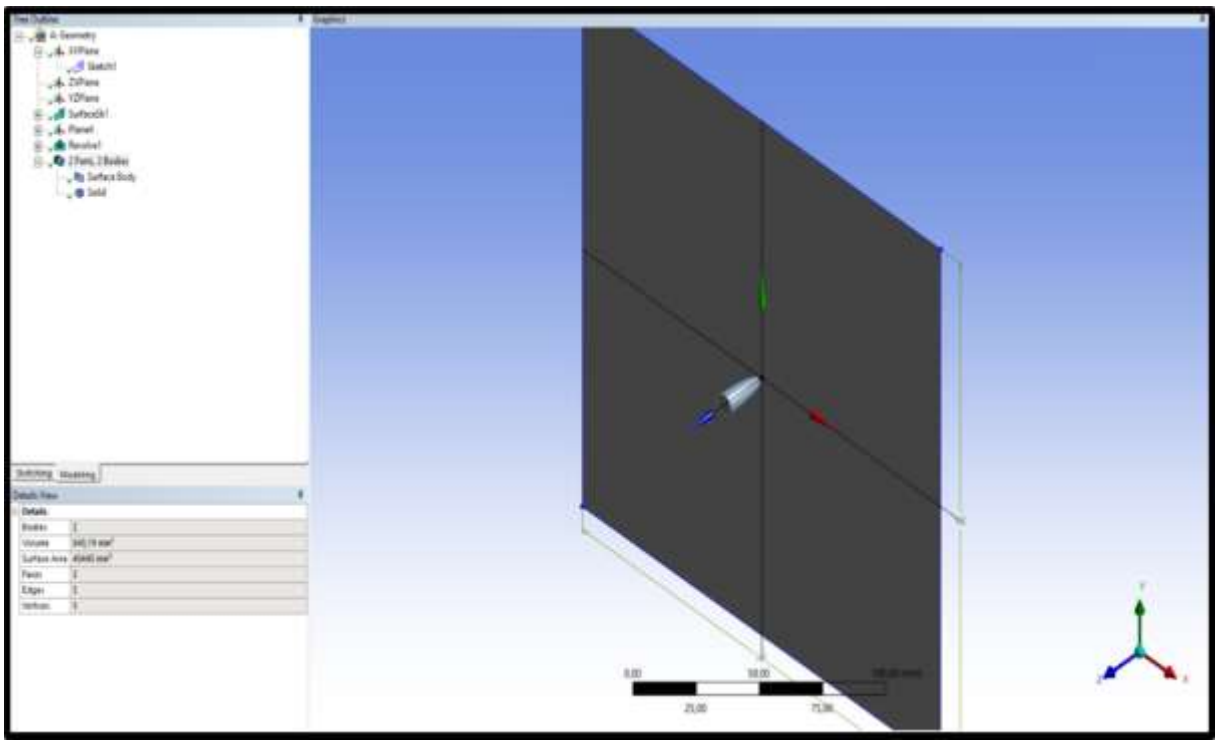
Şekil 1'deki şematik görünümde, zırh genel modelinin ön katman formunu kevlar-bor karbür-kevlar yapısı oluşturmaktadır. Bor karbür seramik malzemenin, ön ve arka yüzeyinde tek bir katman kalınlığı 0,5 mm olan kevlar kumaşla kaplanmış ve 0,3 mm kalınlığa sahip ultra yüksek moleküler ağırlıklı polietilen (UHMWPE) ise tabakalı zırh sisteminde destek plaka olarak kullanımı gerçekleştirilmiştir. Modellerde, bor karbür seramik malzeme kalınlığı kademeli olarak artmış, kevlar ve ultra yüksek moleküler ağırlıklı polietilen malzemenin ise kalınlıkları sabit tutulmuştur. Zırh modellerine malzemeler sırayla eklenmiş ve dört adımda Şekil 1'deki genel zırh modeli elde edilmiştir. Tablo 1'de zırh modellerinin, malzeme içerikleri ve kalınlıkları verilmiştir. Çarpışma analizleri de Tablo 1'de verilen malzeme sırasına göre yapılmıştır. Modellemeler Ansys programının Acp-pre kısmında yapılmıştır.

Tablo 1. Zırh modelleri, malzeme ve kalınlıkları

Model Sırası	**Zırh Modeli**	**Kalınlık**
	2 mm B_4C	2 mm
ZM1	1 mm Kevlar 29 + 2 mm B_4C	3 mm
	1 mm Kevlar 29 + 2 mm B_4C + 1 mm Kevlar 29	4 mm
	1 mm Kevlar 29 + 2 mm B_4C + 1 mm Kevlar 29 + 6 mm UHMWPE	10 mm
	2,5 mm B_4C	2,5 mm
ZM2	1 mm Kevlar 29 + 2,5 mm B_4C	3,5 mm
	1 mm Kevlar 29 + 2,5 mm B_4C + 1 mm Kevlar 29	4.5 mm
	1 mm Kevlar 29 + 2,5 mm B_4C + 1 mm Kevlar 29 + 6 mm UHMWPE	10,5 mm
	3 mm B_4C	3 mm
ZM3	1 mm Kevlar 29 + 3 mm B_4C	4 mm
	1 mm Kevlar 29 + 3 mm B_4C + 1 mm Kevlar 29	5 mm
	1 mm Kevlar 29 + 3 mm B_4C + 1 mm Kevlar 29 + 6 mm UHMWPE	11 mm
	3,5 mm B_4C	3,5 mm
	1 mm Kevlar 29 + 3,5 mm B_4C	4,5 mm

ZM4	1 mm Kevlar 29 + 3,5 mm B_4C + 1 mm Kevlar 29	5,5 mm
	1 mm Kevlar 29 + 3,5 mm B_4C + 1 mm Kevlar 29 + 6 mm UHMWPE	11,5 mm
	4 mm B_4C	4 mm
ZM5	1 mm Kevlar 29 + 4 mm B_4C	5 mm
	1 mm Kevlar 29 + 4 mm B_4C + 1 mm Kevlar 29	6 mm
	1 mm Kevlar 29 + 4 mm B_4C + 1 mm Kevlar 29 + 6 mm UHMWPE	12 mm

Mermi geometrisi, 7.62 x 51 mm zırh delici mermi çekirdeğidir. Mermi malzemesi olarak Rc62 çeliği atanmıştır. Çarpışma analizlerinde, NIJ-STD-01.01.06 standardı örnek alınarak mermi hızı 960 m/s alınmıştır. Şekil 2'de zırh modeli ve mermi geometrisinin görünümü verilmiştir. Zırh model geometrisinin kalınlıkları Ansys Acp-pre bölümünde eklenmiş, katmanlar belirlenmiştir. Modellerin katman görünümü Şekil 3'te gösterilmiştir. Zırh yapısında kullanılan malzemelerin parametreleri Ansys malzeme kütüphane veri tabanına manuel olarak girilmiştir.



Şekil 2. Zırh ve mermi çekirdeği geometrisi

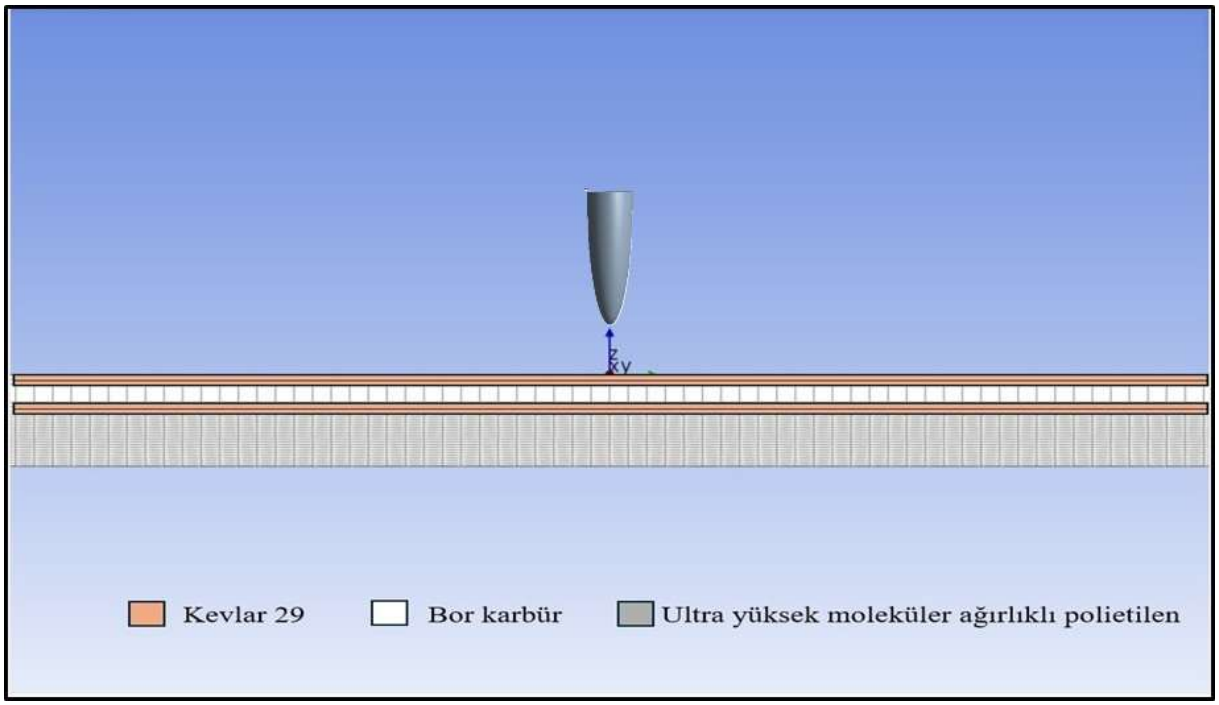
Tasarımlarda kullanılan ve doğrudan literatür çalışmalarında alınan, kevlar 29 ve ultra yüksek moleküler ağırlıklı polietilen kumaşın Tablo 2'de ve Tablo 3'te de bor karbür seramiğinin ve mermi çekirdeği geometrisinin malzeme değerleri verilmiştir.

Tablo 2. Ultra yüksek moleküler ağırlıklı polietilen ve Kevlar 29 kumaşın mekanik malzeme değerleri (Guo et al., 2022; Jiang et al., 2022).

Malzeme Değerleri	Ultra Yüksek Moleküler Ağırlıklı Polietilen	Kevlar 29/ Epoksi
Yoğunluk (kg/m³)	970	1259
Elastisite Modülü (X, Y, Z) GPa	144,2;2,87:2,87	20,5;20,5;6,0
Poisson Oranı (XY, YX, XZ)	0,1;0,1;0,4	0,21;0,33;0,33
Kayma Modülü (XY, YZ, XZ) GPa	4,5;4;1,225	0,77;2,71;2,71
Çekme (X, Y, Z) GPa	4;0,7;07	0,685;0,685;12,0
Basma (X, Y, Z) GPa	4;0,7;0,7	0,685;0,685;12,0

Tablo 3. Bor karbür seramik ve mermi geometri malzemelerinin değerleri (Guo et al., 2022; Jiang et al., 2022)

MALZEME	YOĞUNLUK	YOUNG MODÜLÜ	POISSON ORANI
Bor karbür (B_4C)	2,510 g/cm^3	442 GPa	0,16
Mermi Geometri	7800 kg/m³	210 GPa	0,29

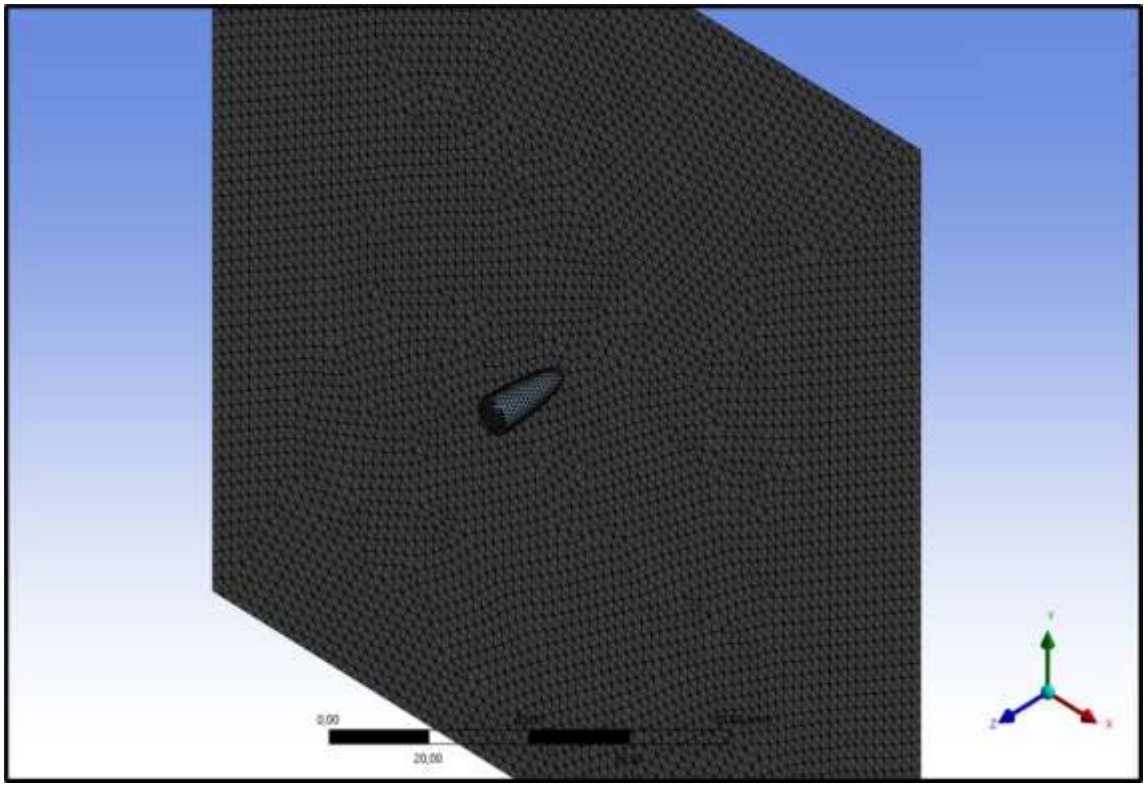


Şekil 3. Ansys Acp-pre kısmında katmanları belirlenen zırh modelinin görüntüsü

SONLU ELEMANLAR ANALİZİ

Zırhların modellemesinin akabinde sonlu elemanlara bölme metodu uygulanmıştır. Bu kapsamda her bir zırh modeli ortalama 421 bin ağ eleman yapısına bölünmüştür. Şekil 4'te ağ eleman yapısı görüntüsü verilmiştir. Ansys Explicit Dynamic bölümü kullanılarak çarpışma analizleri gerçekleştirilmiştir. Analizlere, ilk olarak modellerde kullanılan seramik malzemeler incelenmiş olup akabinde seramik malzemenin önüne kevlar kumaş eklenmiş daha sonra seramik malzemenin arkasına kevlar malzeme eklenmiştir. Son olarak destek plaka ultra

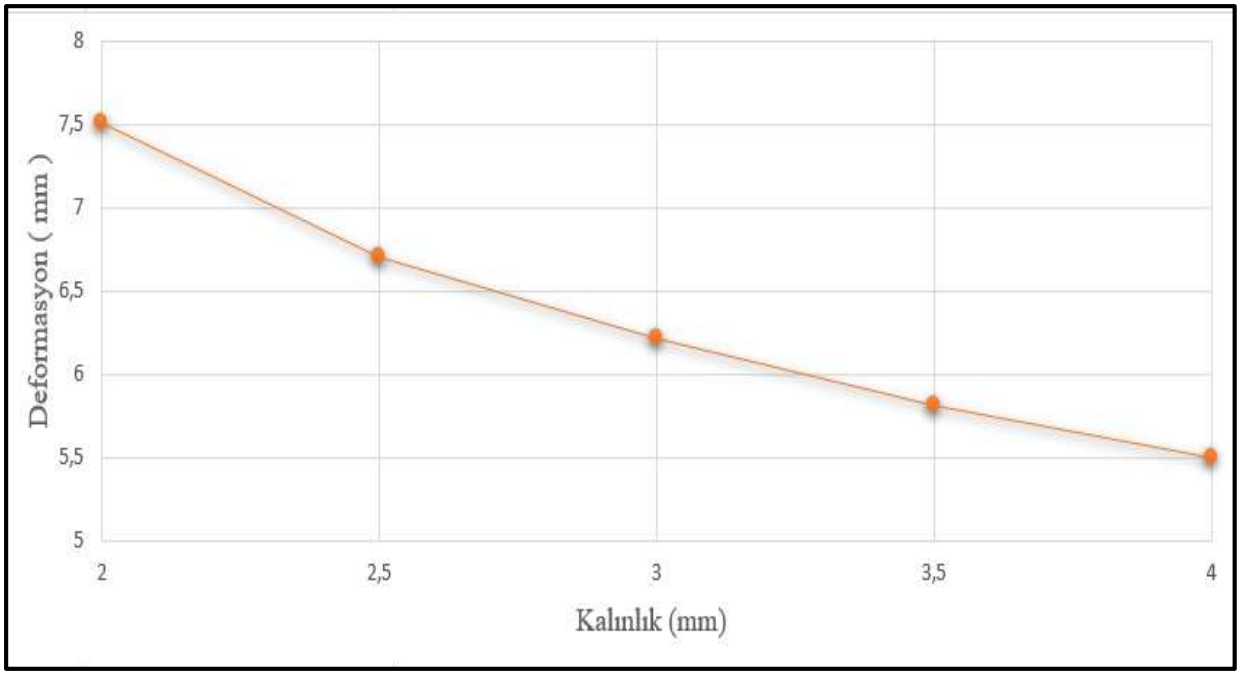
yüksek moleküler ağırlıklı polietilen kumaş dahil edilerek Şekil 1'de verilen genel zırh modelinin çarpışma analizleri incelenmiştir. Zırh modelinin her bir tarafı ankastre olacak şekilde ayarlanmıştır. Mermi çekirdeği, zırh modeline dik bir açıda 960 m/s hızda çarptırılmıştır. İncelemesi gerçekleştirilen bütün analizler aynı şartlarda yapılmıştır.



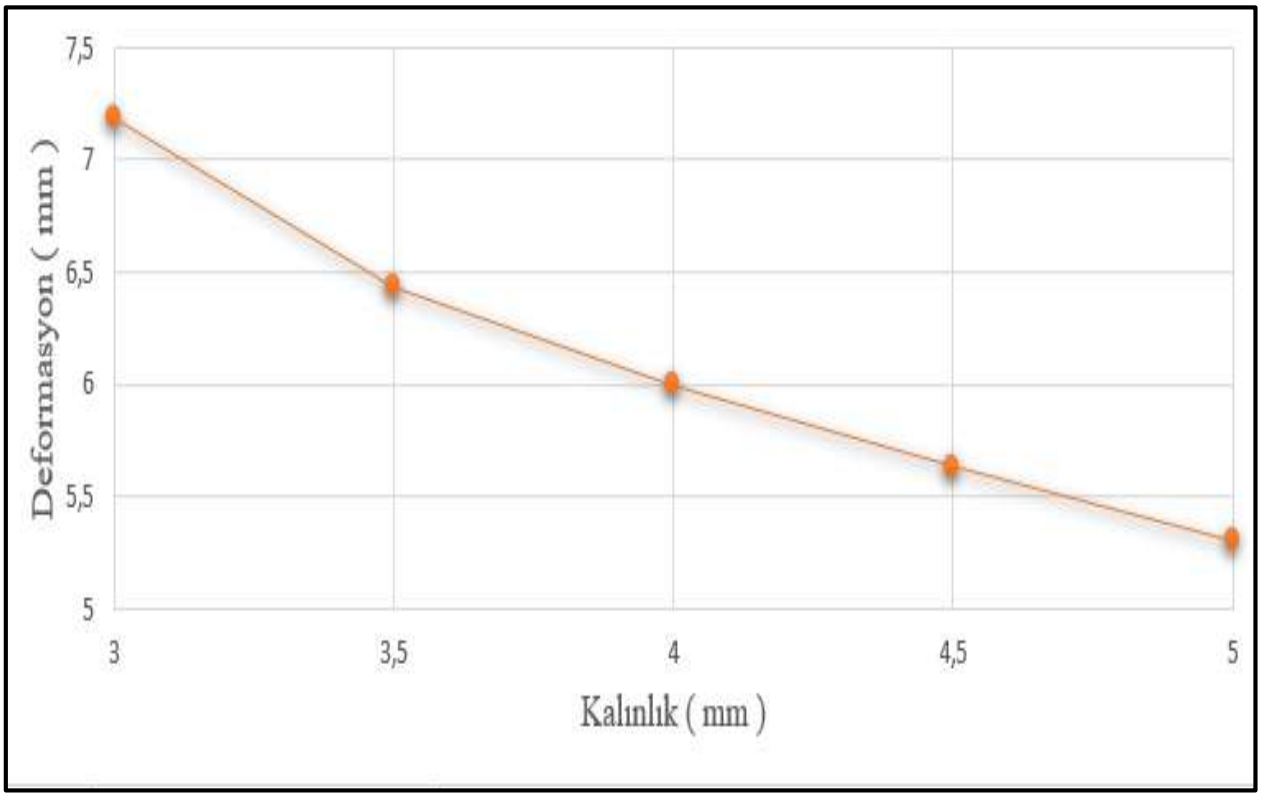
Şekil 4. Zırh modeli ağ eleman yapısı

SONUÇLAR VE TARTIŞMA

Zırh modellerinde kullanılan bor karbür seramik malzemenin analizleri neticesinde deformasyon sonuçları Şekil 5'teki grafikte verilmiştir. Grafik incelendiğinde, seramik malzemenin kalınlığı 2 mm'den 4 mm'ye çıktığında, kalınlık artışıyla birlikte malzemenin yapısal direnci artırmış, mermi çekirdeğinden gelen darbeyi geniş alana yayarak etkileşim süresini uzamış buna bağlı olarak deformasyon miktarları düşmüştür. Seramik malzemenin önüne kevlar eklendiğinde, kevlar kumaşın örgülü yapısından dolayı çarpma anında mermi üzerinde sürtünme kuvvetini artırarak mermi hızını bir miktar azaltmış, seramik malzemedeki hasarlanmayı bir miktar düşürmüştür. Şekil 6 'daki deformasyon grafiğinde verilmiştir.



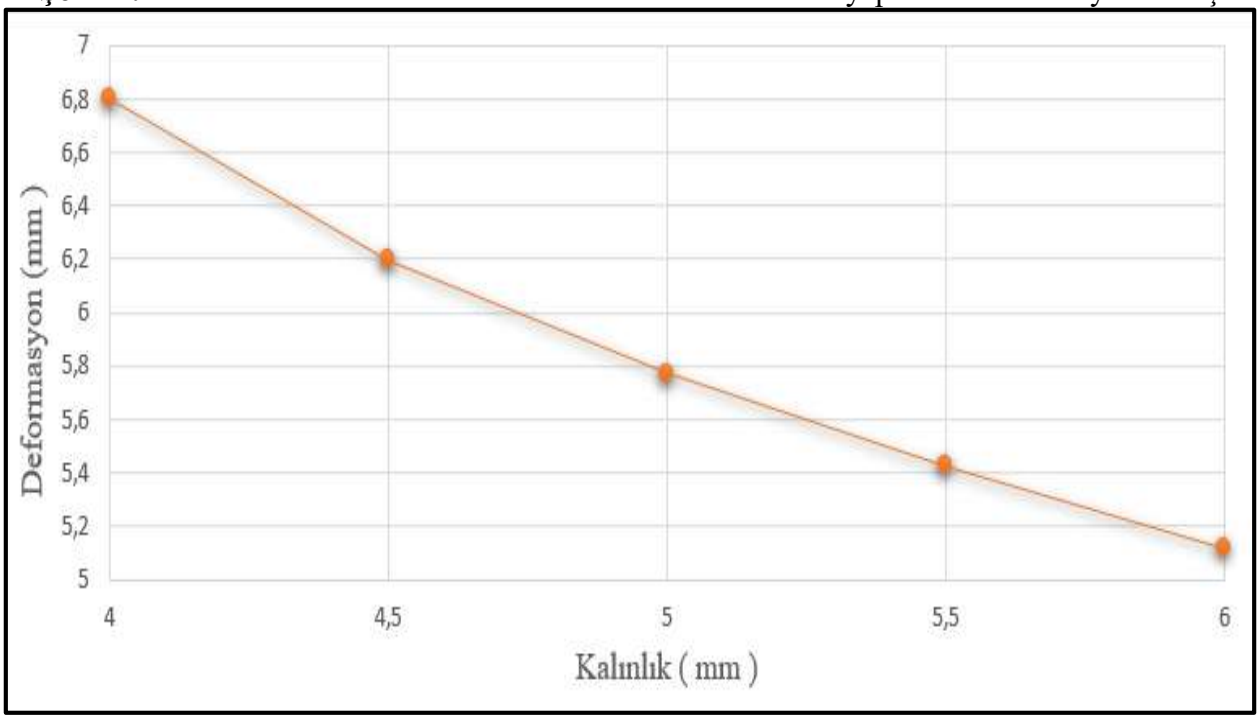
Şekil 5. Zırh modellerinde kullanılan saf bor karbür seramik malzemelerin deformasyon grafiği



Şekil 6. Zırh modelleri yapısındaki kevlar-seramik birlikte kullanımının deformasyon grafiği

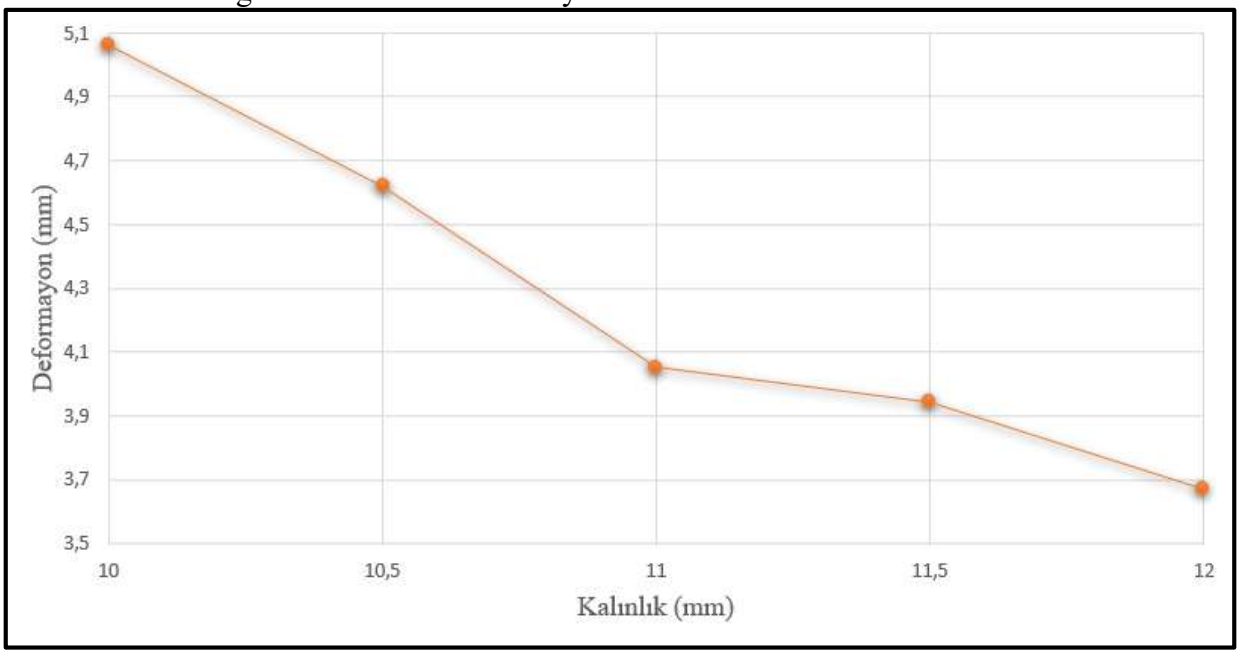
Kevlar- seramik- kevlar yapısının çarpışma analizi sonrası deformasyon sonuçları Şekil 7'deki grafikte verilmiştir. Grafik irdelendiğinde, bor karbür seramiğinin arka yüzeyinde de aramid kökenli kevlar kumaş kullanımı zırh üzerindeki deformasyona azaltıcı yönde etki etmiştir.

Şekil 7. Zırh modellerindeki kevlar-bor karbür seramik-kevlar yapısının deformasyon sonuç

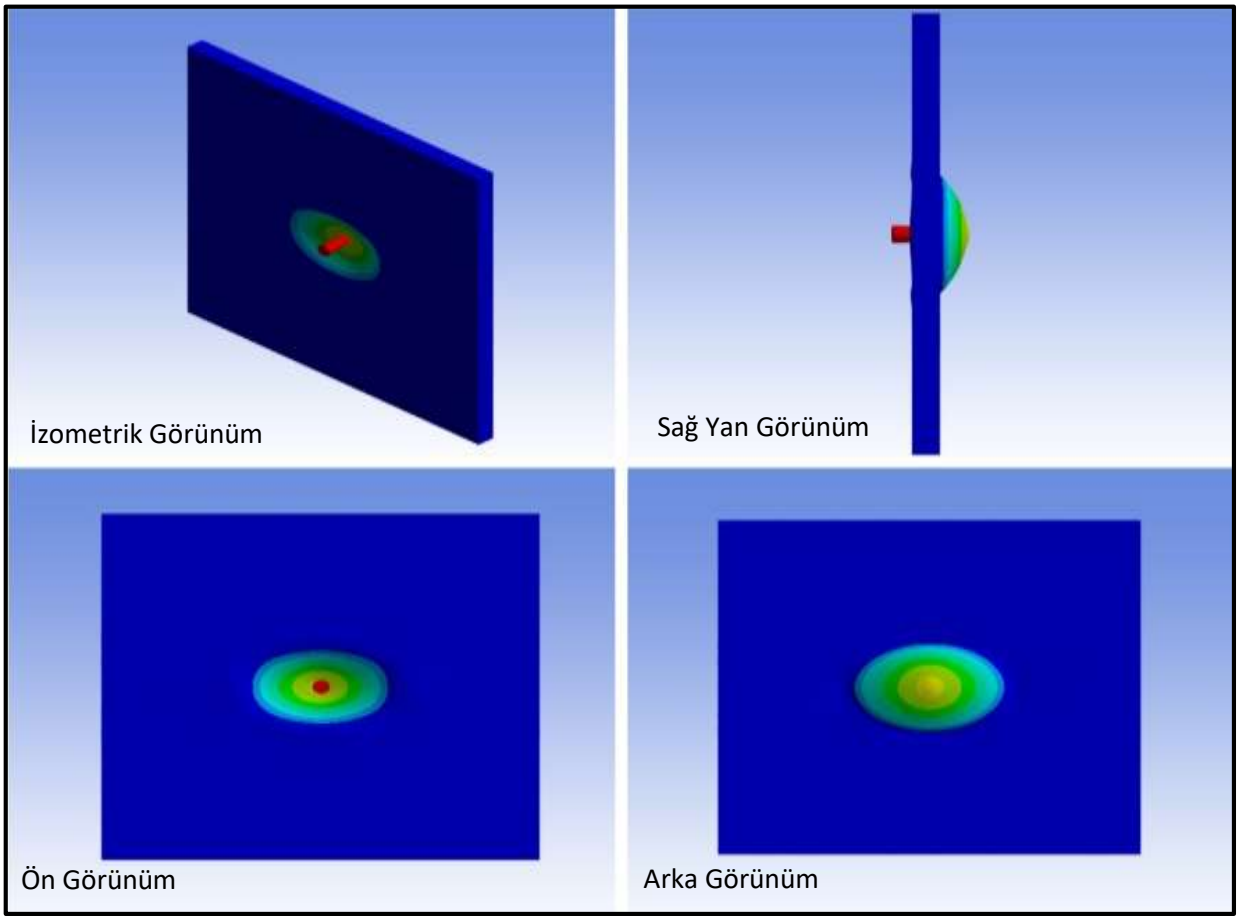


grafiği

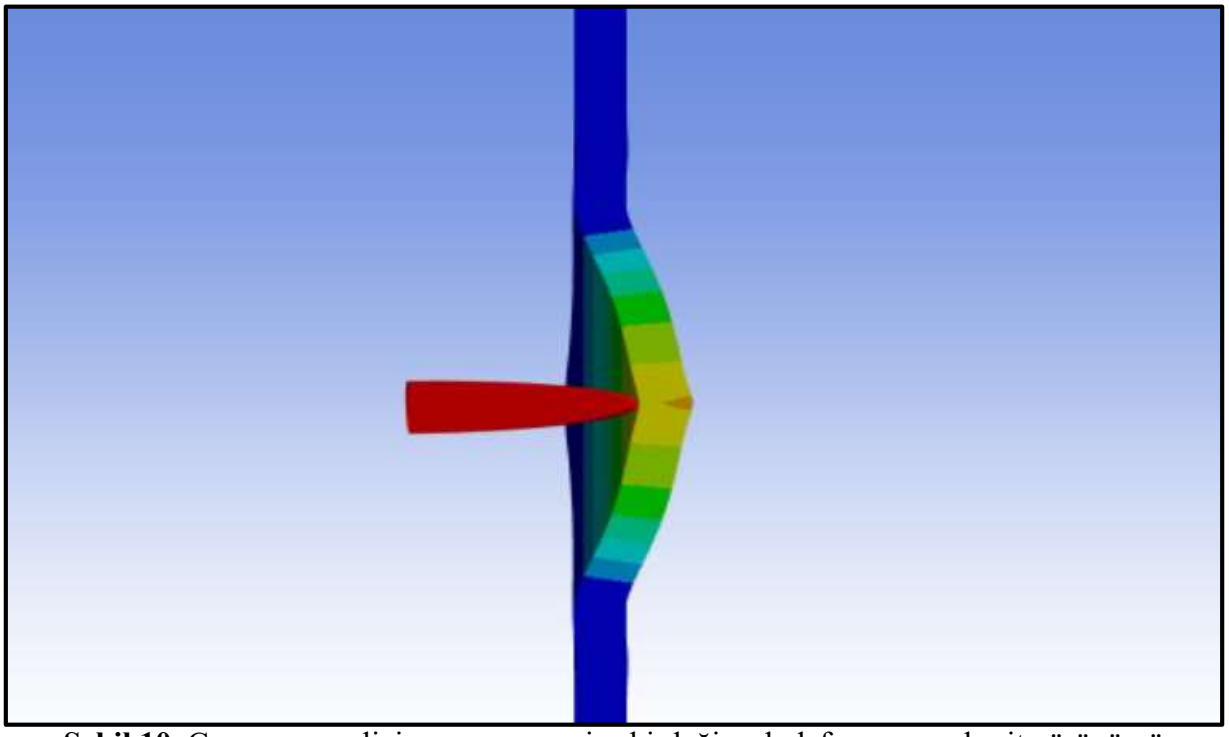
Genel zırh modellerinin deformasyon sonuçları Şekil 8'de verilmiştir. Şekil 1'de verilmiş şematik gösterimde ön katman yapısına (kevlar -bor karbür-kevlar) destek plaka ultra yüksek moleküler ağırlıklı polietilen (UHMWPE) kumaş eklendiğinde ise polietilen kumaş temas yüzeyini artırarak zırh modelindeki deformasyonu bir miktar daha azalmıştır. Çarpışma analizlerinden sonra mermi-zırh deformasyon görüntüleri Şekil 9'da, Şekil 10'da ise analiz sonrası mermi çekirdeği-zırh kesit görünümü verilmiştir. Mermi, zırhı tamamen delmemiştir. Bu durum bütün genel zırh modellerinde aynıdır.



Şekil 8. Genel zırh modellerinin, kevlar-bor karbür seramik-kevlar-ultra yüksek moleküler ağırlıklı polietilen birlikte kullanımın deformasyon grafiği

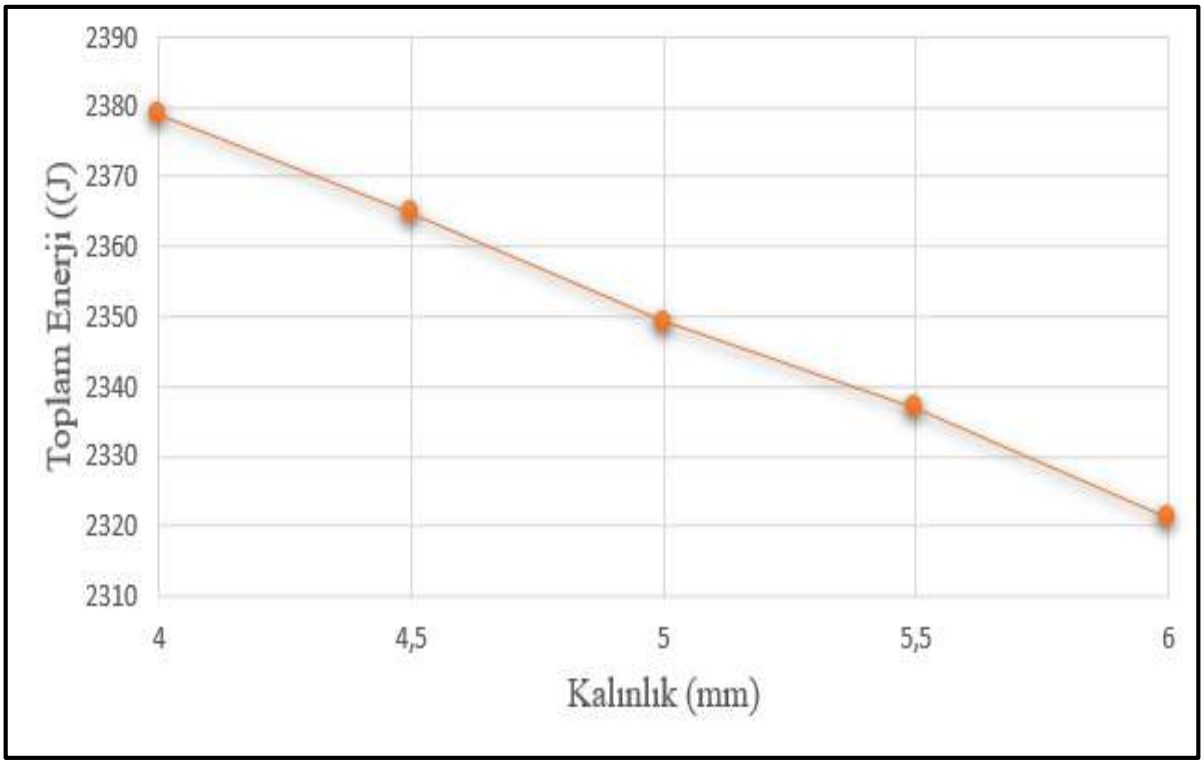


Şekil 9. Analiz sonrası mermi çekirdeği ve zırhın çeşitli açılardan deformasyon görüntüleri

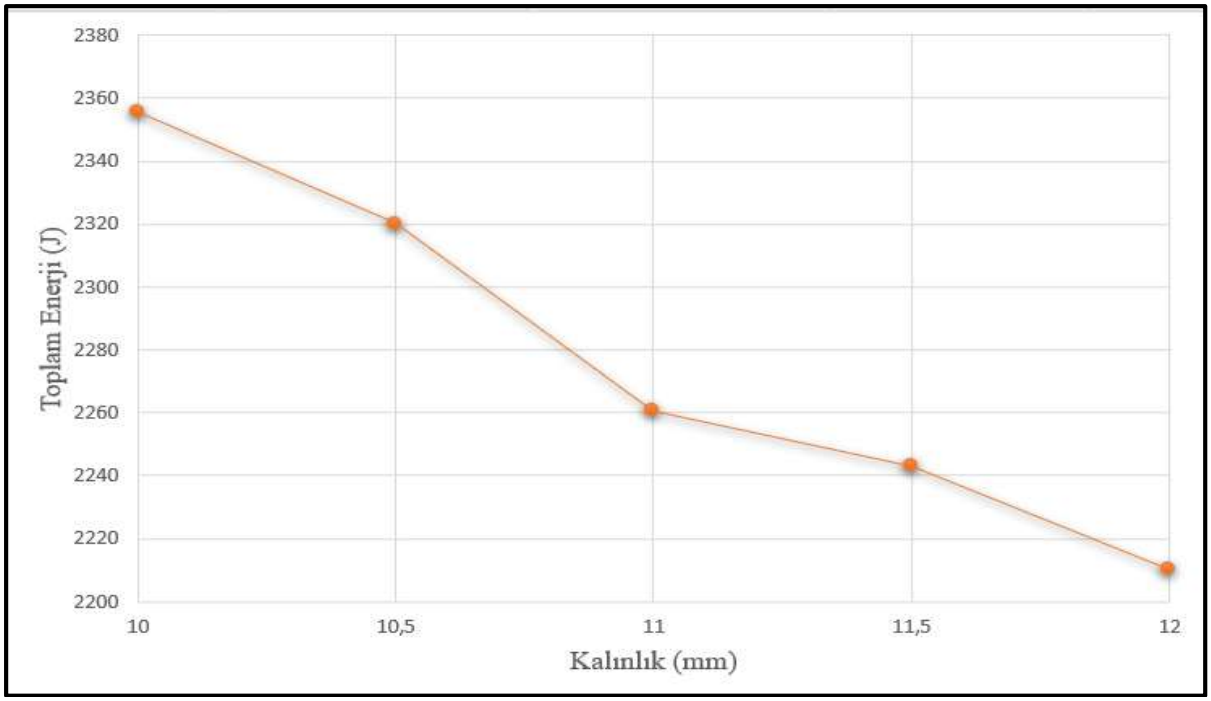


Şekil 10. Çarpışma analizi sonrası mermi çekirdeği-zırh deformasyon kesit görünümü

Zırh modelindeki toplam enerji, seramik malzemenin kalınlık miktarı arttıkça çatlakların ara yüzeyinin oluşumunda harcanan şok enerjisi azalmış ve yine kalınlık doğrultusunda seramik malzemenin enerji sönümleme performansı artmış bu duruma bağlı olarak enerji miktarı azalmıştır. Zırh modelinde kullanılan kompozit kumaşlar enerjinin azalmasında önemli rol oynamıştır. Zırh modelinin ön katmanı yani kevlar-seramik-kevlar yapısından açığa çıkan toplam enerji miktarları Şekil 11'deki grafikte verilmiştir. Seramik malzemenin arka yüzeyinde de kullanılan kevlar kumaş, ultra yüksek moleküler ağırlıklı polietilen destek plakanın enerji sönümleme kabiliyetini artırmıştır. Şekil 12'de, modele ultra yüksek moleküler ağırlıklı polietilen kumaş eklendiğinde analizler neticesinde açığa çıkan enerji sonuçları verilmiştir. Grafiklere bakıldığı zaman, destek plaka ultra yüksek moleküler ağırlıklı polietilen kumaş, ön katman yapısından (kevlar-bor karbür-kevlar) açığa çıkan toplam enerjiden sırasıyla 23.2 J, 44.8 J, 88.5 J, 93.8 J ve 111.3 J enerji sönümlemesi yapmıştır.



Şekil 11. Zırh modellerinin kevlar-bor karbür-kevlar yapısından açığa çıkan toplam enerji grafiği



Şekil 12. Kevlar- bor karbür-kevlar-ultra yüksek moleküler ağırlıklı polietilen zırh modellerinin çarpışma analizi sonrası açığa çıkan toplam enerji veri grafiği

SONUÇ

Bu çalışmada çok katmanlı kompozit-seramik zırh modellenmiş ve 960 m/s hızda çarpışma analizi yapılmıştır. İncelemelere önce zırh yapısındaki seramik malzemelerin analizden başlanmış. Sonra sırasıyla kevlar-seramik, kevlar-seramik-kevlar ve son olarak destek plaka olarak kullanılan ultra yüksek moleküler ağırlıklı polietilen kumaş eklenerek analizler tamamlanmıştır.

Bu neticede seramik malzemenin kalınlığı arttıkça zırh üzerindeki deformasyon miktarı azalmış, kevlar kumaşların bor karbür seramik malzemenin önünde ve arka yüzeyinde kullanımı, seramik malzeme üzerinde deformasyon miktarını azaltıcı yönde etki etmiştir. Polietilen destek plaka, zırhta temas yüzeyini artırarak deformasyonu azaltıcı yönde etkilemiştir. Zırh üzerindeki toplam enerji, kevlar ve polietilen kumaşın malzeme özelliği sayesinde, seramik malzemenin kalınlık artışı doğrultusunda azalmıştır. Ulusal Adalet Enstitüsü (National Institute of Justice, NIJ) NIJ-SV-01.01.06 standardında ölümcül yaralanmaya yol açan zırh arka yüz deformasyon miktarını 44 milimetre olarak yayınlamıştır (Department of Justice et al., n.d.). Modellemesi yapılan ve çarpışma analizi gerçekleştirilen zırh modellerinin hiçbiri bu değeri geçmemiştir.

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ARAŞTIRMA YÖNTEMLERİNDE ÖRNEKLEM SEÇİMİ: NİCEL VE NİTEL YAKLAŞIMLARIN FARKI

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Özet
Toplumsal olguları anlama, açıklama ve yorumlama sürecinde araştırma yöntemleri, sosyal bilimlerin gelişimiyle birlikte nicel ve nitel olmak üzere iki temel paradigma etrafında biçimlenmiştir. Nicel yaklaşım, doğa bilimlerinden miras aldığı pozitivist gelenek doğrultusunda, ölçülebilir veriler aracılığıyla genellenebilir sonuçlara ulaşmayı hedeflerken; nitel yaklaşım, daha çok yorumlayıcı ve keşif odaklı bir perspektif benimseyerek bireylerin yaşantılarını, anlam dünyalarını ve bağlamsal etkileşimlerini derinlemesine incelemeye odaklanmaktadır. Bu iki yaklaşım yalnızca kullandıkları veri toplama araçları ve analiz teknikleri açısından değil, aynı zamanda bilgiye ve gerçekliğe ilişkin dayandıkları ontolojik ve epistemolojik kabuller açısından da birbirinden ayrılmaktadır. Derleme niteliği taşıyan bu çalışma, nicel ve nitel araştırma yaklaşımlarının örneklem seçimi ve örneklem büyüklüğüne ilişkin farklılıklarını incelemeyi amaçlamaktadır. Bu bağlamda, nicel araştırmalarda yaygın olarak tercih edilen, olasılık teorisine dayalı tesadüfi örnekleme teknikleri ile nitel araştırmalarda sıklıkla kullanılan, belirli amaçlara yönelik geliştirilen amaçlı örnekleme stratejileri karşılaştırmalı olarak ele alınmıştır. Ayrıca her iki yöntemde örneklem büyüklüğünün nasıl belirlendiği, bu kararlarda etkili olan yöntemsel gerekçeler ve araştırma sorusuyla kurulan ilişki detaylı bir biçimde analiz edilmiştir. Bu tartışma, araştırmacıların yöntemsel seçimlerini daha bilinçli bir şekilde yapabilmelerine katkı sağlamayı hedeflemektedir.
Anahtar Kelimeler: Örnekleme, Örneklem büyüklüğü, Nicel, Nitel.

SAMPLE SELECTION IN RESEARCH METHODS: THE DIFFERENCE BETWEEN QUANTITATIVE AND QUALITATIVE APPROACHES

Abstract
In the process of understanding, explaining and interpreting social phenomena, research methods have been shaped around two basic paradigms, quantitative and qualitative, with the development of social sciences. While the quantitative approach aims to reach generalizable results through measurable data in line with the positivist tradition inherited from the natural sciences, the qualitative approach adopts a more interpretive and exploratory perspective and focuses on examining individuals' experiences, worlds of meaning and contextual interactions in depth. These two approaches differ not only in terms of the data collection tools and analysis techniques they use, but also in the ontological and epistemological assumptions they rely on regarding knowledge and reality. This review study aims to examine the differences between quantitative and qualitative research approaches regarding sample selection and sample size. In this context, random sampling techniques based on probability theory, which are widely preferred in quantitative research, and purposive sampling strategies developed for specific purposes, which are frequently used in qualitative research, are discussed comparatively. In addition, how the sample size is determined in both methods, the methodological justifications for these decisions and the relationship with the research question are analyzed in detail. This discussion aims to contribute to researchers to make more informed methodological choices.
Keywords: Sampling, Sample size, Quantitative, Qualitative.

TÜRKİYE'NİN YEDİ BÖLGESİNDE GASTRONOMİDE YEREL OTLARIN KULLANIMI

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ÖZET

Bu çalışma, Türkiye'nin farklı coğrafi bölgelerinde doğadan toplanan yerel otların ve endemik bitkilerin gastronomideki kullanım biçimlerini incelemeyi amaçlamaktadır. Anadolu'nun zengin florası, farklı iklim ve ekosistemlere sahip olması nedeniyle çok sayıda yenilebilir, tıbbi ve aromatik bitki türüne ev sahipliği yapmaktadır. Çalışmada önce yerel otlar tanımlanmış, ardından bu otlar etnobotanik, tıbbi ve besin değerleri açısından sınıflandırılmıştır. Anadolu'da ot kullanımının tarihsel gelişimi, halk hekimliği ve geleneksel mutfak kültürü içerisindeki rolü kültürel bir perspektifle ele alınmıştır. Yerel otların gastronomideki kullanım alanlarına dair yapılan değerlendirmelerde, geleneksel yemeklerdeki işlevleri, fonksiyonel özellikleri ve vegan-vejetaryen mutfakta taşıdıkları potansiyel ayrıntılı olarak incelenmiştir. Bu çerçevede özellikle madımak, evelik, ısırgan otu, ebegümeci, cibez, arapsaçı, turp otu, labada, sirmo, çiriş otu ve ışkın gibi yöresel otların kullanımına odaklanılmış; bu bitkilerin hem geleneksel tariflerdeki yeri hem de sağlık açısından katkıları ortaya konmuştur. Ayrıca, Türkiye'nin yedi ana bölgesine göre ot tüketim alışkanlıkları, yerel tarifler, pişirme teknikleri ve festivaller bağlamındaki kültürel yansımalar karşılaştırmalı olarak analiz edilmiştir. Yerel otların gastronomideki yeri sadece beslenmeye katkı sunmakla kalmayıp; aynı zamanda kültürel kimliğin korunması, doğal kaynakların sürdürülebilir kullanımı ve kırsal kalkınma açısından da çok boyutlu bir işlev taşımaktadır. Çalışma, yerel bitki çeşitliliğinin mutfak kültürüne yansımasının önemine dikkat çekmekte ve edinilen bilgilerin bilimsel araştırmalarla desteklenmesi gerekliliğini vurgulamaktadır.

Anahtar Kelimeler: Yerel otlar, endemik bitkiler, Geleneksel mutfak, Bölgesel mutfaklar

USE OF LOCAL HERBS IN GASTRONOMY IN SEVEN REGIONS OF TURKEY

ABSTRACT

This study aims to examine the gastronomic use of local herbs and endemic plants collected from nature in different geographical regions of Turkey. The rich flora of Anatolia, due to its different climates and ecosystems, hosts a large number of edible, medicinal and aromatic plant species. In the study, local herbs were first identified, then these herbs were classified in terms of ethnobotanical, medicinal and nutritional values. The historical development of the use of herbs in Anatolia, their role in folk medicine and traditional culinary culture were discussed from a cultural perspective. In the evaluations made on the areas of use of local herbs in gastronomy, their functions in traditional dishes, their functional properties and their potential in vegan-vegetarian cuisine were examined in detail. In this context, the use of local herbs such as madımak, evelik, stinging nettle, ebegümeci, cibez, arapsaçı, radish grass, labada, sirmo, çiriş grass and işkın was focused on; both the place of these plants in traditional recipes and their contributions to health were revealed. In addition, herb consumption habits, local recipes,

cooking techniques and cultural reflections in the context of festivals were comparatively analyzed according to the seven main regions of Turkey. The place of local herbs in gastronomy not only contributes to nutrition; it also has a multidimensional function in terms of preserving cultural identity, sustainable use of natural resources and rural development. The study draws attention to the importance of reflecting local plant diversity in culinary culture and emphasizes the need to support the information obtained with scientific research.
Keywords: Local herbs, Endemic plants, Traditional cuisine, Regional cuisines

GİRİŞ

Yerel ve geleneksel otlar, tarih boyunca doğayla kurulan ilişkinin en canlı yansımalarından biri olarak hem bireysel beslenme alışkanlıklarında hem de kültürel yaşam pratiklerinde önemli bir yer edinmiştir. Türkiye, üç farklı fitocoğrafik bölgenin kesişim noktasında yer alan eşsiz florası sayesinde, doğal yollarla yetişen ve tüketilen yüzlerce farklı yabani ot türünü barındırmaktadır. Bu çeşitlilik, yalnızca biyolojik zenginliği değil, aynı zamanda toplumsal hafızada yer etmiş çok katmanlı bir kültürel mirası da temsil etmektedir (Şenkul & Kaya, 2017). Türkiye'de yerel otlara dair bilgiler uzun yıllar boyunca kırsal kesimlerde sözlü kültür aracılığıyla aktarılmış, bu aktarım süreciyle birlikte otların yemeklerdeki işlevi yalnızca gıda temelli bir ihtiyaç olarak değil, aynı zamanda sağaltıcı ve simgesel bir değer olarak da şekillenmiştir (Inaltong, 2006). Farklı bölgelerde yetişen ve tüketilen otların türleri, kullanım biçimleri, pişirme teknikleri ve kültürel temsilleri birbirinden farklılık göstermektedir. Bu durum, gastronomik çeşitliliğin bölgesel özelliklerle nasıl iç içe geçtiğini ortaya koymaktadır (Doğan vd., 2004). Bu çalışma, Türkiye'deki yerel ve geleneksel otların gastronomi içerisindeki rolünü disiplinlerarası bir bakışla incelemeyi amaçlamaktadır. Çalışmanın birinci bölümünde, yerel otların tanımı, etnobotanik sınıflandırması, yenilebilir, tıbbi ve aromatik özellikleri ile endemik türlerin coğrafi dağılımları detaylı biçimde değerlendirilmiştir. İkinci bölümde, Anadolu'nun farklı dönemlerinde ot kullanımına dair tarihsel süreç irdelenmiş, bu sürecin mutfak kültürü üzerindeki etkileri ve tarifler aracılığıyla aktarılan geleneksel bilgi tartışılmıştır. Üçüncü bölümde ise yerel otların gastronomideki kullanım alanları ele alınmış; geleneksel yemeklerdeki yeri, çorbalar, zeytinyağlılar, fonksiyonel gıdalarla ilişkisi ve vegan–vejetaryen mutfakta taşıdığı potansiyel aktarılmıştır. Dördüncü bölümde Türkiye'nin yedi coğrafi bölgesinde hangi otların öne çıktığı, bunların nasıl hazırlandığı ve hangi yemeklerde kullanıldığı incelenmiş, pazarlar ve festivaller bağlamında ot kültürünün sosyal ve ekonomik boyutları ortaya konmuştur (Akan & Balos, 2023).

Otların gastronomik değerinin yalnızca geleneksel tariflerle sınırlı kalmadığı, aynı zamanda sürdürülebilir mutfak pratiklerinin, kırsal kalkınmanın ve yerel ekonomilerin desteklenmesinde de işlevsel bir unsur hâline geldiği görülmektedir. Bu yönüyle yerel otlar, kültürel kimliğin taşınmasında, doğal kaynakların korunmasında ve gastronomi turizminin çeşitlendirilmesinde stratejik bir öneme sahiptir (Doğan, 2016).

YEREL OTLARIN TANIMI VE SINIFLANDIRILMASI

Doğal çevrenin sunduğu bitki çeşitliliği, insanlık tarihi boyunca hem beslenme alışkanlıklarını hem de kültürel yapıları doğrudan etkilemiştir. Türkiye'nin sahip olduğu biyolojik zenginlik, yerel halkın doğayla olan ilişkisini şekillendirmiş, özellikle doğadan toplanan otların mutfaklarda yer bulmasına zemin hazırlamıştır. Doğal ortamda yetişen, belirli bir bölgeye ait olan ve kuşaktan kuşağa aktarılarak günümüze ulaşan otlar, kültürel kimliğin sürdürülebilirliğinde temel bir rol üstlenmiştir. Bu otlar yalnızca yemeklik malzeme olarak değil, aynı zamanda şifa aracı, geleneksel uygulama unsuru ve toplumsal belleğin taşıyıcısı olarak da değerlendirilmektedir (Faydaoğlu ve Sürücüoğlu, 2011).

Yerel ve geleneksel otlar, belirli bir coğrafyada tanımlanan doğal bitkiler olarak tanınmakta, topluluklar tarafından bilinen adlarla anılmakta ve genellikle bölgenin gastronomi kültürünün

temel yapı taşları arasında yer almaktadır. Türkiye gibi biyoçeşitlilik açısından zengin ülkelerde bu bitkiler, coğrafi özelliklere göre farklı adlarla tanımlanmakta, kullanımları da bölgeden bölgeye değişiklik göstermektedir (Muminjanov ve Karagöz, 2019). Bu yönüyle yerel otların incelenmesi, yalnızca botanik bir analiz değil, aynı zamanda kültürel değerlerin ve geleneksel bilgi birikiminin aktarımı açısından da önem arz etmektedir.

Yerel Otların Tanımı

Yerel ve geleneksel otlar, belirli bir coğrafi bölgede doğal olarak yetişen, o bölge halkı tarafından bilinen, kullanılan ve kültürel hafızada yer edinmiş bitkiler olarak tanımlanır. Bu otlar genellikle doğadan toplanmakta, yüzyıllardır süregelen bilgi aktarımıyla tanınmakta ve çoğunlukla yemek yapımında ya da geleneksel tıpta kullanılmaktadır. Bu bitkilerin doğrudan doğadan toplanması, onları kültürel mirasın bir parçası hâline getirmekte, kullanım biçimleri de geleneksel uygulamaların temel taşı olarak kabul edilmektedir (Dogan, 2016).

Yerel otların geleneksel niteliği, yalnızca doğal kökenlerine değil, aynı zamanda kullanım biçimlerinin halk arasında süreklilik göstermesine dayanmaktadır. Bu bitkiler, çoğu zaman belirli bir yöreyle özdeşleşmekte ve yöre halkı tarafından kendi adlandırmalarıyla tanımlanmaktadır. Dolayısıyla, aynı bitki türü farklı bölgelerde farklı adlarla anılmakta ve farklı tariflerde yer almaktadır (Tuzlacı, 2011). Bu durum, Türkiye gibi çok çeşitli iklim ve topografyaya sahip ülkelerde ot kültürünün zenginliğini ortaya koymaktadır.

Yerel ve geleneksel otların tanımlanmasında yalnızca botanik özellikler değil, halk arasındaki bilinirlik ve kullanılagelme süreci de dikkate alınmaktadır. Bu bitkiler çoğu zaman ilkbahar ve yaz aylarında doğadan toplanmakta, kurutularak ya da taze şekilde tüketilmekte, yemeklerde, salatalarda, turşularda veya otlu peynirlerde kullanılmaktadır. Aynı zamanda bazı türler halk hekimliği uygulamalarında, yara iyileştirme, sindirim düzenleme gibi amaçlarla da değerlendirilmektedir (İnaltong, 2015).

Yerel otların tanımı, sadece bitki bilimi açısından değil, aynı zamanda sosyal ve kültürel anlamda da önem taşımaktadır. Bu tanım, geleneksel bilginin korunmasına, yerel mutfak mirasının yaşatılmasına ve gastronomi turizminin gelişimine katkı sağlayan temel bir çerçeve sunmaktadır.

Etnobotanik Açıdan Türkiye’de Yabani Otlar

Etnobotanik, insan topluluklarının bitkilerle kurduğu ilişkiyi inceleyen bilim dalıdır. Bu disiplin, bitkilerin geleneksel kullanımlarını, halk arasındaki adlandırmalarını, kullanım amaçlarını ve kültürel değerlerini kayıt altına almayı hedefler. Türkiye, sahip olduğu zengin florası ve tarihsel kültür birikimi ile etnobotanik çalışmalar açısından önemli bir araştırma alanı sunar. Anadolu’nun farklı bölgelerinde yapılan saha çalışmaları, halkın doğal ortamda yetişen otları tanıdığını, adlandırdığını, çeşitli biçimlerde kullandığını ve bu bilgiyi kuşaktan kuşağa aktardığını göstermektedir (Dogan vd, 2004).

Etnobotanik açıdan değerlendirildiğinde, Türkiye'de yabani otların mutfak kültüründe kullanımı yalnızca bir beslenme alışkanlığı değil, aynı zamanda kültürel bir ifade biçimidir. Yerel halk, otları çoğu zaman doğrudan doğadan toplayarak yemeklerde ya da şifa amacıyla kullanmakta, bu bilgi ise geleneksel yaşam pratiklerinin ayrılmaz bir parçası olarak korunmaktadır. Erzurum’dan Ege’ye, Karadeniz’den Akdeniz’e uzanan geniş bir coğrafyada bu bitkilere yönelik bilgi ve deneyim, sözlü kültür aracılığıyla günümüze taşınmakta, bazı bölgelerde bu bilgi yazılı kaynaklara da aktarılmaktadır (Bulut, 2005; Çakılcıoğlu vd., 2010).

Yabani otların hangi amaçlarla kullanıldığına ilişkin yapılan etnobotanik araştırmalar, bu bitkilerin besin, ilaç, boya ve baharat gibi çok sayıda alanda değerlendirildiğini göstermektedir. Anadolu'daki halk toplulukları, farklı bitki türlerini mevsimsel olarak toplamakta, bu bitkileri geleneksel tariflerde değerlendirmekte ve bazılarını da kurutarak yıl boyu kullanmaktadır

(Ertuğ, 2003). Otların kullanımına dair bilgiler, yaşlı kuşaklar aracılığıyla genç nesillere aktarılmakta, böylece hem bitki bilgisi hem de kültürel hafıza korunmaktadır.
Türkiye'de yapılan etnobotanik araştırmalar, aynı bitki türünün farklı bölgelerde farklı amaçlarla kullanıldığını da ortaya koymaktadır. Bazı otlar yalnızca yemeklik olarak değerlendirilirken, aynı türler başka bölgelerde tıbbi ya da aromatik amaçlarla da kullanılabilmektedir. Bu durum, hem bölgesel kullanım çeşitliliğini hem de kültürel anlam derinliğini gözler önüne sermektedir. Ayrıca, bazı yerel otların ekonomik değeri de artmakta, yerel pazarlarda ve festivallerde satışa sunulmakta, böylece geleneksel bilgi modern ekonomiyle bütünleşmektedir (Akan ve Balos, 2023)

Tıbbi, Aromatik ve Yenilebilir Bitkilerin Özellikleri

Doğal ortamlarda yetişen bitkiler, tarih boyunca insan sağlığının korunmasında ve beslenme ihtiyaçlarının karşılanmasında önemli bir rol üstlenmiştir. Tıbbi, aromatik ve yenilebilir bitkiler, bu işlevsel kullanım alanlarıyla hem mutfak kültürünün hem de geleneksel tıbbın temel kaynaklarını oluşturur. Bu bitkiler, biyolojik yapılarına ve kimyasal bileşenlerine göre farklı özellikler taşıyarak çok yönlü biçimde değerlendirilmektedir. Türkiye'nin iklimsel ve coğrafi yapısı, bu çeşitliliği destekleyen önemli bir faktör olmuş, bu durum özellikle yerel halkın doğaya dayalı bilgi birikimiyle birleşerek çok sayıda bitkinin farklı amaçlarla kullanılmasını sağlamıştır (Faydaoğlu ve Sürücüoğlu, 2011).
Tıbbi bitkiler, genellikle halk hekimliğinde kullanılan ve çeşitli rahatsızlıklara karşı şifa amacıyla değerlendirilen bitkilerdir. Bu bitkiler, yaprak, kök, çiçek veya kabuk kısımlarındaki etken maddeler sayesinde sindirim sistemini düzenleme, solunum yollarını rahatlatma ya da bağışıklık sistemini destekleme gibi amaçlarla kullanılmaktadır. Anadolu'da bu tür bitkilere yönelik bilgi büyük oranda sözlü gelenekle aktarılmış, köy yaşamında halk arasında deneyimle biçimlenmiş uygulamalar aracılığıyla korunmuştur (Ertuğ, 2014).
Aromatik bitkiler, yoğun kokuları ve uçucu yağ içerikleriyle bilinir. Bu bitkiler çoğunlukla baharat olarak değerlendirilmekte, yemeklerde aroma artırıcı unsur olarak kullanılmakta, aynı zamanda kozmetik ve parfümeri gibi sanayi alanlarında da önemli bir girdi sağlamaktadır. Kekik, rezene, adaçayı, nane gibi türler Türkiye'de farklı bölgelerde yaygın olarak yetişmekte ve pazarlarda satılmaktadır. Bu bitkiler hem kurutulmuş hem de taze olarak değerlendirilmektedir (Bayram vd., 2010; Ayan, Çalışkan ve Çırak, 2006).
Yenilebilir bitkiler ise doğrudan gıda olarak tüketilen, çoğu zaman yemeklerde ana bileşen ya da tamamlayıcı unsur olarak kullanılan otları kapsamaktadır. Bu tür otlar çiğ olarak salatalarda, pişirilerek sıcak yemeklerde, börek içlerinde ya da turşularda kullanılmaktadır. Besin değeri açısından değerlendirildiğinde, bu bitkiler yüksek lif içeriği, vitamin zenginliği ve doğal antioksidan özellikleriyle sağlıklı beslenme açısından önemli katkılar sunmaktadır (Spina vd., 2008; Kocatepe ve Tırıl, 2015). Özellikle kırsal alanlarda yaşayan halkın sofralarında bu bitkilere sıklıkla yer verildiği görülmektedir. Otlar, hem mevsimsel bir geçim kaynağı hem de kültürel kimliğin parçası olarak değer taşır.
Tıbbi, aromatik ve yenilebilir otlar arasındaki fark, kullanım amacında ve kimyasal bileşimde ortaya çıkar. Ancak bu ayrım çoğu zaman halk arasında belirgin değildir. Aynı bitki hem sağlık amaçlı hem de yemeklerde kullanılabilmekte, bu da bu bitkilerin çok yönlü doğasını yansıtmaktadır. Bu bitkilerin sistematik sınıflandırılması ve bilimsel analizlerle desteklenmesi, hem tarımsal üretimin planlanmasında hem de gastronomik kullanımın yaygınlaştırılmasında önemli rol oynamaktadır.

Endemik Bitki Türleri ve Coğrafi Dağılımları

Endemik bitkiler, yalnızca belirli bir coğrafi bölgede doğal olarak yetişen ve başka hiçbir yerde bulunmayan türlerdir. Bu bitkiler, doğal seçilim, adaptasyon süreçleri ve iklimsel koşulların etkisiyle gelişen ekosistemlerin benzersiz ürünleri arasında yer alır. Türkiye, Avrupa ve Orta Doğu arasında köprü konumunda olması, farklı yükselti ve iklim tiplerine sahip olması

nedeniyle endemik bitki türleri açısından dünyanın en zengin ülkeleri arasında yer alır. Türkiye florasında yer alan yaklaşık 12 bin bitki türünün üçte birinden fazlası endemiktir ve bu durum Türkiye'yi biyolojik çeşitlilik açısından özel bir konuma taşımaktadır (Şenkul ve Kaya, 2017; Uyanık vd., 2013).

Endemik bitkilerin dağılımı, çoğunlukla Toroslar, Amanos Dağları, İç Anadolu'nun stepleri, Doğu Anadolu'nun dağlık bölgeleri ve Ege kıyılarındaki mikroklimalar gibi özgün habitatlarda yoğunlaşmaktadır. Bu bölgeler, iklimin, toprağın ve diğer çevresel etmenlerin etkisiyle yalnızca o alana özgü bitkilerin gelişmesine olanak sağlamıştır. Örneğin, Van Gölü çevresinde yetişen ve yöre halkı tarafından tüketilen bazı otlar yalnızca bu bölgede doğal olarak bulunmaktadır (Atasoy, 2010). Benzer şekilde, Ege Bölgesi'nde yalnızca belirli ovalarda yetişen bazı yabani otlar, hem endemik nitelik taşımakta hem de bölge mutfağında sıklıkla kullanılmaktadır (Tan ve Taşkın, 2009).

Endemik bitkiler sadece biyolojik açıdan değil, aynı zamanda kültürel ve ekonomik açıdan da önemli değerler taşır. Halk tarafından tanınan ve kullanılan bazı endemik türler, geleneksel tariflerde yer almakta, aynı zamanda doğal şifa kaynağı olarak değerlendirilmektedir. Özellikle ot festivallerinde bu bitkilerin tanıtımı yapılarak hem biyoçeşitliliğin korunmasına katkı sağlanmakta hem de yerel ekonomiye destek olunmaktadır (Karadağ ve Özer, 2022; Keskin ve Dönmez, 2020).

Türkiye'deki endemik bitkilerin önemli bir kısmı, aynı zamanda tehdit altındaki türler arasında yer almaktadır. Tarımsal faaliyetler, kentleşme, orman yangınları ve iklim değişikliği gibi faktörler, bu türlerin yaşam alanlarını daraltmakta ve bazılarını yok olma tehlikesiyle karşı karşıya bırakmaktadır. Bu nedenle, endemik bitki türlerinin korunması yalnızca doğayı koruma açısından değil, kültürel mirasın sürdürülmesi açısından da bir zorunluluk hâline gelmiştir (H. Muminjanov, 2019; Uysal, 2004).

TÜRKİYE'DE OT KÜLTÜRÜNÜN TARİHSEL GELİŞİMİ

Anadolu toprakları, tarih boyunca farklı medeniyetlere ev sahipliği yapmış, bu medeniyetlerin doğa ile kurduğu ilişki, özellikle bitkisel kaynakların kullanımında belirleyici olmuştur. Tarımın ilk örneklerinin görüldüğü bu coğrafyada, yabani otların toplanması ve işlenmesi, sadece geçim aracı değil aynı zamanda kültürel bir pratik olarak yüzyıllar boyunca varlığını sürdürmüştür. Göçebe yaşamdan yerleşik düzene geçiş sürecinde, doğada bulunan yenilebilir bitkiler temel besin kaynakları arasında yer almış, bu süreçle birlikte otlara dair bilgi halk belleğinde biçimlenerek günümüze kadar ulaşmıştır (Baytop, 2000; Gürsoy, 2001).

Ot kültürü, Anadolu'nun farklı bölgelerinde iklim ve toprak özelliklerine göre çeşitlenmiş, her bölge kendi doğal kaynaklarına uygun bitkileri tanımış, adlandırmış ve yemek kültürüne dâhil etmiştir. Antik dönemden Osmanlı mutfağına kadar uzanan süreçte, otlar yalnızca kıtlık zamanlarının besini olarak değil, aynı zamanda lezzet ve sağlık açısından zengin içerikler olarak değerlendirilmiştir (İnaltong, 2006; Dilsiz, 2010). Ege'de enginar, cibez, turp otu gibi türler, Doğu Anadolu'da madımak, ışkın, evelik gibi bitkiler yüzyıllardır sofralarda yer almakta, bu bitkiler bölgesel mutfakların kimliğini oluşturmaktadır.

Otların tarihsel süreçteki rolü, yalnızca bireysel tüketimle sınırlı kalmamış, aynı zamanda toplumsal yaşamın farklı alanlarına da yansımıştır. Halk hekimliği, dini ritüeller, bahar şenlikleri gibi kültürel pratiklerde otlara özel anlamlar yüklenmiş, bu da sözlü gelenek yoluyla kuşaklar arası bilgi aktarımını güçlendirmiştir (Ertuğ-Yaraş, 1997; Çomaklı, 2011). Bu yönüyle ot kültürü, Anadolu'nun çok katmanlı tarihsel yapısı içinde beslenme alışkanlıklarının ötesine geçerek, kimlik taşıyıcı ve kültürel bütünlük sağlayıcı bir unsur hâline gelmiştir.

Anadolu'da Bitki Kullanımının Tarihi Süreci

Anadolu, tarihsel süreç boyunca bitkisel kaynakların yoğun şekilde kullanıldığı önemli bir kültür havzası olarak öne çıkmıştır. Neolitik Dönem'den itibaren yerleşik hayata geçilmesiyle

birlikte, doğada bulunan yabani bitkilerin toplanması sistematik hâle gelmiş, zamanla bu bilgi hem gündelik yaşam pratiklerine hem de kültürel birikime dâhil olmuştur. Arkeobotanik veriler, Anadolu'da bitkisel ürünlerin yalnızca tarım amacıyla değil, doğal ortamdan toplanarak tüketim için de değerlendirildiğini göstermektedir. Bu durum, ot kültürünün temellerinin binlerce yıl öncesine dayandığını ortaya koymaktadır (Ertuğ-Yaraş, 1997; Etkin, 2000).
Antik Anadolu medeniyetleri, bitkilere yalnızca besin değeri açısından değil, aynı zamanda tıbbi, sembolik ve ritüel anlamlar yüklemiş, bitki kullanımı halk arasında kutsal sayılan uygulamaların da parçası hâline gelmiştir. Hitit tabletlerinde şifalı otlardan bahsedilmesi, bitkisel tedavi yöntemlerinin yazılı olarak kayıt altına alındığını göstermektedir. Benzer biçimde, Antik Yunan döneminde Anadolu'da kurulan tıp okulları, doğadaki otları tedavi edici nitelikleriyle incelemiş, bu bilgi Roma ve Bizans dönemlerinde gelişerek aktarılmıştır (Yeşilada, 2012).
İslamiyet'in Anadolu topraklarında yayılmasıyla birlikte bitkisel tedavi bilgileri İslam tıbbı ile birleşmiş, otlara dair bilgi hem halk arasında hem de bilimsel eserlerde derlenmiştir. Ortaçağ'da yaşamış hekimler, doğadan toplanan bitkilerin kaynatılarak, ezilerek ya da kurutularak kullanılması gerektiğini yazılı olarak aktarmış, bu da halk hekimliğinde kullanılan bitki repertuarını genişletmiştir. Selçuklu ve Osmanlı dönemlerinde ise bu bilgi sistematik hâle getirilmiş, saray mutfağında bazı otlara yer verilmiş, şerbetler, macunlar ve çeşitli yemek tarifleriyle birlikte yazılı kültürde korunmuştur (Baytop, 2000).
Anadolu'da bitki kullanımının tarihsel gelişimi, yalnızca yazılı belgelerle değil, aynı zamanda halk arasında süregelen sözlü gelenekle de desteklenmiştir. Köy yaşamında kuşaktan kuşağa aktarılan bilgiler, hangi otun ne zaman toplanacağı, nasıl kurutulacağı, hangi yemeklerde kullanılacağı gibi bilgileri içermekte, bu da bitki bilgisinin toplumun belleğinde canlı kalmasını sağlamaktadır. Bugün Anadolu'nun farklı bölgelerinde rastlanan bu bilgiler, tarihsel sürekliliğin bir göstergesi olarak değer taşımaktadır (Bulut, 2005; Gürsoy, 2014).

Geleneksel Mutfakta Yabani Otların Yeri

Anadolu mutfağı, doğadan elde edilen malzemelerin yemeğe dönüşmesiyle şekillenen zengin ve köklü bir geçmişe sahiptir. Bu mutfak anlayışının temel taşlarından biri, yabani otların yemeklik olarak değerlendirilmesidir. Doğal çevreyle uyum içinde yaşayan yerel topluluklar, yüzyıllar boyunca doğadan topladıkları otları farklı pişirme yöntemleriyle sofralarına taşımış, bu süreçte oluşan tarifler yöresel mutfağın ayrılmaz bir parçası hâline gelmiştir. Her bölge, iklimine ve topografyasına uygun otları tanımış ve bu otları kendi mutfak kültürüyle bütünleştirerek özgün yemek çeşitleri ortaya çıkarmıştır (Gürsoy, 2001; İnaltong, 2015).
Geleneksel mutfakta kullanılan otlar, sadece beslenme ihtiyacını karşılamakla kalmamış, aynı zamanda şifalı özellikleriyle de tercih edilmiştir. Mevsimine göre doğadan toplanan bu bitkiler, haşlanarak salata şeklinde sunulmakta, kavrularak yemek olarak tüketilmekte ya da börek içi olarak değerlendirilmektedir. Ebegümeci, semizotu, ısırgan otu, labada, sirken gibi bitkiler, Anadolu'nun pek çok bölgesinde bilinen ve yaygın şekilde tüketilen örnekler arasında yer almaktadır (Yücel vd., 2011).
Yabani otlar, geleneksel yemek tariflerinde genellikle zeytinyağı, yoğurt ve tahıl ürünleriyle bir araya getirilmiş, böylece hem lezzet hem de besin değeri açısından zengin tabaklar ortaya çıkmıştır. Bu uygulama, mutfak kültürünün sade, doğal ve işlevsel yönünü yansıtmaktadır. Aynı zamanda, yöresel tariflerde kullanılan otlar, halk arasında bitkinin tanınmasını sağlamış, toplama yöntemlerinden saklama tekniklerine kadar birçok bilgi halk kültürü içinde canlı kalmıştır (Karaman ve Sezgin, 2022).
Geleneksel mutfakta ot kullanımının bir diğer yönü de mevsimselliğe olan bağlılıktır. İlkbahar aylarında yeşeren otlar, kış boyunca depolanan bakliyat ve tahıllarla birleştirilmiş, bu da doğal üretim döngüsüne uyumlu bir beslenme alışkanlığını beraberinde getirmiştir. Bu yaklaşım, hem ekonomik bir geçim modelini desteklemiş hem de sürdürülebilir mutfak anlayışının temelini

oluşturmuştur. Ot yemeklerinin ev içindeki üretimi, kadim bilgiyle birleşerek kültürel belleğin önemli bir bileşeni hâline gelmiş, bu bilgi hem sözlü hem de yazılı kaynaklarla günümüze kadar ulaşmıştır (Ertuğ, 2003).

Halk Hekimliği ve Şifa Kültüründe Otların Kullanımı

Anadolu'da ot kültürü yalnızca mutfakla sınırlı kalmamış, halk hekimliği uygulamaları içinde önemli bir yer edinmiştir. Geçmişten günümüze kadar uzanan bu bilgi birikimi, çoğu zaman yazılı kaynaklara dayanmadan sözlü kültür yoluyla aktarılmış, toplumun doğal çevresiyle kurduğu ilişkiyi doğrudan yansıtmıştır. Doğada yetişen otların çeşitli rahatsızlıkları tedavi etmek amacıyla kullanılması, halk arasında deneyimle şekillenmiş, bu bilgi kuşaktan kuşağa aktarılmıştır (Bulut, 2005; Polat ve Satıl, 2012).

Halk hekimliğinde kullanılan bitkiler genellikle doğal yollarla toplanmakta, kurutularak ya da taze şekilde tüketilmektedir. Bu bitkilerden bazıları doğrudan çiğ olarak kullanılırken, bazıları kaynatılarak çay hâline getirilmekte ya da merhem şeklinde uygulanmaktadır. Ihlamur, kekik, nane, ebegümeci, ısırgan otu gibi bitkiler halk arasında soğuk algınlığı, sindirim problemleri, yara tedavisi ve bağışıklık sistemi güçlendirme amacıyla yaygın olarak kullanılmaktadır (Yeşilada, 2012; Çakılcıoğlu vd., 2010).

Anadolu'nun farklı bölgelerinde yapılan etnobotanik araştırmalar, halkın sağlık sorunlarına karşı bitkisel çözümleri öncelikli olarak tercih ettiğini göstermektedir. Örneğin Elazığ, Erzurum, Ordu ve Samsun çevresinde yapılan saha çalışmaları, bitkilerin sadece mutfakta değil, aynı zamanda koruyucu ve tedavi edici amaçlarla da kullanıldığını ortaya koymaktadır (Demir vd., 2017; Türkan vd., 2006). Bu durum, halkın doğayı yalnızca geçim kaynağı olarak değil, aynı zamanda şifa kaynağı olarak da değerlendirdiğini göstermektedir.

Şifa kültüründe bitkilerin kullanımı, dinsel ve kültürel öğelerle de bütünleşmiştir. Bazı bitkiler, nazardan korunmak ya da kötü enerjiden arınmak amacıyla kullanılmış, bazıları ise doğum, ölüm gibi geçiş ritüellerinde belirli uygulamaların parçası olmuştur. Bu ritüellerde kullanılan otlar, toplumun inanç sistemi ile doğa arasındaki bağı güçlendirmiş, kültürel hafızanın korunmasına katkı sağlamıştır (Ertuğ-Yaraş, 1997; Doğan, Uğulu ve Durkan, 2013).

Halk hekimliğinde ot kullanımının bu kadar yaygın olmasında, modern sağlık hizmetlerine erişimin sınırlı olduğu dönemlerde bitkisel çözümlerin kolay ulaşılabilirliği ve etkili sonuçlar vermesi etkili olmuştur. Bu bilgi zamanla yerel şifacıların ve yaşlı bireylerin rehberliğinde toplumda karşılık bulmuş, bugünkü geleneksel tıp uygulamalarına zemin hazırlamıştır. Günümüzde bu bilgilerin korunması ve bilimsel temele oturtulması, hem kültürel mirasın yaşatılması hem de sürdürülebilir sağlık sistemleri için önem arz etmektedir.

Yerel Tarifler ve Kullanım Biçimleri

Anadolu mutfağı, bölgesel zenginliğini doğrudan doğadan elde edilen ürünlerle şekillendirmiş, bu süreçte özellikle yabani otlar temel malzemeler arasında yer almıştır. Doğal ortamda yetişen otların yemeklerde kullanımı, farklı bölgelerde gelişen geleneksel tariflerle çeşitlenmiş, bu tarifler hem lezzet hem de sağlık açısından halk mutfağında önemli bir yer edinmiştir. Yerel tarifler, çoğu zaman kuşaktan kuşağa sözlü biçimde aktarılmış, zamanla bölgenin mutfak kimliğini oluşturan temel unsurlar hâline gelmiştir (Karaca vd., 2015).

Doğu Anadolu'da evelik, madımak, ışkın gibi bitkiler haşlanarak ya da kavrularak yemek olarak tüketilmekte, bazen bulgurla birlikte pişirilmekte, bazen de yoğurtla karıştırılarak sunulmaktadır. Erzurum mutfağında evelik aşı, madımak yemeği ya da çiriş otu kavurması, bu kullanım biçimlerinin öne çıkan örnekleridir. Ege Bölgesi'nde ise cibez, radika, arapsaçı ve turp otu gibi otlar genellikle zeytinyağlı olarak hazırlanmakta, limon ve sarımsakla tatlandırılmakta ya da yumurtayla kavrulmaktadır (Kök vd., 2020).

Bazı otlar ise içli yemeklerde tercih edilmekte, özellikle börek ve gözleme gibi hamur işlerinin iç harcında yer almaktadır. Labada, ebegümeci, ısırgan otu gibi bitkiler bu tür kullanımlarda

sıklıkla değerlendirilmektedir. Karadeniz Bölgesi'nde ısırgan otu çorbası ve mıhlama gibi yemekler, otların hem taze hem de kurutulmuş hâlde kullanıldığı örnekler arasında yer almaktadır (Yücel vd., 2010).
Yöresel tariflerin en dikkat çeken yönlerinden biri, mevsimselliğe olan sıkı bağlılıktır. İlkbahar aylarında toplanan otlar taze olarak tüketilirken, bazı türler yaz sonuna doğru kurutulmakta ve kışlık yemeklerde kullanılmak üzere saklanmaktadır. Bu yöntem, yalnızca beslenme sürekliliğini sağlamakla kalmamakta, aynı zamanda geleneksel saklama tekniklerinin sürdürülmesine de katkı sunmaktadır (Tuzlacı, 2011). Aynı bitkinin farklı bölgelerde farklı tariflerde yer bulması, bu kültürün zenginliğini ve bölgesel yorumlarını gözler önüne sermektedir.
Yerel tarifler, yalnızca yemeklerin hazırlanma biçimlerini değil, aynı zamanda sosyal yaşamın ve kültürel hafızanın da önemli bir bileşenini yansıtır. Bayramlarda, düğünlerde ya da mevsimsel kutlamalarda hazırlanan ot yemekleri, toplumsal birlikteliği güçlendiren simgesel bir işlev de üstlenmiştir. Bu yemekler, sofralarda yalnızca beslenme amacıyla değil, aynı zamanda paylaşım ve aidiyet duygusunun bir aracı olarak yer almıştır.

Bölgesel Farklılıklar ve Sözlü Kültürel Aktarım
Türkiye'nin coğrafi yapısı, iklim çeşitliliği ve tarımsal gelenekleri, yabani ot kullanımında bölgesel farklılıkların ortaya çıkmasına neden olmuştur. Her bölgenin kendine özgü flora yapısı, halkın doğayla olan ilişkisini biçimlendirmiş, bu da mutfak kültürüne yansıyan farklı tariflerin ve bitki kullanım biçimlerinin oluşmasını sağlamıştır. Aynı bitki türü farklı bölgelerde farklı adlarla anılmakta, çeşitli pişirme teknikleriyle yemeklere katılmakta ya da farklı amaçlarla kullanılmaktadır. Bu durum, Türkiye'de ot kültürünün yalnızca doğal kaynaklara değil, aynı zamanda kültürel birikime dayalı olarak şekillendiğini göstermektedir (Baytop, 1994; Ertuğ, 2014).
Ege Bölgesi'nde zeytinyağlı yemekler öne çıkarken, Doğu Anadolu'da tahılla karıştırılarak hazırlanan ot yemekleri ön plandadır. Karadeniz Bölgesi'nde otlar genellikle çorba ve kavurma şeklinde değerlendirilirken, Akdeniz'de taze tüketim ve salata formunda sunumlar yaygındır. Bu farklılık, iklimin yanı sıra, sosyal yapı ve ekonomik koşulların da ot kültürüne yön verdiğini ortaya koymaktadır (Çetinkaya ve Yıldız, 2018).
Bu zenginliğin korunmasında sözlü kültürün rolü oldukça büyüktür. Yabani otlara ilişkin bilgi, çoğunlukla aile içinde kuşaktan kuşağa aktarılan deneyimlere dayanmakta, özellikle kadınlar bu bilgi aktarımında belirleyici bir rol üstlenmektedir. Otların hangi mevsimde toplanacağı, nasıl ayıklanacağı, hangi tariflerde kullanılacağı gibi bilgiler çocuklara, torunlara ya da komşulara aktarılmakta, bu süreç zamanla bölgesel mutfak kimliğinin oluşmasına katkı sunmaktadır (Boztoprak vd, 2017).
Sözlü kültürel aktarım yalnızca tarif bilgisiyle sınırlı kalmamakta, otlara dair inançları, halk hikâyelerini, deyimleri ve ritüelleri de içermektedir. Bazı bitkiler uğur getirdiğine inanılarak evin girişine asılmakta, bazıları ise bahar aylarında yapılan törenlerde sembolik anlamlar yüklenerek kullanılmaktadır. Bu durum, otların sadece beslenme veya tedavi amacıyla değil, kültürel belleğin taşıyıcısı olarak da yaşatıldığını göstermektedir (Gürsoy, 2001).
Günümüzde yazılı kaynakların artması ve gastronomi turizminin gelişmesiyle birlikte, bu sözlü bilgi sistemli biçimde belgelenmekte, akademik çalışmalar ve yöresel festivaller aracılığıyla geniş kitlelere ulaştırılmaktadır. Bu durum, hem bölgesel farklılıkların tanınmasını sağlamakta hem de geleneksel bilginin unutulmadan yaşatılmasına olanak sunmaktadır.

YEREL OTLARIN GASTRONOMİDE KULLANIM ALANLARI

Yerel otlar, doğadan toplanarak mutfaklara taşınan ve yüzyıllar boyunca halkın beslenme alışkanlıklarını şekillendiren doğal ürünler arasında yer almaktadır. Doğal ve katkısız yapıları, geleneksel bilgiyle harmanlanan kullanım biçimleri ve bölgesel çeşitlilikleriyle bu otlar,

günümüzde yalnızca kırsal mutfaklarda değil, şehir merkezlerindeki modern gastronomi uygulamalarında da kendine yer bulmuştur. Gıda güvenliğine dair farkındalığın artması, sağlıklı beslenme anlayışının yaygınlaşması ve otantik lezzetlere olan ilginin yükselmesi, yerel otların gastronomideki önemini daha görünür kılmıştır (Özhan ve Pehlivan, 2022).
Geleneksel mutfaklarda sade ve doğal tariflerle tüketilen bu otlar, günümüzde yaratıcı sunumlarla modern tabaklara entegre edilmekte, özellikle yerel kimliği yansıtan restoranlarda sıkça tercih edilmektedir. Ayrıca sağlıklı yaşam temelli beslenme biçimlerinin yükselişiyle birlikte, lif, vitamin ve antioksidan yönünden zengin bu bitkiler, fonksiyonel gıda olarak da değer görmektedir (Kocatepe ve Tırıl, 2015). Vegan ve vejetaryen mutfak anlayışının gelişmesiyle birlikte, et ve hayvansal ürünlerin yerini alan otlar, bitkisel temelli tariflerin vazgeçilmez öğeleri arasında yer almaktadır.
Gastronomik deneyimi zenginleştiren bu doğal unsurlar, yöresel yemek kültürünün sürdürülebilirliğini sağlamanın yanında, turistik destinasyonlarda özgünlük yaratmakta ve destinasyon markalaşmasına katkı sunmaktadır. Yerel otların mutfaklarda değerlendirilmesi yalnızca beslenme ile sınırlı kalmayıp, aynı zamanda ekonomik bir değer olarak da ön plana çıkmaktadır. Pazarlarda taze olarak satışa sunulan bu bitkiler, özellikle bahar aylarında kırsal alanlarda yaşayan halk için önemli bir gelir kaynağı oluşturmaktadır (Akan ve Balos, 2023; Karaca vd., 2015).
Yerel otların gastronomideki yeri, sadece doğal bir malzeme olarak değil, aynı zamanda kültürel kimliğin, ekolojik duyarlılığın ve geleneksel bilgi birikiminin de bir yansımasıdır. Bu nedenle, bu otların kullanım alanlarının incelenmesi, yalnızca yemek kültürüne değil, aynı zamanda toplumsal belleğe dair önemli bir kaynak niteliği taşımaktadır.

Yenilebilir Otlar
İnsanoğlu yaşam serüvenine avcılık ve toplayıcılıkla başladı. Yiyecek ve içecek ihtiyacını kimi zaman etle, kimi zaman otlarla gidermeye çalışmış, özellikle toplama mevsiminde otlarla karnını doyurmak zorunda kalmıştır. İlk çağlardan günümüze kadar insanoğluna eşlik eden ‘ot’ terimi, çoğu zaman insan eliyle yetiştirilmeyen, doğada kendiliğinden yetişen ve insan müdahalesine maruz kalmayan otlar anlamında kullanılıyor. Başka bir deyişle ‘yabani ot’ kelimesi, ekimi yapılmayan ve doğada kendiliğinden yetişen otlar anlamında kullanılır ve bunlara da yabani ot veya ayrık otu denir. İnsanlar bu yabani otları kendi bölgelerinde farklı amaçlar için farklı şekillerde kullanmışlardır (Çetinkaya & Yıldız, 2018).
Yeryüzündeki canlılardan biri olan otlar, bulundukları bölgenin özelliklerini taşırlar. Her çimin kendine özgü bir bölgesi vardır ve bu çim bölgenin özellikleri ile büyür. Bir çimin yetiştiği bölge, sıcaklık, nem, yağış ve çeşitli iklimsel özellikler bakımından kendine özgüdür. Toprak yapısı, denize yakınlık ve iklim gibi birçok özelliğe bağlı olarak her bölgede her ot yetişmez. Bu nedenle dünyanın sadece belirli bölgelerinde bulunan otlar ‘endemik otlar’ olarak adlandırılır. Belirli bir bölgeye özgü, sadece o bölgede yetişen, toksik olmayan, insan sağlığı için yararlı ve yenilebilir endemik otlara yenilebilir endemik otlar denir. Kısacası, içerikleri insan vücuduna uygun, tüketilebilen ve sadece belirli bir bölgede yetişen bir grup bitkiye verilen isimdir. Nitrat içeren yenilebilir yerli otlar, bu zararlı maddeyi ortadan kaldırmak için yerel halk tarafından uzun süre pişirilir. Bu nedenle yenilebilir yerli otların ağırlıklı olarak çiçek, yaprak ve tohum gibi kısımları tüketilmektedir (İskenderoğlu, 2018). Yenilebilir endemik bitkilerin yanı sıra birçok tıbbi ve aromatik endemik tür de bulunmaktadır.
Yerli yenilebilir otlar, insan sağlığı için iyileştirici ve tedavi edici özellikleri nedeniyle eski çağlardan beri halklar ve medeniyetler tarafından kullanılmaktadır. Bazı endemik bitkiler sadece gıda ve ilaç olarak kullanılmaz, aynı zamanda ekonomik gelir elde etmek için ticareti de yapılır. Örneğin, anti-enflamatuar, antitümör ve antibakteriyel özellikleriyle bilinen geleneksel bir ilaç olan Patrinia villosa, Çin'in güney kıyılarına özgü yenilebilir bitkilerden biridir (Xu, vd., 2020).

Yenilebilir otlar, yeterli olgunluğa ulaşmış ve bir veya daha fazla parçası uygun bir biçimde hasat edilerek tüketim için yemek pişirmede kullanılan yabani otlar olarak tanımlanmaktadır. Yenilebilir yabani otlar, yenilebilir yabani bitkiler, yenilebilir bitkiler, yenilebilir otlar ve otlar gibi çeşitli isimlerle de adlandırılır. Bugün bahçede veya tarlada topladığımız yenilebilir otlar geçmişte yabani otlardı ve insanoğlu bu yenilebilir yabani otları daha etkili hale getirmek için yetiştirdi. Ancak dünyada kültüre alınmamış birçok yenilebilir bitki gıda olarak kullanılmaktadır. Yenilebilir otların pestisit içermemesi ve daha fazla lezzete sahip olması, yabani otların, hatta ekilmiş olanların bile tercih edildiği anlamına gelmektedir. Araştırmalar birçok yenilebilir bitkinin protein, mineral, vitamin ve antioksidan içerdiğini göstermiştir. Dünya üzerinde yaşayan insan nüfusunun hayatta kalmak için yaklaşık on beş farklı ana bitki türünü tükettiği bilinmektedir (Koç Apuhan ve Beyazkaya 2019).
Yonca ve hindiba gibi bazı bitkiler için hasat sonbaharda ilk yağmurlardan sonra yapraklar ortaya çıktığında başlar ve ilkbahara kadar sürer. Bazı otlar ise sadece ilkbaharda hasat edilip tüketilebilir. Kısacası, her mevsim tek bir ot bulunmamakta ve her mevsim farklı otlar ortaya çıkmaktadır (Tuzlacı, 2011: 13).
Sundriyal ve Sundriyal (2004) çalışmalarında yenilebilir otların ilkbaharda daha fazla büyüdüğünü, yazın ise otların büyüme oranının düşük olduğunu belirtmişlerdir.
Türkiye'de insanlar beslenme ihtiyaçlarını çevredeki dağlardan ve ormanlardan yenilebilir otlar toplayarak karşılamaktadır. Bu gelenek özellikle kırsal kesimlerde yaygındır. Yenilebilir otlar genellikle genç ve yumuşak olduklarında hasat edilir ve tüketilir. Yenilebilir otların toprak üstü kısımları veya kökleri sebze olarak kullanılır. Yenilebilir otlar ya çiğ olarak ya da haşlama ve kavurma gibi işlemlerden geçirildikten sonra tüketilir. Bu işlemlerle çeşitli çorbalar, sebze yemekleri, salatalar, sarmalar, ot kızartmaları ve turşular hazırlanır. Ayrıca otlar kurutularak çay ve baharat olarak da mutfağımızda kullanılmaktadır (Tuzlacı, 2011).
Yenilebilir otlar ve kullanımları bölgeden bölgeye değişmektedir. Yenilebilir otlar birçok alanda doğrudan veya dolaylı olarak kullanılmaktadır. Gıda kaynağı olarak kullanılmasının yanı sıra geleneksel tıp ve biyoteknoloji gibi doğrudan kullanım alanları da bulunmaktadır. Bu bitkilerin su temini, toprak oluşumu, erozyon kontrolü ve tozlaşma gibi dolaylı katkı sağladığı alanlar da bulunmaktadır (Karabak, 2017).
Türkiye'nin farklı bölgelerinde, her bölgenin özelliklerine uygun olarak kendiliğinden yetişen çeşitli otlar bulunmaktadır. Bu otlar ve kullanım şekilleri her bölgenin geleneklerini ve kültürlerini yansıtmaktadır. Otların kullanımıyla ilgili gelenek ve görenekler yıllar boyunca aktarılmış ve günümüze kadar ulaşmıştır. Ancak, geçmişte yoğun olarak kullanılan bitkilerle karşılaştırıldığında, yaşlanma, modernleşme eğilimleri, teknolojik gelişmeler ve hazır gıda tüketimi gibi beslenme alışkanlıklarının ortaya çıkması, yenilebilir bitkilerin tüketiminde bir azalmaya yol açmıştır (Uysal, 2008).

Geleneksel Yemeklerde Yenilebilir Otların Kullanımı

Yenilebilir yabani otlar, yüzyıllardır Anadolu mutfağında önemli bir yer edinmiş, özellikle kırsal bölgelerde yaşayan halkın beslenme alışkanlıklarının temel bileşenlerinden biri olmuştur. Doğal ekosistemlerde kendiliğinden yetişen bu bitkiler, insan eliyle kültive edilmeden toplanmakta, mevsimine uygun şekilde değerlendirilmekte ve çeşitli yemeklerde kullanılmaktadır. Bu bitkilerin kullanımı yalnızca maddi yetersizliklerle açıklanamayacak kadar köklü bir yaşam pratiğine dayanmaktadır. Doğayla kurulan bütüncül ilişki, toplumsal hafızada bu otların yalnızca besin değil, aynı zamanda sağlık ve gelenekle bütünleşen simgeler olmasını sağlamıştır (Baytop, 2000; Tuzlacı, 2011).
Anadolu'nun farklı coğrafi bölgelerinde, yenilebilir otların mutfaklardaki kullanım şekilleri yerel kültüre ve doğaya bağlı olarak çeşitlilik göstermektedir. Ege Bölgesi'nde cibez, arapsaçı, radika ve turp otu gibi bitkiler, genellikle zeytinyağıyla sotelenip limon ve sarımsakla tatlandırılarak servis edilirken; Doğu Anadolu'da evelik, madımak, ışgın ve çiriş gibi otlar

bulgur ya da pirinçle birleştirilerek tencere yemekleri şeklinde tüketilmektedir (Tan & Taşkın, 2009; Çetinkaya & Yıldız, 2018). Bazı yörelerde bu otlar, yoğurtla karıştırılarak meze veya çorba haline getirilmekte; börek, gözleme, mücver ve köfte iç harcında da sıklıkla yer almaktadır. Örneğin, Van'a özgü otlu peynir, yalnızca bir süt ürünü değil; aynı zamanda bölgenin yabani bitki örtüsünün zenginliğini yansıtan geleneksel bir lezzettir (Karaman & Sezgin, 2022).

Yabani otların gastronomideki rolü, yalnızca lezzet açısından değil, aynı zamanda besin değerleri bakımından da önem taşımaktadır. Bu bitkiler; demir, fosfor, kalsiyum gibi temel minerallerin yanı sıra C vitamini, diyet lifi ve potasyum açısından da oldukça zengindir. Doğal yapıları gereği katkı maddesi içermeyen bu otlar, özellikle geçmişte kıtlık dönemlerinde güvenli besin kaynakları olarak görülmüş; günümüzde ise sağlıklı beslenme trendleri doğrultusunda yeniden değer kazanmıştır (Kocatepe & Tırıl, 2015; Karabak, 2017).

Yenilebilir yabani bitkilerin kullanımı yalnızca Türkiye ile sınırlı değildir. Tarihsel olarak Mısır, Yunan, Roma, Selçuklu ve Osmanlı uygarlıklarında da bu otların çeşitli şekillerde gıda, ilaç ve sağlık amacıyla değerlendirildiği bilinmektedir (Karadağ, 2015). Bu yönüyle yenilebilir otlar, sadece gastronomik bir malzeme değil; aynı zamanda kültürel ve tarihsel bir mirasın taşıyıcısı olarak kabul edilmektedir.

Türkiye'nin sahip olduğu iklim çeşitliliği ve zengin bitki örtüsü, bu alandaki kullanım potansiyelini daha da artırmaktadır. Yaklaşık 12.000 bitki türünün bulunduğu ülkemizde, bu türlerin 3.000 kadarı endemiktir ve doğrudan doğadan toplanarak mutfaklara taşınmaktadır (Demir, 2013). Karaca, Yıldırım ve Çakıcı'ya (2015) göre yenilebilir otlar, tarımsal üretimle değil doğadan kendi kendine yetişen, tamamı ya da belli kısımları tüketilebilen bitkilerdir. Aynı bitki farklı yörelerde farklı isimlerle anılabildiği gibi, aynı adla anılan farklı türlere de rastlanmaktadır. Bu nedenle bu bitkiler hem "yabani ot" hem de "yabancı ot" olarak adlandırılabilmektedir (Kallas, 1996; Leonti vd., 2006).

Türkiye'de halkın yenilebilir ot tüketimine ilişkin yapılan saha araştırmalarında, bu otların hala önemli bir besin kaynağı olduğu ortaya konmuştur. Kocadağ ve arkadaşlarının (2021) gerçekleştirdiği bir çalışmada, katılımcıların yaklaşık %66'sı yenilebilir otları düzenli olarak tükettiklerini belirtmiş, bu tüketim oranının yaş, cinsiyet gibi demografik değişkenlere göre farklılık gösterdiği ifade edilmiştir. Bu durum, yerel otların yalnızca beslenme ihtiyacını karşılamaya yönelik değil; aynı zamanda yöresel gastronomi kimliğini oluşturan temel unsurlar arasında yer aldığını göstermektedir. Nitekim bölgesel mutfaklar, sahip oldukları ot çeşitliliğiyle farklılaşmakta; bu bitkiler yöresel yemek tariflerinin vazgeçilmez bileşenlerinden biri haline gelmektedir.

Yenilebilir otlar üzerine yapılan akademik çalışmalar büyük ölçüde etnobotanik incelemelere ve medikal amaçlı kullanımlara odaklanmıştır (Özvatan, Gürdal & Kültür, 2013; Demir, Sürmen, Özer & Kutbay, 2017; Altundağ Çakır & Kutlu, 2020; Polat vd., 2015; Özer, Çoban & Bouljak, 2020). Bununla birlikte son dönemde gastronomi disiplininde bu bitkilerin yerel mutfaklardaki kullanımı, reçeteleri ve besin değerleri üzerine yapılan araştırmalar artış göstermektedir (Çetinkaya & Yıldız, 2018; Şimşek, Durmuş & Çakmak, 2020; Karadağ & Özer, 2022). Ayrıca Demirci ve Aktepe'nin (2021) yürüttüğü bibliyometrik analiz, yenilebilir otlarla ilgili yayınların daha çok biyoloji ve gıda mühendisliği alanlarında yoğunlaştığını; ancak gastronomi alanında da önemli bir ivme kazanıldığını göstermektedir. Bitkilerin görsel estetikten beslenme fonksiyonuna, kültürel mirastan turistik çekicilik unsuru olarak değerlendirilmesine kadar geniş bir yelpazede araştırma konusu haline gelmesi, disiplinler arası yaklaşımın gerekliliğini ortaya koymaktadır.

Türkiye'nin zengin bitki örtüsünden elde edilen yenilebilir yabani otlar; tarihsel, kültürel, biyolojik ve gastronomik açıdan çok yönlü değerlendirilebilecek potansiyele sahiptir. Doğadan toplanarak sofralara taşınan bu bitkiler, yalnızca geçmişin geleneksel mutfaklarında değil, aynı zamanda geleceğin sürdürülebilir beslenme modellerinde de önemli bir yer edinmeye adaydır.

Bu bağlamda, hem kültürel mirasın korunması hem de sağlıklı ve doğal beslenme pratiklerinin teşvik edilmesi açısından, bu otların gastronomiye kazandırılması büyük önem taşımaktadır. Anadolu'nun farklı bölgelerinde gelişen geleneksel tarifler, otların kullanım çeşitliliğini yansıtırken, aynı zamanda yöresel mutfak kimliğini de görünür kılmaktadır. Bu yemeklerin sürdürülebilirliği, sözlü kültürün yanı sıra yazılı kaynaklara aktarılan tariflerle de sağlanmakta, bu durum hem kültürel hem de gastronomik mirasın korunmasına katkı sunmaktadır. Geleneksel yemeklerde yerel ot kullanımı Tablo 1'de verilmiştir.

Tablo 2. Geleneksel Yemeklerde Yerel Ot Kullanımı

Yerel Ot	Yemek Türü	Bölge
Evelik	Tencere yemeği, çorba	Doğu Anadolu
Çiriş	Kavurma, börek içi	Doğu Anadolu
Madımak	Haşlama, yoğurtlu yemek	İç Anadolu
Cibez	Zeytinyağlı, salata	Ege
Turp Otu	Kavurma, yumurtalı yemek	Ege
Işkın	Doğrudan tüketim, reçel	Doğu Anadolu
Ebegümeci	Kavurma, börek içi	Marmara
Isırgan Otu	Çorba, börek içi	Karadeniz
Arapsaçı	Zeytinyağlı, kavurma	Ege
Sirken	Haşlama, iç harç	İç Anadolu
Madımak	Haşlama, yoğurtlu	İç Anadolu
Evelik	Tencere yemeği, çorba	Doğu Anadolu

Kaynak: (Belli & Uluer, 2023; Kocadağ vd., 2021)

3.3. Otlu Peynirler, Çorbalar ve Zeytinyağlılar

Yabani otların geleneksel mutfakta değerlendirilme biçimleri arasında öne çıkan üç temel uygulama alanı, otlu peynir üretimi, çorba yapımı ve zeytinyağlı yemeklerdir. Bu uygulamalar, farklı bölgelerde halkın doğayla kurduğu ilişkinin somut birer yansıması olarak değerlendirilmekte, aynı zamanda hem besin değerinin korunmasını hem de kültürel sürekliliğin sağlanmasını mümkün kılmaktadır. Doğadan toplanan otlar, özellikle ilkbahar ve yaz aylarında daha fazla tüketilmekte, bölgesel damak zevkine uygun biçimlerde işlenerek sofralarda yer bulmaktadır (Tuzlacı, 2011; Gürsoy, 2001).

Otlu peynirler, Türkiye'nin özellikle doğu ve güneydoğu bölgelerinde yaygın olarak üretilmektedir. Bu peynirler, inek, koyun ya da keçi sütünden elde edilen peynir kütlesine doğal ortamda toplanan otların eklenmesiyle hazırlanmakta, hem dayanıklılık hem de aromatik özellik açısından zenginleşmektedir. Van otlu peyniri, bu üretim biçiminin en bilinen örneklerinden biridir. Bu peynirin içinde genellikle sirmo, mendi, heliz, yabani nane gibi aromatik otlar kullanılmakta, bu da peynirin yalnızca besleyici bir gıda olmasını değil, aynı zamanda yöresel kimliğin bir parçası olmasını sağlamaktadır (Tunçtürk vd., 2014; Güvenç ve Kaya, 1996).

Çorba kültürü ise özellikle Karadeniz ve İç Anadolu bölgelerinde otların yoğun biçimde kullanıldığı bir alanı temsil eder. Isırgan otu, evelik, labada, ebegümeci gibi bitkiler, süt, yoğurt veya bulgurla birlikte pişirilerek çorba hâline getirilmekte, bu tarifler hem doyurucu hem de şifa verici özellikleriyle öne çıkmaktadır. Bu çorbalar, özellikle kış aylarında bağışıklık sistemini destekleyici özellikleri nedeniyle tercih edilmekte, aynı zamanda ekonomik birer beslenme alternatifi sunmaktadır (Demir vd., 2017; Yücel, Şengün ve Çoban, 2012).

Zeytinyağlı yemekler ise daha çok Ege ve Akdeniz mutfaklarının temel unsurları arasında yer almakta, bu bölgelerde yetişen otlar zeytinyağı ile hafif ısıda pişirilerek ana yemek ya da meze olarak servis edilmektedir. Arapsaçı, turp otu, cibez, radika gibi otlar genellikle haşlanarak ya da doğrudan kavrularak limon, sarımsak ve baharatlarla tatlandırılmaktadır. Bu tür tarifler,

sağlıklı beslenme anlayışını desteklemekte ve düşük kalorili, yüksek lif içeriği sayesinde dengeli bir öğün alternatifi sunmaktadır (Tan ve Taşkın, 2009; Kök vd., 2020).
Otlu peynirler, çorbalar ve zeytinyağlılar, yalnızca geleneksel mutfak hafızasını taşımakla kalmayıp, aynı zamanda yerel tarım ürünlerinin değerlendirilmesini teşvik eden birer kültürel ve ekonomik değerdir. Bu yemek türlerinin belgelenmesi ve korunması, Türkiye'nin gastronomik zenginliğininsürdürülebilirliği açısından büyük önem taşımaktadır.
Otlu peynirler, çorbalar ve zeytinyağlılarda kullanılan başlıca yerel otlar Tablo 2'de gösterilmiştir.

Tablo 3. Otlu Peynirler, Çorbalar ve Zeytinyağlılarda Kullanılan Başlıca Yerel Otlar

Yerel Ot	Yemek Türü	Bölge
Sirmo	Van otlu peyniri	Doğu Anadolu
Işkın	Yoğurtlu çorba, doğrudan tüketim	Doğu Anadolu
Arapsaçı	Zeytinyağlı, kavurma	Ege
Isırgan Otu	Çorba, börek içi	Karadeniz
Evelik	Tencere yemeği, çorba	Doğu Anadolu
Turp Otu	Zeytinyağlı, salata	Ege
Cibez	Zeytinyağlı, yumurtalı yemek	Ege
Çiriş Otu	Börek içi, kavurma	Doğu Anadolu
Ebegümeci	Kavurma, çorba, börek içi	Marmara
Labada	Yoğurtlu yemek, çorba	İç Anadolu
Van Otlu Peyniri	Sirmo, Mendi, Siyabo	Doğu Anadolu

Kaynak: (Kök vd., 2020)

3.4. Vegan ve Vejetaryen Mutfakta Kullanım Potansiyeli
Son yıllarda sağlıklı yaşam, hayvansal gıdalardan uzak durma eğilimi ve çevresel kaygılar, vegan ve vejetaryen beslenme biçimlerine olan ilgiyi artırmıştır. Bu beslenme anlayışında bitkisel kaynaklı gıdalar ön plandadır ve doğadan toplanan yenilebilir otlar, bu alanda değerlendirilebilecek en doğal ürünler arasında yer almaktadır. Yüksek lif ve mineral içeriği, doymamış yağ asitleri, vitamin zenginliği ve düşük kalori özellikleri sayesinde yerel otlar, özellikle et ve süt ürünlerinin yer almadığı tariflerde işlevsel bir alternatif oluşturmaktadır (Kocatepe ve Tırıl, 2015; Spina vd., 2008).
Vegan mutfakta yerel otlar çoğunlukla ana yemeklerde sebze yemeği olarak değerlendirilmekte, zeytinyağlı pişirme yöntemiyle tüketilmektedir. Arapsaçı, radika, cibez ve turp otu gibi türler, haşlanarak ya da kavrularak hem sıcak hem de soğuk tabaklarda sunulmaktadır. Bu otlar, zengin aroma profilleri sayesinde baharat kullanımını azaltmakta, doğal lezzetleriyle sofralara katkı sunmaktadır. Aynı zamanda glütensiz beslenmeyi benimseyen bireyler için de güvenli bir gıda alternatifidir (Karadağ ve Özer, 2022).
Vejetaryen mutfakta ise yerel otların yumurta, yoğurt veya süt ürünleriyle birleşerek tariflerde yer bulduğu görülmektedir. Isırgan otu ve ebegümeci gibi otlarla hazırlanan mücver, otlu omletler ya da yoğurtlu meze çeşitleri, geleneksel mutfakta olduğu kadar vejetaryen mutfakta da besleyici öğünler arasında yer almaktadır. Otların kıvam verici özelliği sayesinde yumurta ve un gibi bağlayıcılar daha az kullanılmakta, bu da doğal ürün kullanımını desteklemektedir (Kök vd., 2020).

Yabani otların vegan ve vejetaryen mutfaktaki işlevselliği yalnızca besin değeriyle sınırlı kalmamakta, aynı zamanda kültürel kökenli sürdürülebilir gıda sistemlerine de katkı sağlamaktadır. Doğadan toplama yöntemiyle elde edilen bu bitkiler, endüstriyel üretime bağlı kalmadan elde edilmekte, bu da çevreye olan etkilerini azaltmaktadır. Özellikle kırsal bölgelerde yaşayan bireylerin kendi tüketimini doğadan sağlaması, hem ekonomik hem de ekolojik bir avantaj yaratmaktadır (Etkin, 2000; Muminjanov ve Karagöz, 2019).
Yabani otların vegan ve vejetaryen mutfaklar için taşıdığı potansiyel, hem yerel pazarlarda ürün çeşitliliğini artırmakta hem de gastronomi turizmi bağlamında doğal içerikli menüler oluşturulmasına olanak sunmaktadır. Bu yönüyle değerlendirildiğinde, yerel otlar yalnızca geleneksel mutfağın değil, aynı zamanda çağdaş beslenme eğilimlerinin de vazgeçilmez bileşenleri arasında yer almaktadır. Tablo 3'te vegan ve vejetaryen mutfakta kullanılan yerel otlar verilmiştir.

Tablo 4. Vegan ve Vejetaryen Mutfakta Kullanılan Yerel Otlar

Yerel Ot	Kullanıldığı Yemek Türü	Besleyici Özellikleri / İşlevi
Arapsaçı	Zeytinyağlı, kavurma	Sindirimi kolaylaştırır, antioksidan içeriklidir
Isırgan Otu	Çorba, mücver, omlet	Yüksek demir ve C vitamini içerir
Cibez	Haşlama, zeytinyağlı, salata	Lif kaynağıdır, düşük kalorilidir
Ebegümeci	Kavurma, yoğurtlu meze, gözleme	Bağırsakları düzenler, iltihap önleyicidir
Radika	Salata, haşlama, sıcak sebze yemeği	Karaciğer dostudur, detoks etkisi gösterir
Labada	Börek içi, yoğurtlu soğuk meze	Yüksek lif ve potasyum içerir
Turp Otu	Yumurtalı kavurma, vegan çorba	Sindirimi kolaylaştırır, iştah açıcıdır
Madımak	Vegan tencere yemeği, bulgurlu kavurma	Protein ve kalsiyum içerir
Isırgan	Çorba, Börek	Lifli, düşük kalorili

Kaynak: (Spina vd., 2008; Kocatepe & Tırıl, 2015)

3.5. Fonksiyonel Gıda Olarak Yerel Otlar

Fonksiyonel gıdalar, yalnızca temel besin öğelerini sağlamakla kalmayıp, aynı zamanda sağlık üzerinde olumlu etkiler oluşturarak hastalıklardan korunmayı destekleyen ürünlerdir. Bu tanım kapsamında değerlendirildiğinde, doğadan toplanan yerel otlar, sahip oldukları vitamin, mineral, antioksidan, fenolik bileşen ve lif içerikleriyle fonksiyonel gıda niteliği taşımaktadır. Anadolu'da geleneksel olarak tüketilen birçok yabani ot, halk arasında sadece beslenme amacıyla değil, aynı zamanda bedensel direnci artırma, sindirimi düzenleme, bağışıklık sistemini destekleme ve vücudu arındırma gibi işlevlerle kullanılmaktadır (Spina vd., 2008; Etkin, 2000).
Yerel otların fonksiyonel gıda özelliği, hem geleneksel halk bilgisiyle hem de modern bilimsel çalışmalarla desteklenmektedir. Isırgan otu, demir ve C vitamini yönünden zengin olması sayesinde kansızlıkla mücadelede destekleyici bir unsur olarak görülmektedir. Yine ebegümeci, yüksek lif içeriğiyle sindirim sistemine olumlu katkı sağlamakta, aynı zamanda antiinflamatuar etkileriyle öne çıkmaktadır. Arapsaçı ve radika gibi bitkiler ise karaciğer fonksiyonlarını destekleyici etkileriyle tanınmakta, bu otlar bazı bölgelerde detoks amacıyla tüketilmektedir (Yeşilada, 2012; Faydaoğlu ve Sürücüoğlu, 2011).

Fonksiyonel gıdalar arasında değerlendirilen otlar, aynı zamanda düşük kalori içermeleri nedeniyle diyetisyenler ve sağlıklı beslenmeyi benimseyen bireyler tarafından da önerilmektedir. Doğal yollarla toplanmaları, katkı maddesi içermemeleri ve geleneksel mutfakla uyumlu tariflerde kullanılmaları, bu bitkileri günümüz gastronomi anlayışında değerli bir unsur hâline getirmiştir. Bu durum, geleneksel bilgiyle modern sağlık anlayışı arasında köprü kurarak, yerel otların tüketimini artırmakta ve sürdürülebilir beslenme sistemlerine katkı sunmaktadır (Kocatepe ve Tırıl, 2015).

Yerel otların fonksiyonel etkileri yalnızca bireysel sağlık üzerinde değil, aynı zamanda toplumsal sağlık politikaları açısından da önem taşımaktadır. Özellikle kırsal bölgelerde yaşayan bireylerin doğadan sağladığı bu ürünler, hem ekonomik anlamda ulaşılabilir hem de kültürel bağlamda kabul gören sağlıklı beslenme araçları olarak değerlendirilmektedir. Bu yönüyle yerel otlar, fonksiyonel gıda yaklaşımının yalnızca sanayi ürünü değil, aynı zamanda doğanın sunduğu doğal kaynaklarla da mümkün olabileceğini göstermektedir (Doğan, 2016). Fonksiyonel Özellikleriyle Yerel Otlar Tablo 4'te verilmiştir.

Tablo 5. Fonksiyonel Özellikleriyle Yerel Otlar

Yerel Ot	Fonksiyonel Özellik	Desteklediği Sağlık Alanı
Isırgan Otu	Yüksek demir ve C vitamini içeriği	Kansızlıkla mücadele, bağışıklık sistemi
Ebegümeci	Anti-inflamatuar ve lif yönünden zengin	Sindirim sistemi, iltihap önleyici etki
Arapsaçı	Karaciğer dostu, ödem atıcı	Detoks, karaciğer sağlığı
Radika	Antioksidan etkili, idrar söktürücü	Böbrek fonksiyonları, vücut arındırma
Madımak	Protein ve kalsiyum içeriği	Kas ve kemik sağlığı
Labada	Lif kaynağı, potasyum zengini	Bağırsak hareketliliği, tansiyon kontrolü
Cibez	Düşük kalori, A ve C vitamini içeriği	Kilo yönetimi, hücre yenilenmesi
Çiriş Otu	Antimikrobiyal özellik, vitamin desteği	Bağışıklık sistemi, cilt sağlığı
Kuşburnu	Antioksidan	Bağışıklık sistemi

Kaynak: (Doğan, 2016)

Yenilebilir Otlar Üzerine Yapılmış Çalışmalar

Yenilebilir otlar üzerine yapılan akademik araştırmalar, çok boyutlu bir yapıya sahip olmakla birlikte, çalışmaların önemli bir kısmı bu bitkilerin biyolojik tanımı, kimyasal içerikleri ve tıbbi etkileri üzerine yoğunlaşmaktadır. Bu bağlamda, yenilebilir otlar sıklıkla fitokimyasal analizler, antioksidan düzeyleri, antimikrobiyal etkileri, halk hekimliğindeki kullanımları ve farmakolojik potansiyelleri çerçevesinde değerlendirilmiştir. Ancak bu bitkilerin gastronomi bağlamındaki kullanımları, mutfak kültürü içerisindeki yerleri ve beslenme alışkanlıklarına olan katkılarına yönelik çalışmalar henüz sınırlı düzeydedir. Son yıllarda bu alana yönelik ilgi artmış olsa da, literatürün genelinde sağlık ve etnobotanik eksenli yaklaşımın ağırlıkta olduğu görülmektedir (Faydaoğlu & Sürücüoğlu, 2011; Karaca vd., 2015; Xu vd., 2020).

Türkiye'de bu alandaki öncü çalışmalar, hem akademik literatür hem de halk kültürüne dayalı kaynakların derlenmesi açısından önemli katkılar sunmuştur. Baytop'un (1999) "Türkçe Bitki Adları Sözlüğü" adlı eseri, Türkiye florasında yer alan bitkilerin adlandırılmasına ilişkin önemli bir başvuru kaynağı olmasının yanı sıra, birçok bitkinin kullanım şekli ve coğrafi

dağılımına dair bilgiler içermektedir. Bu yönüyle, yenilebilir otlar hakkında sistematik bir terminoloji kazandırma çabası açısından literatürdeki ilk temel eserlerden biri sayılmaktadır. Aynı şekilde Tuzlacı'nın (2011) "Türkiye'nin Yabani Besin Bitkileri ve Ot Yemekleri" isimli çalışması, bitkilerin toplanma dönemleri, tüketim şekilleri, yöresel isimleri ve halk arasındaki kullanımı hakkında kapsamlı bilgiler sunarak gastronomiyle etnobotaniği bir araya getiren önemli bir kaynaktır.

Son yıllarda özellikle etnobotanik perspektifle gerçekleştirilen saha araştırmalarında artış olduğu gözlemlenmektedir. Bu çalışmalar, Türkiye'nin farklı bölgelerinde yetişen yenilebilir otların tespit edilmesi, yöresel adlandırmalarının belgelenmesi ve geleneksel kullanım biçimlerinin kayıt altına alınması gibi amaçlarla yürütülmektedir (Kök vd., 2020; Nohutçu vd., 2019; Demir vd., 2017; Ayaz, 2020; Tan & Taşkın, 2009). Bu tür araştırmalar, hem halk bilimi hem de biyolojik çeşitliliğin sürdürülebilirliği açısından önem taşımakta; geleneksel bilgilerin unutulmasını önleyerek kuşaktan kuşağa aktarılmasına olanak sağlamaktadır.

Yenilebilir otların tıbbi ve fonksiyonel kullanımlarına dair bilimsel incelemeler de dikkat çekicidir. Geleneksel halk hekimliğinde çeşitli rahatsızlıkların tedavisinde kullanılan bu bitkilerin, modern farmakoloji ile birlikte laboratuvar ortamında analiz edilerek antioksidan, antienflamatuvar ve antimikrobiyal özelliklerinin değerlendirildiği çalışmalara rastlanmaktadır (Faydaoğlu & Sürücüoğlu, 2011; Xu vd., 2020). Bu çerçevede yapılan araştırmalar, birçok yenilebilir ot türünün bağışıklık sistemi üzerinde olumlu etkileri olduğunu, bazı türlerin ise mide-bağırsak rahatsızlıklarına karşı destekleyici tedavi olarak kullanıldığını ortaya koymuştur.

Yenilebilir otların beslenme bilimi açısından taşıdığı potansiyel de giderek daha fazla dikkate alınmaya başlanmıştır. Bu bitkilerin çoğu, düşük kalori değerine sahip olmaları, yüksek lif içeriği ve mikro besin öğeleri bakımından zengin olmaları sayesinde sağlıklı yaşamı destekleyen unsurlar arasında değerlendirilmektedir. Ancak bu yönleriyle ilgili akademik çalışmalar halen sınırlı sayıda olup, mevcut literatürün büyük bir kısmı bitkilerin beslenme yerine tedavi edici özelliklerine odaklanmıştır.

Yenilebilir otların gastronomik açıdan değerlendirilmesine ilişkin çalışmaların ise genellikle bölgesel düzeyde yoğunlaştığı gözlemlenmektedir. Bu çalışmalarda otların hangi yörelerde yaygın olarak kullanıldığı, hangi tariflerde değerlendirildiği ve yerel halk tarafından nasıl hazırlandığı gibi konular ele alınmaktadır. Bu bağlamda gastronomi alanında yapılan araştırmalar, genellikle otların kullanım biçimleri, yemek reçeteleri ve kültürel kimlik açısından taşıdıkları değer üzerine odaklanmaktadır (Çetinkaya & Yıldız, 2018; Şimşek, Durmuş & Çakmak, 2020; Karadağ & Özer, 2022; Kökler & Çetinkaya, 2022).

Diğer taraftan, Demirci ve Aktepe (2021) tarafından yapılan bibliyometrik analizde, Türkiye'de yenilebilir bitkilere yönelik yapılan yayınların büyük oranda gıda mühendisliği ve biyoloji alanında yoğunlaştığı, gastronomi alanındaki çalışmaların ise sınırlı sayıda olduğu tespit edilmiştir. Bu durum, disiplinler arası iş birliklerine duyulan ihtiyacı ortaya koymakta ve yenilebilir otların hem kültürel hem de bilimsel bağlamda daha kapsamlı araştırılması gerektiğine işaret etmektedir.

Yenilebilir otlar üzerine yapılmış çalışmalar genel olarak biyolojik, kimyasal ve tıbbi boyutlara odaklanmış; etnobotanik literatürde önemli bir yere sahip olmuştur. Ancak bu otların kültürel ve gastronomik boyutlarının daha derinlemesine incelenmesi gerektiği açıktır. Özellikle Türkiye gibi bitki çeşitliliği açısından zengin bir coğrafyada, bu doğal kaynakların gastronomiye entegrasyonu hem beslenme alışkanlıklarının sürdürülebilirliğini destekleyecek hem de yerel kültürlerin korunmasına katkı sağlayacaktır. Önümüzdeki dönemde, bu alandaki çalışmaların gastronomi, beslenme bilimi, kültürel antropoloji ve halk bilimi disiplinlerini bir araya getiren daha kapsamlı araştırmalara dönüşmesi, hem akademik hem de pratik açıdan önemli kazanımlar sağlayacaktır.

TÜRKİYE'DE BÖLGELERE GÖRE OT TÜKETİMİ VE UYGULAMA ÖRNEKLERİ

Türkiye, farklı iklim tiplerinin, topografik yapıların ve biyolojik çeşitliliğin bir arada bulunduğu coğrafi konumuyla, bitkisel kaynaklar açısından zengin bir ülke konumundadır. Bu doğal çeşitlilik, bölgelere özgü bitki türlerinin gelişmesini sağlamış, her bölge kendi ekolojik koşullarına uygun otları tanımış, bu otları beslenme kültürüne ve gündelik yaşantısına entegre etmiştir. Bu nedenle Türkiye'de ot tüketimi yalnızca yaygınlık açısından değil, aynı zamanda bölgesel çeşitlilik bakımından da dikkat çekici bir örüntü sunmaktadır (Şenkul ve Kaya, 2017; Doğan vd., 2004).

Her bölgenin kendine özgü flora yapısı, mutfak kültürünün temel malzemelerinden biri olan yerel otların kullanımını doğrudan etkilemiş, bu etkileşim gastronomi açısından özgün tariflerin ortaya çıkmasına neden olmuştur. Ege Bölgesi'nde zeytinyağlı ve haşlama teknikleriyle hazırlanan ot yemekleri, Doğu Anadolu'da bulgur ve yoğurtla birleşerek tencere yemeğine dönüşmekte, Karadeniz'de ise çorba ve kavurma biçiminde sunulmaktadır. Bu farklılık, ot tüketiminin yalnızca biyolojik bir çeşitlilik değil, aynı zamanda kültürel ve sosyolojik bir çeşitlilikle de iç içe geçtiğini göstermektedir (Tan ve Taşkın, 2009; Karadağ ve Özer, 2022).

Bölgesel farklılıkların bu denli belirginleşmesinde iklim, toprak yapısı, toplumsal yaşam tarzı, tarımsal faaliyetler ve tarihsel alışkanlıklar etkili olmuştur. Aynı ot türü bir bölgede yemeklik olarak değerlendirilirken, başka bir bölgede şifa amacıyla kullanılmakta ya da hiç tanınmamaktadır. Bu durum, ot kültürünün yalnızca doğaya değil, aynı zamanda toplumsal belleğe ve geleneksel bilgiye dayandığını göstermektedir (Çetinkaya ve Yıldız, 2018).

Türkiye'de otların tüketimi, yalnızca ev içi uygulamalarla sınırlı kalmamış, yerel pazarlar, festivaller ve kırsal kalkınma temelli projeler aracılığıyla daha geniş kitlelere ulaşmış, bu sayede hem yerel ürünlerin korunması hem de ekonomik bir değer yaratılması sağlanmıştır. Her bölge, sahip olduğu bitki zenginliğini ve geleneksel kullanım bilgisini modern sunum biçimleriyle birleştirerek kendi gastronomi kültürünü tanıtma imkânı bulmuştur.

Ege Bölgesi

Ege Bölgesi, Türkiye'nin en zengin bitki örtüsüne sahip bölgelerinden biri olarak, yerel otların hem çeşitliliği hem de tüketim sıklığı bakımından öne çıkmaktadır. Akdeniz ikliminin etkisiyle yılın büyük bölümünde yeşil kalan doğası, yabani otların kolaylıkla yetişmesine ve yaygın şekilde toplanmasına imkân tanımaktadır. Bu doğal zenginlik, bölge halkının yüzyıllardır doğayla iç içe bir yaşam sürmesiyle birleşerek, ot kültürünün mutfakla bütünleştiği bir yapıyı ortaya çıkarmıştır (Kök vd., 2020; Karadağ ve Özer, 2022).

Ege Bölgesi'nde en yaygın kullanılan otlar arasında radika, arapsaçı, turp otu, cibez, ebegümeci, labada ve kuşkonmaz gibi türler yer almaktadır. Bu otlar, genellikle zeytinyağı ile haşlama ya da kavurma yöntemiyle hazırlanmakta, sarımsak ve limonla tatlandırılarak sıcak ya da soğuk olarak tüketilmektedir. Bölge mutfağında ot yemekleri, ana öğünlerin ayrılmaz bir parçası hâline gelmiş, özellikle bahar aylarında yapılan ot yemekleri sofralarda ön plana çıkmıştır (Tan ve Taşkın, 2009; İnaltong, 2006).

Otların tüketimi yalnızca ev mutfağıyla sınırlı kalmamakta, aynı zamanda yerel restoranların menülerine de yansımaktadır. Özellikle İzmir, Aydın ve Muğla gibi şehirlerde düzenlenen ot festivalleri, hem bölge halkı hem de ziyaretçiler için önemli bir kültürel etkinlik hâline gelmiştir. Bu festivallerde sunulan yemek çeşitliliği, sadece gastronomik bir deneyim sunmakla kalmamakta, aynı zamanda doğadan gelen geleneksel bilginin gelecek nesillere aktarılmasına katkı sağlamaktadır (Karabak, 2017; Muminjanov ve Karagöz, 2019).

Bölge halkı tarafından toplanan otlar, pazar yerlerinde taze olarak satılmakta, bu uygulama hem ekonomik bir gelir kaynağı yaratmakta hem de yerel ürünlerin korunmasına yardımcı olmaktadır. Ege Bölgesi'nde otların bu denli yaygın kullanımı, bölgesel gıda kültürünün

doğayla olan güçlü bağını açıkça göstermekte, sürdürülebilir yaşam pratiklerinin mutfak üzerindeki etkisini örneklendirmektedir (Kocatepe ve Tırıl, 2015).

Doğu Anadolu Bölgesi

Doğu Anadolu Bölgesi, Türkiye'nin en yüksek rakıma sahip ve sert kara ikliminin etkili olduğu coğrafyalarından biridir. Bu özellikler, bölgede yalnızca belirli dönemlerde yetişebilen, dayanıklı yapıya sahip yabani otların gelişmesini mümkün kılmıştır. Bahar aylarında karların erimesiyle birlikte dağlık ve yaylalık alanlarda belirli türler yoğun biçimde toplanmakta, bu otlar gerek günlük yemeklerde gerekse geleneksel şifa uygulamalarında değerlendirilerek bölgenin kültürel dokusunu beslemektedir (Tuzlacı, 2011; Alan ve Padem, 1989).

Bölge mutfağında en sık karşılaşılan yabani otlar arasında evelik, ışkın, çiriş, madımak, tel pancarı ve mendi gibi türler yer almaktadır. Bu otlar çoğunlukla haşlama veya kavurma yöntemiyle hazırlanmakta, bazı tariflerde yoğurt, bulgur veya süt gibi tamamlayıcı ürünlerle birleştirilerek sunulmaktadır. Erzurum, Van, Hakkâri ve çevresinde yapılan saha çalışmaları, bu otların bölge halkı tarafından hem beslenme hem de sağlık amaçlı tüketildiğini göstermektedir (Çetinkaya ve Yıldız, 2018; Bulut, 2005).

Çiriş otu, Van ve Hakkâri çevresinde hem yemeklik hem de börek içi olarak değerlendirilmekte, bazı evlerde geleneksel yöntemlerle kurutularak kışlık kullanım için saklanmaktadır. Işkın ise doğrudan taze olarak tüketilmekte, bazı bölgelerde reçel yapımında da değerlendirilmektedir. Madımak ise genellikle kavrularak ya da bulgurla birlikte pişirilerek sulu yemek hâlinde sofralara taşınmaktadır. Bu uygulamalar, otların yalnızca mevsimsel değil aynı zamanda dayanıklı biçimde kullanılmasına olanak tanımaktadır (Güvenç ve Kaya, 1996; Tunçtürk vd., 2014).

Doğu Anadolu'da otların mutfaktaki yerinin yanı sıra, halk hekimliği ve geleneksel şifa uygulamalarında da önemli bir rolü bulunmaktadır. Bazı bitkiler sindirim sistemini düzenlemek, bazıları ise soğuk algınlığına karşı koruma sağlamak amacıyla tüketilmektedir. Bu kullanım biçimleri, nesiller boyu sözlü olarak aktarılmış, bölgedeki toplulukların doğayla kurduğu bağı güçlendirmiştir (Bulut, 2005; Doğan vd., 2004).

Otların bu çok yönlü kullanımı, sadece beslenme alışkanlıklarını değil, aynı zamanda ekonomik yaşamı da etkilemektedir. Bahar aylarında yaylalardan toplanan bu otlar yerel pazarlarda satışa sunulmakta, bölge halkı için ek gelir kaynağı oluşturmaktadır. Ayrıca Van otlu peyniri gibi ürünler, bu otların işlenerek geleneksel gıda ürünleri içinde değerlendirilmesine olanak sunmakta, bölgesel gastronominin kimliğini güçlendirmektedir.

Karadeniz Bölgesi

Karadeniz Bölgesi, yıl boyu nemli ve ılıman iklim koşulları, yoğun yağış miktarı ve zengin bitki örtüsü ile Türkiye'nin en yüksek doğal çeşitliliğe sahip alanlarından biridir. Bu ekolojik yapı, yabani otların geniş bir yelpazede yetişmesine olanak tanımış, ot toplama ve değerlendirme alışkanlığı bölge halkının günlük yaşamının bir parçası hâline gelmiştir. Özellikle kırsal yerleşimlerde doğadan toplanan bitkiler, hem beslenme hem de geleneksel sağlık uygulamaları açısından önemli bir yere sahiptir (Demir vd., 2017; Türkan vd., 2006).

Karadeniz mutfağında sık kullanılan yerel otlar arasında ısırgan otu, evelik, karalahana, madımak, pazı, kuşekmeği ve labada öne çıkmaktadır. Bu otlar genellikle çorba, kavurma ya da gözleme iç harcı şeklinde değerlendirilmekte, bölgeye özgü tariflerle birleşerek sofra kültürünün ayrılmaz bir unsuru olmaktadır. Isırgan otu çorbası, mıhlama, karalahana kavurması ve evelik dolması gibi yemekler, Karadeniz mutfağının karakteristik örnekleri arasında yer almaktadır (Yücel vd., 2010).

Bölgedeki ot kullanımının önemli özelliklerinden biri, otların çok yönlü ve mevsimsel olarak değerlendirilmesidir. İlkbaharda taze olarak toplanan otlar, yaz aylarında kurutularak kış tüketimi için hazırlanmakta, bazı türler turşu veya salamura hâlinde de saklanmaktadır. Bu

uygulamalar, hem gıda israfını önlemekte hem de mevsim dışı dönemlerde de bitkisel besin tüketimini sürdürme imkânı sunmaktadır (Çakılcıoğlu vd., 2010).
Karadeniz'de ot toplama bilgisi genellikle kadınlar aracılığıyla kuşaktan kuşağa aktarılmakta, sözlü kültürün taşıyıcısı olan bu bilgi günümüzde de kırsal yaşamın bir parçası olarak varlığını sürdürmektedir. Ayrıca bazı bölgelerde otların pazarlarda satışa sunulması, yerel ekonomiye katkı sağlamakta ve doğal kaynak temelli geçim modellerinin korunmasına olanak tanımaktadır (Demirel ve Samav, 2021). Bu bölgeye özgü ot kültürü, yalnızca mutfakla sınırlı kalmayıp, folklorik anlatılar, yerel deyimler ve mevsimsel kutlamalarla birlikte bütünleşerek, toplumsal hafızada güçlü bir yer edinmiştir. Bu nedenle Karadeniz'deki ot tüketim alışkanlığı, hem biyolojik çeşitliliğin hem de kültürel sürekliliğin bir göstergesi olarak değerlendirilmektedir.

Marmara Bölgesi
Marmara Bölgesi, geçiş iklimi özelliği ve tarım arazilerinin çeşitliliği sayesinde farklı bitki türlerinin bir arada yetişebildiği bir coğrafi yapıya sahiptir. Bu durum, bölge mutfağında hem Ege hem de Karadeniz mutfaklarından izler taşıyan ot kullanım alışkanlıklarının gelişmesine neden olmuştur. Kırsal alanlarda yaşayan halk, mevsimsel olarak doğadan topladığı yabani otları geleneksel tariflerle birleştirerek hem ekonomik hem de kültürel açıdan değerli ürünler ortaya koymaktadır (Tunçgenç ve Tunçgenç, 2008).
Bölgede yaygın olarak kullanılan otlar arasında ebegümeci, labada, gelincik, ısırgan otu, kuşekmeği ve çiriş gibi türler yer almaktadır. Bu otlar çoğunlukla börek içi, kavurma, haşlama ya da yoğurtlu meze olarak tüketilmektedir. Bursa ve çevresinde çiriş otu kullanılarak yapılan börekler, Edirne'de haşlanarak tüketilen labada ve Tekirdağ mutfağında ebegümeciyle hazırlanan kavurmalar, bu bölgesel farklılıkların özgün örneklerini yansıtmaktadır (Taşkın, 2011; Üçer ve Pekşen, 2001).
Marmara Bölgesi'nde ot kültürünün önemli bir özelliği, bu ürünlerin yalnızca geleneksel mutfakta değil, aynı zamanda şehir merkezlerinde yer alan modern restoranlarda da değerlendirilmesidir. Özellikle yerel üreticilerin pazarlarda sunduğu taze otlar, hem kentli tüketicilerin ilgisini çekmekte hem de kırsal kesimde yaşayan bireyler için ek gelir kaynağı oluşturmaktadır. Bu durum, doğal kaynakların sürdürülebilir şekilde değerlendirilmesine ve kırsal kalkınma dinamiklerinin güçlenmesine katkı sağlamaktadır (Kocadağ vd., 2021).

İç Anadolu Bölgesi
İç Anadolu Bölgesi, kara iklimi etkisinde bulunan, geniş bozkır alanlara sahip bir bölge olmasına rağmen, ilkbahar ve yaz aylarında zenginleşen doğal örtüsüyle çok sayıda yabani ot türüne ev sahipliği yapmaktadır. Özellikle kırsal alanlarda doğadan toplanan otlar, bölge halkı tarafından hem günlük yemeklerde hem de kışlık ürün hazırlığında sıklıkla değerlendirilmektedir. Bölgenin geleneksel yaşam biçimi ve tarımsal üretime dayalı kültürü, bu otların mutfaklarda yer bulmasına olanak sağlamaktadır (Yücel vd., 2012; Okcu ve Kaplan, 2018).
Bölgede yaygın olarak kullanılan başlıca otlar arasında madımak, evelik, labada, gelincik, kazayağı, ısırgan otu ve sığır dili yer almaktadır. Bu otlar, çoğunlukla kavrularak, yoğurtla karıştırılarak ya da bulgurlu sıcak yemek olarak hazırlanmakta, bazı tariflerde börek ve gözleme iç harcı olarak da kullanılmaktadır. Madımak yemeği, bölge mutfağının en bilinen örneklerinden biri olup, özellikle Tokat ve çevresinde geleneksel beslenme kültürünün önemli bir parçası hâline gelmiştir (Bulut, 2018; Yücel vd., 2011).

Akdeniz ve Güneydoğu Anadolu Bölgeleri

Akdeniz ve Güneydoğu Anadolu bölgeleri, farklı iklim özellikleri, topografik yapılar ve kültürel miraslarıyla Türkiye'nin bitki çeşitliliği açısından öne çıkan alanları arasında yer almaktadır. Akdeniz iklimi, yıl boyunca yeşil kalan bitki örtüsüyle otların sürekli olarak toplanmasına imkân tanımakta, Güneydoğu Anadolu'da ise kurak yaz koşullarına uyum sağlamış dayanıklı bitki türleri öne çıkmaktadır. Bu farklı ekolojik yapı, otların bölgesel mutfaklara entegre edilme biçimini şekillendirmekte ve her iki bölgeye özgü tariflerin oluşmasına katkı sağlamaktadır (Baytop, 2000; Muminjanov ve Karagöz, 2019).

Akdeniz Bölgesi'nde en sık karşılaşılan otlar arasında turp otu, radika, arapsaçı, hardal otu, sirken, hindiba ve rezene bulunmaktadır. Bu otlar çoğunlukla zeytinyağlı biçimde hazırlanmakta, bazı tariflerde haşlanarak sarımsak ve limonla tatlandırılmaktadır. Antalya, Mersin ve Adana gibi illerde otlar, hem yöresel yemeklerde hem de modern mutfak uygulamalarında geniş bir kullanım alanına sahiptir. Özellikle bahar aylarında düzenlenen ot festivalleri, bu ürünlerin hem ekonomik hem de kültürel değerini artırmaktadır (Certel vd., 2006; Özhan ve Pehlivan, 2022).

Güneydoğu Anadolu Bölgesi'nde ise çiriş, ışkın, evelik, mendik ve heliz gibi otlar ön plana çıkmaktadır. Bu otlar özellikle dağlık alanlardan toplanmakta ve bulgur, yoğurt ya da et ürünleri ile birlikte pişirilerek sofralara taşınmaktadır. Şanlıurfa, Gaziantep ve Diyarbakır gibi şehirlerde yabani otlar yalnızca günlük yemeklerde değil, aynı zamanda geleneksel sağlık uygulamalarında da değerlendirilmektedir. Bazı türler, kurutularak kış aylarında tüketilmekte ve uzun süre saklanabilmektedir (Akan ve Balos, 2023; Alan ve Padem, 1989).

Akdeniz ve Güneydoğu Anadolu Bölgeleri'nde yaygın tüketilen yerel otlar ve kullanım biçimleri Tablo 5'te gösterilmiştir.

Tablo 5. Akdeniz ve Güneydoğu Anadolu Bölgeleri'nde Yaygın Tüketilen Yerel Otlar ve Kullanım Biçimleri

	Yemek Türü / Kullanım Biçimi	Kullanım Alanı	
	Zeytinyağlı, haşlama, salata	Ana yemek, meze	

	Kavurma, salata	Yan yemek, kahvaltı	
	Haşlama, zeytinyağlı, yoğurtlu meze	Meze, detoks yemeği	
	Börek içi, kavurma, kurutulmuş saklama	Hamur işi, sıcak yemek	

	Çiğ tüketim, şerbet, reçel	Tatlı, atıştırmalık	
	Tencere yemeği, yoğurtlu yemek	Ana yemek	
	Otlu peynir yapımında kullanılır	Süt ürünleri	

	Kavurma, zeytinyağlı, salata	Meze, sıcak yemek	
	Kavurma, salamura, kurutularak saklama	Ana yemek, meze	

Kaynak: (Karaman & Sezgin, 2022)

Yerel Pazarlar ve Festivallerde Ot Kültürü

Türkiye'nin farklı bölgelerinde yetişen yerel otlar, yalnızca ev içi tüketimle sınırlı kalmayıp, ekonomik ve kültürel etkinlikler aracılığıyla daha geniş topluluklara ulaşmaktadır. Yerel pazarlar, bu otların satışa sunulduğu, halkla buluştuğu önemli alanlar olarak dikkat çeker. Taze ya da kurutulmuş halde pazarlarda sergilenen otlar, hem üretici hem de tüketici açısından doğal gıdaya erişimin temel kaynaklarından biridir. Bu durum, özellikle kırsal alanlarda yaşayan bireyler için ek gelir yaratmakta, aynı zamanda biyolojik çeşitliliğin ekonomik değere dönüştürülmesine olanak sağlamaktadır (Kocadağ vd., 2021; Doğan vd., 2004).

Yerel pazarlarda otların satışı, çoğu zaman mevsimsel bir düzende gerçekleşmekte, özellikle ilkbahar aylarında ot çeşitliliği ve talep önemli ölçüde artmaktadır. İzmir, Antalya, Şanlıurfa, Artvin ve Tokat gibi şehirlerde bu dönemde pazarlarda gözlenen hareketlilik, yalnızca ekonomik canlılıkla sınırlı kalmamakta, aynı zamanda kültürel bir alışveriş ortamı da sunmaktadır. Pazar tezgâhlarında yalnızca ürün değil, otların nasıl tüketileceğine dair bilgi ve tarif de paylaşılmakta, böylece sözlü kültür canlı tutulmaktadır (Inaltong, 2006; Yücel vd., 2012).

Festivaller ise yerel otların tanıtıldığı, yemeklerin hazırlandığı, halkla doğrudan bir temasın sağlandığı özel etkinliklerdir. Özellikle Ege Bölgesi'nde her yıl düzenlenen Alaçatı Ot

Festivali, bu tür organizasyonların en bilinen örneklerinden biridir. Festival süresince farklı ot türlerinden yapılan yemekler tanıtılmakta, yöresel tarifler atölyelerde uygulanmakta, halk oyunları ve kültürel etkinliklerle geleneksel bilgi kamusal alana taşınmaktadır (Karadağ ve Özer, 2022). Benzer organizasyonlar Mersin, Hatay, Sinop, Tokat ve Van gibi şehirlerde de giderek yaygınlaşmakta, ot kültürü yerel gastronomi turizmiyle bütünleşmektedir.

Yerel pazarlar ve festivaller aracılığıyla otların mutfaktaki rolü yeniden tanımlanmakta, bu ürünler yalnızca beslenme değil aynı zamanda kültürel sürdürülebilirlik açısından da önem kazanmaktadır. Kırsal kalkınma politikalarında bu tür organizasyonların teşvik edilmesi, hem yöresel ürünlerin korunmasına hem de gastronomik mirasın görünürlük kazanmasına katkı sunmaktadır. Otlar, bu yönüyle hem doğal kaynak hem de kültürel değer taşıyan bir unsur olarak geleceğe taşınmaktadır (Etkin, 2000; Muminjanov ve Karagöz, 2019).

Türkiye'de yerel pazarlar ve ot festivalleri Tablo 6'da verilmiştir.

Tablo 6. Türkiye'de Yerel Pazarlar ve Ot Festivalleri

		Öne Çıkan Otlar	
		Radika, turp otu, arapsaçı	

		Sirken, hindiba, hardal otu	
		Işkın, çiriş, mendik	

		Madımak, evelik, labada	

		Kuşekmeği, ebegümeci, evelik	
		Zılk, şevketibostan, gelincik	

		Radika, hindiba, yabani rezene	
		Sirmo (heliz), kekik, yarpuz	

		Radika, turp otu, arapsaçı	Kültürel tanıtım, gastronomi turizmi

Kaynak: (Karabak, 2017)

SONUÇ

Türkiye'nin biyolojik çeşitliliği, kültürel mirası ve geleneksel mutfak yapısı dikkate alındığında, yerel ve geleneksel otların gastronomideki yeri yalnızca beslenme pratikleriyle sınırlı kalmamakta, aynı zamanda halk bilimi, ekoloji, sağlık ve ekonomi gibi çok sayıda disiplini ilgilendiren zengin bir alan açığa çıkarmaktadır. Bu çalışmada yerel otların tanımı, sınıflandırılması, etnobotanik özellikleri ve endemik yayılım alanları bölgesel farklılıklarla birlikte değerlendirilmiş, Türkiye'nin yedi coğrafi bölgesinde bu otlara dair kullanım örüntüleri detaylı biçimde ortaya konmuştur.

Her bölge, sahip olduğu ekolojik özellikler doğrultusunda farklı bitki türlerine ev sahipliği yapmakta, bu otlar geleneksel mutfağın temel bileşenleri arasında yer almaktadır. Ege Bölgesi'nde zeytinyağlı ve haşlama teknikleriyle hazırlanan otlar, Doğu ve Güneydoğu Anadolu'da bulgur, yoğurt ve süt ürünleriyle birleşerek sıcak tencere yemeklerine dönüşmekte; Karadeniz'de çorbalar ve kavurmalarla yerel mutfağa entegre edilmektedir. İç Anadolu'da kurak iklime dayanıklı otlar günlük beslenmenin ve kışlık hazırlıkların bir parçası olurken, Marmara'da hem geleneksel hem de modern gastronomi uygulamalarına uyarlanarak şehir mutfağına taşınmaktadır.

Yerel pazarlarda taze ya da kurutulmuş hâlde satılan otlar, kırsal kalkınma açısından ekonomik bir değer oluşturmakta; festivaller aracılığıyla da hem turistik hem kültürel tanıtım malzemesi olarak işlev görmektedir. Özellikle Alaçatı, Sinop, Hatay ve Van gibi şehirlerde düzenlenen ot festivalleri, bu ürünlerin tanınırlığını artırmakta ve geleneksel mutfak bilgisinin kamusal alanda yeniden dolaşıma girmesine katkı sağlamaktadır.

Bu bağlamda yerel otlar, yalnızca gastronomik bir malzeme değil; aynı zamanda doğayla kurulan ilişkinin, kültürel hafızanın, sağlıklı yaşam arayışının ve kırsal kalkınmanın birleşim noktasında duran çok yönlü bir değeri temsil etmektedir. Bu değer, yalnızca geleneksel bilgiyle değil, aynı zamanda bilimsel çalışmalarla da desteklenmeli; tarımsal sürdürülebilirlik, ekolojik koruma ve kültürel mirasın korunması açısından çok disiplinli bir yaklaşımla ele alınmalıdır.

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ÜLKEMİZDE MANEVİ DANIŞMANLIK VE REHBERLİK UYGULAMALARI: TEMEL NİTELİKLER VE YETERLİLİKLER

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ÖZET
İçinde bulunduğumuz modern dönemde yaşam koşullarının giderek ağırlaşması neticesinde bireyler problemlerini adlandırarak yaşadığı acılar ile başa çıkmada dinlerin ve manevi değerlerin gücünden yararlanmaya başlamışlardır. Günümüzde insanların maneviyat açlığı içerisinde olduğu ve farklı manevi arayışlara girdiği görülmektedir Son yıllarda din ve psikoloji üzerinden yürütülen tartışmalar neticesinde gündeme gelen manevi danışmanlık; modern yaşama giderek yabancılaşan insanlar için büyük bir ihtiyaç olarak ortaya çıkmıştır. Manevi danışmanlık; bireylerin sıkıntılı, üzüntülü, acılı hallerinde ve ortaya çıkan ani kriz durumlarında onlara destek vererek anlam arayışlarına eşlik etme sürecidir. Çıkış noktası Batı Hıristiyanlığı olan manevi danışmanlık, dünyanın farklı ülkelerinde kendisine uygulama alanı bulmuştur. Dünyada Amerika, İngiltere, Singapur gibi bazı ülkelerde okullarda görev yapan öğretmenlere manevi danışmanlık eğitimi verilmekte ve öğrencilerine yardımcı olmaları sağlanmaktadır. Ülkemizde de Diyanet İşleri Başkanlığı'na bağlı Aile İrşat ve Rehberlik Bürolarında başlayan ve "Manevi Danışmanlık" olarak adlandırılan uygulamalar farklı alanlarda giderek yaygınlaşmaktadır. 2019 yılında Diyanet İşleri Başkanlığı'nın başvurusu üzerinde Mesleki Yeterlik Kurumu tarafından Manevi Danışmanlık bir meslek olarak kabul edilmiş, bu alandaki ihtiyacı karşılamak üzere DİB kendi personelini hizmet içi eğitimler yoluyla yetiştirmeye başlamıştır. Diyanet İşleri Başkanlığı'nın çeşitli Bakanlıklarla yaptığı protokollere bağlı olarak her geçen gün hizmet alanı genişleyen manevî danışmanlık çalışmaları hastane, hapishane ve diğer sosyal hizmet kurumlarına yayılmış durumdadır. Manevi danışmanlık kapsamında ele alınan sorunlar, ahlaki ve dini konularda olabildiği gibi gündelik yaşam sorunları ile de alakalı olabilmektedir. Çalışmada manevi danışmanlık ve rehberlik kavramı üzerinde durularak, kurumsal bakış açısıyla bu alanda verilen hizmetlerin nitelik ve yeterlilikleri ele alınacaktır.
Anahtar Kelimeler: Manevi Danışmanlık ve Rehberlik, Dini Danışmanlık. Maneviyat

SPIRITUAL COUNSELING AND GUIDANCE PRACTICES IN OUR COUNTRY: BASIC QUALIFICATIONS AND COMPETENCIES

ABSTRACT
As living conditions in the modern era have become increasingly difficult, individuals have begun to name their problems and benefit from the power of religions and spiritual values in coping with the pain they experience. Today, it is seen that people are hungry for spirituality and are seeking different spiritual pursuits. Spiritual counseling, which has come to the fore as a result of discussions on religion and psychology in recent years, has emerged as a great need for people who are increasingly alienated from modern life. Spiritual counseling is the process of accompanying individuals in their search for meaning by supporting them in distressed, sad, painful situations and in sudden crisis situations. Spiritual counseling, which originated in Western Christianity, has found application in different countries around the world. In some countries such as America, England and Singapore, teachers working in schools are given spiritual counseling training and are provided with the opportunity to help their students. In our

country, the practices called “Spiritual Counseling” that started in the Family Guidance and Guidance Offices affiliated to the Presidency of Religious Affairs and are gradually becoming widespread in different areas. In 2019, upon the application of the Presidency of Religious Affairs, Spiritual Counseling was accepted as a profession by the Vocational Qualifications Institution, and the Religious Affairs Directorate started to train its own personnel through in-service training in order to meet the need in this field. Spiritual counseling activities, which are expanding their service area every day due to the protocols made by the Presidency of Religious Affairs with various Ministries, have spread to hospitals, prisons and other social service institutions. The problems addressed within the scope of spiritual counseling can be related to moral and religious issues as well as daily life problems. In the study, the concept of spiritual counseling and guidance will be emphasized and the quality and competence of the services provided in this field will be discussed from an institutional perspective.
Key Words: Spiritual Counseling and Guidance Religious counseling Spirituality

GİRİŞ

Teknolojik gelişmeler her ne kadar iletişim olanaklarını arttırsa da, insanların birbirinden giderek uzaklaştığı bir gerçektir. Bireyler yaşadıkları problemlerle baş etme noktasında farklı arayışlara yönelirken, manevi danışmanlığın bu noktada önem kazanan bir müessese olduğu görülmektedir.

Yaşadığımız modern dönemde, insanların yaşam koşullarının giderek güçleşmesi, toplumsal ve bireysel krizlerin artmasına yol açmıştır. Bu ve benzeri olaylarla yüzleşen insanoğlu içih problemlerini adlandırmada ve yaşadığı acılar ile başa çıkmada, dinlerin ve manevi geleneklerin önemli bir role sahip olduğu görülmektedir. Manevi geleneklerden hareketle, psikoloji ve din üzerinden yürütülen tartışmalar sonucun da manevi danışmanlık alanı ortaya çıkmıştır. Manevi danışmanlığın çıkış noktasının Batı Hıristiyanlığı olduğu, buradan hareketle dünyanın farklı noktalarında kendine uygulama alanı bulduğu bilinmektedir. Özellikle modern hayat ve modern üretim biçimlerinin yabancılaştırdığı insanlar için, manevi danışmanlık büyük bir ihtiyaç olarak görülmektedir.

Manevi danışmanlık hizmetleri dini mekânlar dışında ülkemizde cezaevleri, hastaneler ve huzurevleri gibi farklı alanlarda uygulanmaktadır. Son yıllarda yaşlılar, engelliler, koruma altındaki çocuklar gibi dezavantajlı gruplara yönelik olarak da bu uygulamaların yaygınlaştığı göze çarpmaktadır (Koç Kanca, 2022).

MANEVİYAT VE MANEVİ DANIŞMANLIK KAVRAMI

Tarih boyunca insanoğlu karşılaştığı zorluklar karşısında manevi bir arayış içerisinde çare bulmaya çalışmış; din kurumu bireylerin sığındığı temel kurumlar arasında yer almıştır. İçinde bulunduğumuz çağda teknoloji ne kadar gelişirse gelişsin insanların farklı manevi arayışlara girdiği görülmektedir. İnsanlık için bir anlam kaynağı haline gelen maneviyat kavramı konusunda son yıllarda yapılan çalışmaların arttığı görülmektedir. Batı’da özellikle 1980’li yıllardan itibaren bu alanda yapılan çalışmaların ivme kazandığı dikkat çekmektedir.

Maneviyat ve dinin psikolojik açıdan en önemli faydası, bireyin anlam dünyasını oluşturmasına yardımcı olan sunduğu değerler ve hayata dair açıklamalarıdır. Ayrıca din/maneviyat, sosyal açıdan da kişinin sağlıklı ilişkiler kurmasına katkı sağlayarak yönlendirici bir rol oynamaktadır (Ekşi ve ark.2016). Araştırmalar, dinin ve maneviyatın sosyal destek sağlaması ve sosyal uyumu kolaylaştırmasının, yalnızlık duygusunu ve sosyal izolasyonu azalttığını ve psikolojik sağlamlığı olumlu etkilediğini göstermektedir (Ekşi ve ark.2020; Gürkan, 2022). Maneviyat kavramı ilk dönemlerde din ile olan ilgiye işaret ederken günümüzde farklı şekillerde tanımlanmaktadır(Palouzian,2013: 61-102).İçinde bulunduğumuz çağda maneviyat, dini değerlerin yanı sıra kültürel nitelikleri de kapsayan genel bir kavram olarak kullanılmaktadır (Erdem, 2017: 36).

Bilimsel gelişmeler insanlığa birçok fayda sağlamakla birlikte, ölüm ve sonrasını açıklama, teselli bulma, duygularını tatmin etme konusunda yetersiz kalabilmektedir. Bu noktada bireylerin dini ve manevi açıdan desteklenmeleri önem taşımaktadır. İçinde bulunduğumuz modern dünyada bir takım krizlerle karşı karşıya kalan, yaşamını anlamsız bulan bireylerin yaşadıkları huzursuzlukları gidererek, destek olma ihtiyacı manevi danışmanlık ve rehberlik hizmetlerinin ortaya çıkmasına zemin hazırlamıştır (Düzgüner & Ayten, 2021: 48- 49).

Literatürde manevi bakım, manevi destek, dini danışmanlık ve manevi danışmanlık kavramlarının benzer şekilde kullanıldığı görülmektedir. Maneviyat: bireyin yüce ve kudretli bir güçle kurduğu ilişkiye işaret ederken; manevi danışmanlık uygulamaları din dışında kişisel bir takım problemlere de odaklanmaktadır (Dilen, 2019: 5-9).

Manevi danışmanlık; yaşanan sorunlar karşısında insanlara olumlu bir bakış açısı kazandırarak, onları desteklemeyi amaçlamaktadır (Ekşi,2020: 83). Selçuk'a (2003: 458) göre manevi danışmanlık; "Bir din görevlisinin birebir veya küçük grup ilişkisiyle, yaşamlarındaki problemlerini çözmede onlara yardımcı olma ve birey olarak potansiyellerini kullanmayı geliştirme uygulamasıdır".

Günümüzdeki dini ve manevi danışmanlığın temelini "pastoral care" ifadesi oluşturmaktadır (Ay, 2010: 191). Pastor kelimesi "papaz, mürşit" anlamındadır (İngilizce- Türkçe Sözlük, 1973). Care ise "bir kişiyi çok sevdiği için onunla ilgili olup bitenlerle ilgilenme" şeklinde tanımlanmaktadır (Ok, 2008: 550). Pastoral care, dini temsilcilerin bireyi manevi açıdan desteklemesi, ona yol göstermesi ve nasihat etmesi olarak kabul görmüştür (Cebeci, 2010: 54). Pastoral danışmanlık, Hristiyan ve Yahudi inanışında yer alan bir uygulama olup, bu danışmanlık türünde kişilerin bireysel ve sosyal sorunlarıyla da ilgilenilmektedir. Kavramın psikoloji alanında yetkin din adamlarının kilise dışı faaliyetlerini de ifade etmek amacıyla kullanıldığı görülmektedir (Cebeci, 2012: 63).

Pastoral danışmanlık uygulamalarında dinin insan yaşamındaki etki ve öneminin farkında olmak, psikolojinin tekniklerini göz önünde bulundurmak ve bu alanlardaki gelişmeleri takip etmek önem taşımaktadır (Özdoğan, 2006: 132). Clebsch & Jaekle, manevi danışmanlığın din görevlileri tarafından; bireysel sorun yaşayanları "iyileştirme", hastane, yurt gibi yerlerdeki grupları psiko-sosyal açıdan "destekleme", anlam arayışı içinde olan, hayatında evlilik ve emeklilik gibi yeni dönemeçlerde bulunanlar için ise "yönlendirme" boyutlarından söz etmektedir (aktaran Koç, 2012: 203-204).

Manevi danışmanlık; alanında uzman danışmanlar tarafından yaşadığı sorunlarla baş etme sürecindeki bireylere istek, ihtiyaç ve yönelimlerine göre dini ve manevi tekniklerin kullanılarak destek hizmetinin verilmesidir. Manevi danışmanın görevi sadece kriz dönemlerinde değil, bireylere ve gruplara ihtiyaç duydukları anlarda yardımcı olarak rehberlik etmek ve onları cesaretlendirmektir. Manevi danışmanlar genellikle dinin temsilcileri olarak kabul edilse de, manevi danışmanlık hizmetinin amacı, danışanlara din öğretmek veya doğru dini anlayışı dayatmak değildir (Çağlar ve Göcen, 2020). Clinebell (Aktaran: Koç Kanca, 2022) manevi danışmanlığın temel hedefinin iyi olmayı desteklemek, olumlu davranış değişiklikleri gerçekleştirmek olduğunu ifade etmektedir. Manevi danışmanlık hizmetleri bireyin fizyolojik ve psikolojik dünyası dışında ailesini ve sağlık personelini de kapsamaktadır. Manevi danışmanlığın temel felsefesi; inanç, mezhep, ırk, dil ayrımı yapmaksızın her insanı olduğu gibi kabul ederek, saygı ve hoşgörü çerçevesinde yardıma ihtiyaç duyan bireylere bu hizmeti götürmektir.

Manevi rehberlik sürecinde güven telkin etmek, mahremiyeti korumak, kişiye özerklik tanımak, pozitif yaklaşım sergilemek, empati kurmak, saygı göstermek, gerçekçi olmak, danışmanlık (konuşma) becerisine sahip olmak, sonuca ve faydaya odaklı olmak gibi temel ilkeler önem taşımaktadır. **Manevi danışmanlığın acılar ve travmalar karşısında iyileştiricilik rolü, bunalımlı ve gerilimli zamanlarda yardımcı olmak, çaresizlik**

anlarında yol gösterici olmak, zihnen ve ruhen güçlendirme, özgürleştirici fonksiyonları bulunmaktadır.

Manevi Danışmanların Sahip Olması Gereken Yeterlilikler

Manevi danışmanların sahip olması gereken yeterlilikler Diyanet İşleri Başkanlığı tarafından şu şekilde belirlenmiştir:

- İlahiyat alan bilgisi ve becerisi
- Manevi danışmanlık ve rehberlik faaliyetlerine uygun çalışma ortamı özellikleri hakkında bilgi
- Çalışma ortamını manevi danışmanlık ve rehberlik faaliyetlerine uygun hale getirme becerisi
- Manevi danışmanlık ve rehberlik faaliyetlerinde kullandığı araç, gereç, ekipman ve malzeme ve karşılaması gereken özellikler hakkında bilgi
- Manevi danışmanlık sürecine dair bilgi ve dokümanları kayıt sistemine ve gizlilik kurallarına uygun olarak kayıt altına alma bilgi ve becerisi
- Manevi danışmanlık sürecinde tutulan kayıtları oluşturulan sisteme göre yedekleme yaparak arşivleme becerisi
- Manevi danışmanlık sürecinde kişisel bilgilerin gizliliği ve güvenliğini sağlama bilgi ve becerisi
- Danışanın destek almak istediği konu kendi uzmanlık bilgisinin dışında farklı uzmanlık gerektiriyorsa ilgili birime yönlendirme becerisi
- Danışanın ihtiyacı doğrultusunda manevi destek gereksinimlerini belirleme becerisi
- Danışanın destek almak istediği konunun kapsamını belirleme becerisi
- Danışanın din ve maneviyatla ilişkilendirdiği olumsuzluklar ve kritik yaşam olaylarında, kayıplarla başa çıkma sürecinde ona eşlik etme becerisi
- Danışanın olumlu davranışlarının güçlendirilmesinde manevi danışmanlık sağlama becerisi
- Manevi konularda rehberlik yapma becerisi
- Bireyi veya grubu manevi boyut ve bunun desteklenmesi konusunda bilgilendirme becerisi
- Aldığı geri bildirimlere göre danışanın manevi danışmanlık ihtiyacının giderilip giderilmediğini belirleme becerisi
- Meslektaşlarıyla periyodik olarak deneyim paylaşımında bulunma becerisi.

MANEVİ DANIŞMANLIK VE REHBERLİĞİN TARİHİ GELİŞİMİ

Manevi (psikolojik) danışmanlığın köklerini, tarihin en eski dönemlerine kadar götürmek mümkündür. Antik çağdan bu yana ruhsal hastalıkları tespit edip tedavi etmeye çalışanların genellikle papazlar, rahipler, şamanlar ve medyumlar gibi manevi toplum temsilcileri olduğu görülmektedir. Bu dönemlerden itibaren özellikle akıl hastalıkları, kötü metafizik güçlerin neden olduğu istenmeyen durumlar olarak kabul edildiği için din adamlarının söz konusu rahatsızlıklara şifa bulma amaçlı müdahaleleri olagelmiştir. Öte yandan modern anlamda manevi danışmanlık çalışmalarının Batı'daki tarihsel gelişim sürecine bakıldığında ise, Anton Boisen'in klinik çerçevedeki pastoral çalışmaların öncüsü olduğu görülmektedir. XX. yüzyılın ilk çeyreğinde, "Teolojinin Görevi ve Metotları" isimli çalışmasında bu alanın metodolojisiyle ilgili kişisel yaklaşımını yazan Boisen (1926), inançların kökenini araştırma ve anlama konularında teolojinin, iyi bir bakış açısı sunabileceğini vurgulamıştır.

Bu alandaki kurumsal çalışmalar ise 1930'ların başında, Norman Vincent Peale ile Smiley Blanton'un ortak çalışmalarıyla Amerikan din ve psikiyatri vakfı öncülüğünde yapılmıştır (Şirin, 2014: 33-34). 1940'lı yıllardan itibaren Amerikan Psikoloji Derneği tarafından manevi danışmanlık alanında din psikologları çalışmaya başlamıştır. Bu alanda faaliyet yürüten Transpersonal Psikoloji ve Amerikan Pastoral Danışmanlar Derneği de bu amaçla 1963 yılında kurulmuştur (Şirin, 2014: 35; Yaman, 2016: 84).

Batı'daki manevi danışmanlık hizmetleri, genellikle papazların çalıştıkları kiliselerin yanı sıra hastane, (Larry,2004): 153) huzurevi ve cezaevi gibi kurumlar ekseninde, somut olarak 'günah çıkarma, bebeğin doğuşu/vaftiz edilme, bir evliliğin kutsanması ve cenaze hizmetleri kapsamında ölenlerin ailelerini teselli etme' vb. konular üzerinde uygulanmaktadır. Manevi (psikolojik) danışmanlık hizmetlerinin temelinde, psikolojik rehberlik bağlamında, danışanların günah çıkarmalarını sağlayarak ruhsal sağaltımı gerçekleştirme yer almaktadır. Manevî danışmanlık, dinsel ve ruhsal problemlerin çözümünde kullanılan bir çeşit uygulamalı terapötik danışma sürecini ifade etmektedir(http//www.sanalpsikolog.com).

Başta İngiltere ve Almanya olmak üzere Avrupa ülkelerinde de manevi danışmanlık hizmetlerinin ABD ile eş zamanlı olarak ortaya çıktığı görülmektedir. ABD'de bugün farklı kurumlarda Sağlık Kuruluşlarının Akreditasyonu Birleşik Komisyonu (Joint Commission on the Accreditation of Healthcare Organizations JCAHO) veya Danışma ve Psikolojik Hizmetler Komisyonu (Commissionfor Counseling and Psychological Services-CCAPS) gibi kurumlar tarafından belgelendirilen ve denetlenen manevi danışmanlar görev yapmaktadır.

Ülkemizde manevi danışmanlık ve rehberlik hizmetleri başlangıç aşamasında olmasına rağmen bu alanda yapılan çalışmaların giderek arttığı görülmektedir. Bu alanda ilk kurumsal çalışma 1950'de DİB (Diyanet İşleri Başkanlığı) tarafından hükümlülere yönelik hazırlanan vaaz kitabıyla başlamıştır. 1982'de Din Kültürü ve Ahlak Bilgisi dersleri, 1983'de vaiz kadrosunun tahsis edilmesi, 2001'de Adalet Bakanlığı ile yapılan protokol de göstermektedir ki ülkemizde manevi danışmanlıkla ilgili ilk faaliyet alanı ceza evleri, ilk danışanlar hükümlüler olmuştur. Diyanet İşleri Başkanlığında Aile İrşat ve Rehberlik Büroları 2003'de kurulmuş adı daha sonra Aile ve Dini Rehberlik Büroları olarak değiştirilmiştir. Başkanlık; Aile ve Sosyal Politikalar Bakanlığı ile 2011'de, Türkiye Yeşilay Cemiyeti ile 2014'de, Sağlık Bakanlığı ve Gençlik ve Spor Bakanlığı ile 2015'de AFAD ile 2016'da protokol imzalamıştır. Böylece hastaneler, cezaevleri, kadın konuk evleri, yaşlı bakımevleri, sevgi evleri gibi pek çok kurumda; hastalar, yaşlılar, çocuklar, bağımlılar, mahkûmlar, engelliler, gençler, afetzedeler ve Göç ve Manevi Destek Hizmetleri Daire Başkanlığı'nın kurulmasıyla da mülteciler gibi pek çok kimseye manevi danışmanlık hizmeti verilmeye başlanmıştır (Baygeldi,2018: 10; Düzgüner ve Ayten, 2021: 61- 65).

Ülkemizde 2015 yılında Diyanet İşleri Başkanlığı ile Sağlık Bakanlığı arasında imzalanan protokol çerçevesinde sahada çalışacak manevi danışmanların eğitim çalışmaları yapılmış, Mesleki Yeterlik Kurumu (MYK) tarafından 2019 yılında "Manevi Danışmanlık" unvanının kabul edilmesi ile süreç daha da hızlanmıştır. Ülkemizde manevi danışmanlığın bir meslek olarak tanımlanmasına varan süreçte Diyanet İşleri Başkanlığı din eğitimi ve din hizmetleri alanında dini ihtiyaçları karşılamak üzere çeşitli faaliyetler yürütmüştür (Ulusal Meslek Standardı, 2019:7). Buna göre çeşitli kamu ve özel kurumlarda görev alan manevi danışmanlara hizmet içi eğitimler düzenlenmiş, bu eğitimlerin içerikleri Diyanet İşleri Başkanlığı bünyesinde görev yapan uzmanlar tarafından belirlenmiştir (Dini Danışmanlık Manevi Rehberler Eğitim Semineri, 2018).

Çeşitli devlet kurumları ile işbirliği protokollerinin imzalanması neticesinde "Manevi Bakım ve Danışmanlık" alanı ile ilişkilendirilebilecek lisansüstü ve sertifika programları açılmıştır (Yenen, 2017: 157-219). Ülkemizde Diyanet İşleri Başkanlığı tarafından alandaki ihtiyacı karşılamak amacıyla görevlendirmeler yapılmış, personelin yüz yüze veya uzaktan bir yüksek din öğretimi lisans programından (İlahiyat Fakültesi, İslami İlimler Fakültesi, İlahiyat Lisans Tamamlama Uzaktan Eğitim Programı gibi) mezun olmaları şartı aranmıştır. Ülkemizde bu alanda bir özel bir lisans programı bulunmamakta, hâlihazırdaki İlahiyat lisans programlarının tek başına bu noktada yeterli olmadığı görülmektedir.

2010'lu yıllardan başlayarak Türkiye'de manevi danışmanlık akademik çevrelerde tartışılmaya başlanmış; 2013 yılında Samsun 19 Mayıs Üniversitesi Sosyal Bilimler Enstitüsü bünyesinde "Dini Danışmanlık ve Rehberlik" tezsiz yüksek lisans programının açılmasıyla bir üst noktaya

taşınmıştır (On Dokuz Mayıs Üniversitesi Sosyal Bilimler Enstitüsü, 2020). Bu gelişmenin ardından Erzurum Atatürk Üniversitesi'nde aynı adla bir tezsiz yüksek lisans programı daha kurulmuştur. (Atatürk Üniversitesi İlahiyat Fakültesi, 2020)
2015 yılında DİB'in hastanelerde "manevi destek" hizmetine başlayarak bu kurumlarda hizmete özel personel görevlendirmesiyle üniversitelerdeki ilgili girişimler de hız kazanmıştır. Beş yıllık bu süreçte pek çok üniversitede "Manevi Bakım ve Danışmanlık," (Ankara Sosyal Bilimler Üniversitesi, 2020.) "Manevi Destek ve Danışmanlık" (Katip Çelebi Üniversitesi, 2020), ve "Dini Danışmanlık ve Rehberlik" (Necmettin Erbakan Üniversitesi, 2020) isimleriyle tezsiz yüksek lisans programları açılmıştır. 2018 yılında ise İstanbul Sabahattin Zaim Üniversitesi (İSZÜ) Sosyal Bilimler Enstitüsü bünyesinde ilk kez olarak "Manevi Danışmanlık ve Rehberlik" tezli yüksek programı açılmıştır. Bazı üniversitelerde aynı dönemlerde üniversitelerin sürekli eğitim merkezleri bünyesinde (İstanbul Sabahattin Zaim Üniversitesi, 2020) "Manevi Rehberlik ve Danışmanlık" (Selçuk Üniversitesi Sürekli Eğitim Merkezi, 2020) ve "Manevi Rehberlik ve Değerler Eğitimi" (Yalova Üniversitesi Sürekli Eğitim Merkezi, 2020) gibi sertifika programları da açılmaya başlanmıştır. Eğitimlerin kurumsal açıdan uygun şekilde gerçekleştirilebilmesi için Sakarya Üniversitesi'nde de Sosyal Bilimler Enstitüsüne bağlı bağımsız bir Manevi Danışmanlık ve Rehberlik Anabilim Dalı kurulmuştur (Sakarya Üniversitesi Manevi Danışmanlık ve Rehberlik Anabilim Dalı, 2021). Diğer lisansüstü programların İlahiyat Fakülteleri bünyesinde açıldığı görülmektedir.
Ülkemizde din hizmetlerini yürütmekle görevli Diyanet İşleri Başkanlığı bu görev doğrultusunda manevi danışmanlık hizmetlerinin yürütülmesinden sorumludur. Bu kapsamda Diyanet İşleri Başkanlığı tarafından ihtiyaç duyulan yerlerde dini danışmanlık bürolarının açılmasıyla ilgili çalışma yapılmak, aile sorunlarının çözümüne yönelik dini danışmanlık ve rehberlik hizmeti sunulmasını sağlamak, sosyal ve kültürel değişimler sonucu karşı karşıya kaldığı riskler ve yeni sorunlar karşısında aileyi güçlendirmek için aile bireylerine manevi destek hizmeti sunmak, sevgi evleri, huzurevleri, yetiştirme yurtları, kadın konuk evleri gibi sosyal hizmet kurumlarında dini rehberlik hizmeti sunulmasın sağlamak, çeşitli nedenlerle yurt içinde göç etmek durumunda kalan vatandaşlarımıza dini danışmanlık ve manevi destek sunulması gibi faaliyetler yürütülmektedir (https://dinhizmetleri.diyanet.gov.tr/sayfa/49/ (09/07/2020).

MANEVİ DANIŞMANLIĞIN UYGULAMA ALANLARI

Manevi danışmanlık ve rehberlik hizmetleri, kurumsal anlamda ilk olarak askeri alanda uygulanmaya başlanmış (Karaaslan, 2018), bunu hastaneler izlemiştir. (Şirin, 2016). Hekimler ve sağlık personeli, bireyin fiziksel sağlık boyutuna odaklanırken; psikologlar, psikolojik danışmanlar ve psikiyatristler psikososyal boyutlarına destek sağlamaktadırlar. Manevi danışmanlar ise bireylerin kendi sorunlarına, inançlarıyla ilişkilendirilmiş çözümler geliştirmelerine destek olmaktadırlar (Güven, 2021). Manevi danışmanlık ve rehberlik hizmetlerinin yaygınlaşmasıyla birlikte, huzurevleri, cezaevleri, yurtlar, kadın sığınma evleri, çocuk esirgeme kurumları gibi insanların manevi destek ve rehberliğe ihtiyaç duydukları hemen her yerde bu hizmet sunulmaya başlanmıştır (Baygeldi,2018; Karaaslan, 2018; Topuz, 2016).

Aile ve Sosyal Politikalar Bakanlığı'na (ASPB) Bağlı Kurumlarda Kalan Çocuklara Uygulanan Manevi Destek Hizmetleri

Diyanetin manevi kapsamlı destek çalışması, Sosyal Hizmetler ve Çocuk Esirgeme Kurumu (SHÇEK) ile 1989 tarihinde başlamıştır. 2007 yılında SHÇEK ve Diyanet İşleri Başkanlığı arasında protokol imzalanmış; 2011 tarihinde Aile ve Sosyal Politikalar Bakanlığı kurulmasının ardından Diyanet İşleri Başkanlığı bu hizmetleri Dini Rehberlik Daire Başkanlığı eliyle yürütmeye başlamıştır (Din Hizmetleri, 2016: 66). Protokollerde çocuk yanında çocuğun anne- babası ve ailesi de öncelikli olarak ele alınmıştır.

Söz konusu protokolde ailevi problemlere yönelik çözüm öneriler ortaya koymak, danışmanlık hizmetleri vermek Türk aile yapısının karakteristik özelliği de dikkate alınarak araştırma sonuçlarına dayalı eğitim ve seminerler düzenlemek, ailelerin parçalanmasına yol açan sebepleri ortadan kaldıran tedbirler almak ve projeler geliştirmek, çocuğun korunması ve çocuk haklarıyla ilgili duyarlılığı artırıcı faaliyetler yapmak, özellikle dini ve milli günler olmak üzere çeşitli zamanlarda ahlaki, dini ve milli duyguları geliştirmeye yönelik etkinlikler düzenlemek, engellilere yönelik din hizmetlerine ağırlık vererek, ibadetlere katılma ve din eğitimi hizmeti alma imkanı sağlamak, gibi hususlara yer verilmiştir. (Diyanet, 2007 ve 2018).

İlgili protokol çerçevesinde, İl ve İlçe Müftülükleri bünyesindeki dini açıdan uzman olan vaiz ve vaizeler görevlendirilmiştir. İlgili personelin söz konusu evlerde veya yurtlarda yapıkları programlar, Kur'an öğretimi, sohbet etme, dini bilgiler öğretme, birlikte bazı programlara katılma, belli mekân ziyaretleri, özel gün ve gecelere ait özel programlar olmaktadır. .

Gençlere Yönelik Manevi Destek Hizmetleri

Diyanet İşleri Başkanlığı tüm kesimlere olduğu gibi gençlere yönelik de manevi destek hizmeti sunmayı amaçlamıştır. Bu çerçevede gençlere yönelik tüm hizmetlerine dair Gençlik ve Spor Bakanlığı ile imzaladığı 2018 tarihinde Başkanlık onayıyla yürürlüğe giren bir yönerge hazırlamıştır. Söz konusu yönerge, 2015 tarihli Diyanet İşleri Başkanlığı ile Gençlik ve Spor Bakanlığı arasında imzalanan işbirliği protokolüne dayanılarak yapılmıştır. Söz konusu yönergede temel yaklaşım "gençlerin; bilgi, ahlak, erdem, estetik, ruh güzelliği ve merhamet duygusuyla yetişmelerine, milletimizi bir araya getiren değerlerin, insani haslet ve faziletlerin nesilden nesle aktarılarak üretilmesine katkı sağlayacak; toplumun geleceğe umutla bakabilmesi için insani erdemlerle donatılmış, her yönden iyi yetişmiş, ruhen ve bedenen dinamik bir gençliğe sahip olmasını temin edecek bir yaklaşım benimsenir" (Diyanet İşleri Başkanlığı Gençlik Çalışmaları Yönergesi, Madde-5 (1) şeklinde ifade edilmiş ve söz konusu bu hizmet manevi rehberlik ve din hizmeti olarak nitelendirilmiştir.

DİB, gençlere yönelik manevi destek hizmetleri çerçevesinde ilk olarak kurum içinde bu alanda hizmet verecek gençlere rehberlik ve öncülük yapacak gençlik koordinatörleri il ve ilçe müftülükleri tarafından belirlenmeye başlanmıştır. Gençlik koordinatörleri öğrenci yurtları, gençlik merkezleri ve kamplarında gençlerle bir araya gelmekte ve onlara rehberlik yapmaktadır.

DİB'in gençlere yönelik manevi destek hizmetinin diğer ayağı ise, Diyanet Gençlik Merkezleri, okuma salonları, öğrenci evleri açmak ve gençlik kampları düzenlemek olarak ifade edilebilir. Bu bağlamda ise Kredi Yurtlar Kurumuna (KYK) bağlı yurtlar başta olmak üzere öğrenci yurtlarında barınan gençlik merkezlerinden hizmet alan ve gençlik kamplarına katılan öğrencilere dini danışmanlık ve manevi rehberlik yapmak üzere Başkanlıkça personel görevlendirilmesine ve gençlik merkezleri gençlik kamplarına, başkanlığın personellerinin aktif katılımına karar verilmiştir. Söz konusu evlerde ve yurtlarda kalan öğrencilere uygulanacak manevi rehberliğe dair hangi konuların hangi başlıklar ve görevli tarafından inceleneceğinin belirlendiği müfredat ise Başkanlık tarafından belirlenmektedir. Bu müfredatta genellikle dini bilgiler, tarih şuuru ve medeniyet algısı gibi konular işlenmektedir.

26 Şubat 2015 tarihinde de Gençlik ve Spor Bakanlığı ile Diyanet İşleri Başkanlığı arasında "Değerler Eğitimi" işbirliği protokolü imzalanmış, söz konusu protokol kapsamında bakanlığa bağlı yurtlarda, tesislerde, kamplarda ve gençlik merkezlerinde beden ve ruh sağlıkları ile manevi gelişimlerine katkıda bulunulması amacıyla gençlere, Diyanet İşleri Başkanlığı'na bağlı görevliler tarafından din ve değerler eğitimi verilmesi kararı alınmıştır (Diyanet Protokol 2018) İlgili protokol çerçevesinde yapılan çalışmalarla genç bireylerin beden ve ruh sağlıklarına, manevi gelişimlerine katkıda bulunulması amaçlanmaktadır.

DİB'in gençlere yönelik manevi hizmetlerde işbirliği içinde bulunduğu diğer bir kurum ise Milli Eğitim Bakanlığı'dır. DİB bu çerçevede müftülüklerden her okuldan gönüllü olan

gençlerden Başkanlığın çalışmalarını koordine etmek amacıyla temsilci belirlemesini ve söz konusu temsilcilerle periyodik değerlendirme toplantıları yapmasını talep etmiştir.

Yaşlılara Yönelik Manevi Destek Hizmetleri

Manevi ve dini desteğin yaşlılardaki ölüm korkusunu hafifletmede, arkadaş kazanmada, problem ve sıkıntılar karşısında çözüm bulmada, çaresizlik durumunda rahatlamada, duygusal boşluğun doldurulmasında etkin bir role sahip olduğu toplum tarafından kabul edilmektedir. Huzurevlerinde yapılan her türlü manevi destek ve faaliyet SHÇEK ve Diyanet İşleri Başkanlığı arasında yapılan protokoller doğrultusunda yürütülmekte; ilgili protokol çerçevesinde Diyanet İşleri Başkanlığı'nın faaliyetlerinin ilk adımını konuyla ilgili verilen hutbeler, vaazlar, konferanslar broşürler, yazılı ve görsel yayınlar, kamu spotları oluşturmaktadır. Bunun dışında huzurevlerinde kalan yaşlılara yönelik manevi destek çalışmaları yürütülmekte; bu doğrultuda müftülüklerle beraber oluşturulan programlarla ziyaretler, sohbetler, rehberlik faaliyetleri, ibadetler, etkinlikler yapılmaktadır. Bunlar arasında önemli dini gün ve gecelerde programlar planlama, belirli aralıklarla huzurevleri ziyaretleri, birebir yüz yüze özel görüşmeler yapma, isteyene Kur'an öğretimi gibi faaliyetler sayılabilir. (Din Hizmetleri Genel Müdürlüğü, 2016: 64- 65). Bu hizmetler, yaşlıların sevgi, ilgi, moral, güven, inanç gibi manevi ihtiyaçlarının karşılanmasında önemli bir yer tutmaktadır.

Engellilere Yönelik Manevi Destek Hizmetleri

Engelli çocuğu olan ailelerin ve engelli bireylerin öncelikle içinde bulundukları durumu kabullenme daha sonra bu duruma dair duygu, sıkıntı ve zorluklarla baş edebilme, çevredekilerin gösterdikleri olumsuz davranış ve tepkilerden daha az etkilenme ve bulundukları konumu daha anlamlı kılabilme açısından manevi desteğin gerekliliği açıktır.
Diyanet İşleri Başkanlığı bu çerçevede 111 din görevlisinin 81 ilde engellilere ve ailelerine manevi rehberlik hizmeti sunmasını sağlamıştır (Din Hizmetleri, 2016: 65). Her koordinatör görev yaptığı ilde kaç engelli bulunduğunu, bu engellilerin nerede, kimlerle yaşadığını ve ne iş yaptığı konusunda bilgi edinerek ve ailelerle belli aralıklarla görüşmeler yapmıştır. Engellilerin katılımı ile yapılan bu sunumlarla engellinin hayata tutunması kolaylaştırılmıştır. İl koordinatörlerinin yanı sıra her ilçede de bu hizmeti organize edecek ve yürütecek ilçe koordinatörleri belirlenmiş, İl ve ilçe koordinatörlerinin engellilere hizmet veren STK ve kuruluşlarla ortak çalışmalar yapması ve bu kapsamda Aile ve Sosyal Politikalar Bakanlığı ve Milli Eğitim Bakanlığı ile sürekli iş birliği halinde olmaları istenmiştir (Din Hizmetleri, 2016: 64).DİB, söz konusu proje kapsamında engelli okul, kurs ve rehabilitasyon merkezlerinin periyodik aralıklarla ziyaret edilmesi, engellilere özel sosyal ve kültürel etkinlikler düzenlenmesi, engellilerin manevi gelişimlerine katkıda bulunacak faaliyetlerin planlanması, özellikle engelli ailelerinin psikolojik, manevi ve dini açıdan desteklenmesi için vaaz ve yüz yüze görüşmelerin yapılmasını hedeflemektedir.
DİB'in manevi destek hizmeti verdiği gruplar arasında protokol yapılmayan tek alan engelli grubudur. Yapılan faaliyetler Aile ve Sosyal Politikalar Bakanlığı Engelli ve Yaşlı Hizmetleri Genel Müdürlüğü ile yapılan koordineli çalışmaları (Din Hizmetleri, 2016: 65) ve kurumun kendi içinde resmi yazışmaları ve projeleri bağlamında sürdürülmektedir. Bu bağlamda daha etkin faaliyet yapılabilmesi için işbirliği protokollerine ihtiyaç bulunmaktadır.

Adalet Alanında Manevi Destek Hizmetleri

DİB'in manevi destek uygulamalarının yapıldığı diğer bir saha ise adalet alanındadır. Bu alandaki manevi destek, cezaevlerinde bulunan tutuklu ve hükümlülere yönelik hizmetleri kapsamaktadır. Yapılan protokollerle (Adalet Bakanlığı ve DİB, Protokol 2001 ve 2011) cezaevlerinde bulunan tutuklu ve hükümlülerin manevi duygularını güçlendirerek hem

yaptıkları hata/hataların farkına vardırmak hem de bu hataların tekrarlamamalarını sağlayarak bu insanların topluma yeniden katılabilmelerini desteklemek, tutuklu ve hükümlerin dini duygularını bir motivasyon aracı olarak kullanılmasıyla bireyin kendi içinde barışık bir kişiliğe sahip olmasını sağlamak, tutuklu ve hükümlülerin manevi duygularını güçlendirerek dini ve milli bir kimlik kazandırılmasını sağlamak, manevi duyguların ihtiyacından ve gerekliliğinden bahsedilerek bunların önemini belirtmek, tutuklu ve hükümlülerin yanlış din veya eksik din anlayışlarını düzelterek din konusunda doğru bilgilenmelerini sağlamak amaçlanmaktadır. Amaçları bu şekilde ortaya konulan bu protokollerle, mahkumların ıslah edilmelerine destek ve daha sonrasında kendilerine ve topluma yararlı fertler olmalarına vesile olmak hedef olarak belirlenmiştir. Tutuklu ve hükümlülerin sadece manevi ihtiyaçlarını karşılamak hedeflenmemiş aynı zamanda sorunlarla baş etme ve bu kişileri güçlendirme de bu uygulamalarla hedeflenmiştir.

Diyanet İşleri Başkanlığı tarafından Adalet Bakanlığı ile yapılan protokoller çerçevesinde din adamlarına cezaevlerinde bulunan tutuklu ve hükümlülerin manevi hassasiyetlerine uygun olarak onların hayata bakışını olumlu etkileyecek, onlara umut verecek görevlilerin manevi destek hizmetlerini sağlamasını istemiş, (Bulut, 1997: 53) cezaevlerine diyanet görevlileri atanmaya başlanmıştır. Diyanet personelinin cezaevlerinde yaptığı manevi destek hizmetleri arasında din ve ahlak bilgisi verme, Kur'an öğretimi, aylık konferans düzenleme, manevi rehberlik yapmak ve dini sohbetler icra etme olarak sıralanabilir.

Diyanet İşleri Başkanlığının adalet alanındaki manevi destek çalışmaları zaman içinde daha da güçlenmiş, 2015 yılı itibariyle cezaevlerinde "Gözlem ve Sınıflandırma Merkezi" adıyla kurulan ekipte psikolog, sosyal çalışmacı, öğretmen ve doktorun yanı sıra manevi destek uygulayıcıları olan din adamları görevlendirilmeye başlanmıştır (Gözlem ve Sınıflandırma Merkez Yönetmenliği, 2005: Madde 17).

Sağlık Alanında Manevi Destek Hizmetleri

Diyanet İşleri Başkanlığı'nın girişimiyle DİB ile Sağlık Bakanlığı ortak bir kararıyla hastanelerde yatarak tedavi gören hastalara "din ve moral hizmetleri" adı altında manevi destek hizmetlerinin sunulması görevi DİB'e verilmiş, siyasi tartışmalar neticesinde söz konusu uygulamadan geri adım atılmıştır. 2015 yılından itibaren DİB ve Sağlık Bakanlığı arasında yapılan protokoller ile din kavramı yerine ondan daha geniş olan manevi kavramı kullanılmıştır. Protokolle "Diyanet İşleri Başkanlığı ve Sağlık Bakanlığına bağlı hastane, kurum ve kuruluşlarda talep eden hastalara, hasta yakınlarına ve personeline, içinde bulundukları şartlar göz önünde bulundurularak hastaların iyileşmelerine katkıda bulunmak amacıyla moral, motivasyon ve manevi destek sağlamaktır" denilerek bu amaç belirtilmiştir. (Hastanelerde Manevi Destek Sunmaya Yönelik İşbirliği Protokolü, Madde:1, 2015: 1)

DİB bu yıldan sonra ilk olarak, (2015) "Hastanelerde Manevi Destek Çalıştayı" düzenlemiş ve Türkiye genelinde din psikolojisi, din eğitimi, din sosyolojisi, dini danışmanlık ve rehberlik alanlarında yüksek lisans veya doktora yapmış veya bu alanda çalışmaya gönüllü 1558 müftülük personeli tespit etmiş, söz konusu programın uygulanacağı pilot iller belirlenerek, ilgili personel "hastanelerde manevi destek eğitimi" adı altında 200 saatlik bir eğitim programına tabi tutulmuştur (Han, 2016, 100)

Diyanet İşleri Başkanlığı 2017 yılında yayınladığı yönerge ile bu alanda çalışacak personelde lisans düzeyinde dini yükseköğrenim mezunu olmak, hastanelerde manevi destek hizmetine yönelik olarak Bakanlık ve Başkanlıkça ortaklaşa düzenlenen eğitimi başarı ile bitirmek, alanla ilgili bir sertifika programı bitirmiş olmak ve/veya manevi destek alanında lisansüstü bir programdan mezun ya da halen okuyor olmak tercih sebebidir, şeklindeki esasları şart koşmuştur (Sağlık Kuruluşlarında Manevi Destek Hizmetlerinin Yürütülmesine Dair Yönerge, Madde 5- (1))

SONUÇ

Dünya çapında gün geçtikçe manevi destek ve rehberlik çalışmalarının önem kazandığı düşünüldüğünde Diyanet İşleri Başkanlığı tarafından bu alanda verilen hizmetlerin gelecekte daha önemli hale geleceği görülmektedir.

Gerek hastane gerekse hapishane ve diğer alanlarda hizmet sunanların kişilerin danışanların içinde bulunabilecekleri psikolojileri ve ihtiyaç duydukları manevi destek hakkında temel bilgilere sahip olması gerekmektedir. Bu açıdan DİB ile ilahiyat fakülteleri ve üniversitelerin Sosyal Hizmet, Psikoloji, Sosyoloji, Sosyal Antropoloji ve Sağlık Bilimleri alanlarının işbirliği yapması gerekir. Bu işbirliği hem mesleki bilgiyi hem de hizmetlerdeki kaliteyi artıracaktır. Manevi destek hizmetlerinde dini alandaki uzmanlık dışında yukarıda sözü edilen disiplinlerde de birikime ve donanıma sahip olmak gerekli görülmektedir.

Yapılan protokollerde mevzuatın manevi destek hizmetlerine yönelik imkan tanıdığı görülmekle birlikte uygulamadan kaynaklı sorunların varlığı göze çarpmaktadır. Bu sorunların başında kurumsal tecrübelerin azlığı önemli role sahiptir. Benzer şekilde bu alanda yetişmiş uzmanların sayıca az olması da önemli bir problem olarak görülmektedir. Özellikle çocuk yuvası ve yetiştirme yurtlarında din hizmetleri vermek amacıyla görevlendirilecek personelin psikoloji, sosyoloji ve din eğitimi temelli mesleki formasyona sahip olmaları daha etkin ve verimli hizmet sunma açısından oldukça önemlidir. Buralarda barınan çocuk ve gençlerin özel ve dezavantajlı grup içerisinde yer aldığı dikkate alındığında personelin bilimsel ve psikolojik açıdan donanımlı olmaları önem taşımaktadır.

Ülkemizde manevi danışmanlık için henüz lisans seviyesinde bir yükseköğretim programının bulunmadığı görülmektedir. Farklı bakış açılarına göre yapılandırılan lisansüstü öğretim programlarının ise akreditasyon sürecine tabi olmadığı görülmektedir. Bunun dışında Diyanet İşleri Başkanlığı tarafından görevlenlendirilen manevi danışmanların yeterliliklerini değerlendirecek bir mekanizma da bulunmamaktadır. Ülkemizde manevi danışmanlık meslek standartları oluşturulmuşsa da mesleğin eğitim standartları için aynı şeyi söylemek mümkün görünmemektedir. Bu noktada mesleğe ilişkin eğitimlerin akreditasyon süreçleri işletilerek yürütülmesi önem taşımaktadır.

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EBEVENYLERİN SAĞLIK İNANCI, ANTİBİYOTİK ALGISI VE AŞI TUTUMLARI ARASINDAKİ İLİŞKİ

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Öz: Bu araştırma, ebeveynlerin sağlık inancı, antibiyotik algısı ve aşı tutumları arasındaki ilişkiyi belirlemek amacıyla yapılmıştır. Araştırma, Türkiye'nin Doğu'sunda üçüncü basamak bir üniversitesi hastanesinde 347 ebeveyn ile Ekim 2024-Ocak 2025 tarihleri arasında, tanımlayıcı ve ilişki arayıcı türde yürütülmüştür. Araştırmaya katılmayı kabul eden ebeveynlerden Kişisel Bilgi Formu, Ebeveyn Sağlık İnanç Ölçeği (EBSİÖ), Anne ve Babaların Antibiyotik Algıları Ölçeği (ABANA), Çocukluk Çağı Aşıları Hakkında Ebeveyn Tutumları Ölçeği (PACV) kullanılarak veriler toplanmıştır. Katılımcıların 37.42±09.05 ve eşlerinin yaş ortalaması 37.33±09.87'dir.Katılımcıların %64.5'i aşılar ile ilgili eğitim almış, %92.7'si çocuğuna çocukluk çağı aşılarını yaptırmıştır. Ebeveynler orta düzeyde sağlık inancı, ortanın altında antibiyotik algısı ve orta düzey aşı tutumuna sahip oldukları bulunmuştur. Katılımcıların cinsiyeti, eğitim düzeyi ve hastaneye başvurma sıklığı ile EBSİÖ, ABANA ve PACV toplam puanı arasında istatistiksel olarak anlamlı bir fark olduğu belirlenmiştir ($p<0.05$). Ebeveynlerin PACV Ölçeği'nin toplam puanına göre %54.46'sının aşı tereddütlü olduğu saptanmıştır. Katılımcıların EBSİÖ puanları ile ABANA arasında orta düzeyde pozitif bir ilişki, PACV ile ise zayıf düzeyde pozitif bir ilişki bulunmuştur ($p<0.05$). EBSİÖ toplam puanının PACV'nin %2.2'sini, ABANA toplam puanının ise PACV'nin %2.4'ünü açıkladığı belirlenmiştir. Bulgulara göre ebeveynlerin sağlık inançları, antibiyotik algısı ve aşı tutumlarını güçlendirmek ve bilimsel temelli bilgilere dayalı kararlar almalarını sağlamak amacıyla farkındalık çalışmalarının yapılması, sağlık çalışanlarının konu ile ilgili bilgi düzeylerinin arttırılması için eğitimler ile güçlendirilmesi ve bireysel danışmanlık hizmetlerinin artırılması önerilmektedir.
Anahtar Kelimeler: *Ebeveyn, çocuk, sağlık inancı, antibiyotik algısı, aşı tutumu*

THE RELATIONSHIP BETWEEN PARENTS' HEALTH BELIEFS, ANTIBIOTICS PERCEPTIONS AND VACCINE ATTITUDES

Abstract: This study was conducted to determine the relationship between parents' health beliefs, perceptions of antibiotics, and attitudes toward vaccination. The research was conducted as a descriptive and correlational study with 347 parents at a tertiary university hospital in Eastern Türkiye between October 2024 and January 2025. Data were collected from parents who agreed to participate using the Personal Information Form, the Parental Health Belief Scale (PHBS), Parents' Perceptions of Antibiotics Scale (PPAS), and the Parent Attitudes about Childhood Vaccines (PACV) Scale. The mean age of participants was 37.42±09.05, and the mean age of their spouses was 37.33±09.87. Among the participants, 64.5% had received education about vaccines, and 92.7% had vaccinated their children with childhood vaccines. It was found that the parents had a moderate level of health beliefs, a below-moderate perception of antibiotics, and a moderate attitude toward vaccines. Statistically significant differences were found between participants' gender, education level,

and frequency of hospital visits and the total scores of the PHBS, PPAS, and PACV scales ($p<0.05$). Based on the total PACV scores, 54.46% of parents were identified as vaccine-hesitant. A moderate positive correlation was found between PHBS and PPAS scores, and a weak positive correlation between PHBS and PACV scores ($p<0.05$). It was determined that PHBS total scores explained 2.2% of the variance in PACV scores, while PPAS total scores explained 2.4%. Based on the findings, it is recommended to carry out awareness-raising initiatives to strengthen parents' health beliefs, perceptions of antibiotics, and vaccine attitudes, to provide training programs to enhance healthcare professionals' knowledge on the subject, and to increase the availability of individual counseling services to support evidence-based decision- making.
Keywords: Parent, child, health belief, perception of antibiotics, vaccine attitude

ÇOCUK MEKANLARINDA SALUTOJENİK TASARIMIN DUYU BÜTÜNLÜĞÜNE ETKİSİ

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ÖZET
Çocukluk, mekânsal deneyimlerin yalnızca fiziksel değil; aynı zamanda duygusal, bilişsel ve sosyal boyutlarıyla içselleştirildiği en duyarlı gelişim evrelerinden biridir. Özellikle 2–7 yaş arası çocuklar, çevresel uyarıcılara karşı yüksek düzeyde açık olup, mekânın taşıdığı anlamı duyusal ipuçları, ritim ve tekrar üzerinden yapılandırırlar. Bu yaş grubundaki bireyler için risk, yalnızca fiziksel güvenlik ihlali değil; aynı zamanda öngörülemezlik, yönsüzlük, aşırı uyarım ve aidiyet eksikliği gibi durumları da kapsar. Dolayısıyla, erken çocukluk döneminde mekân tasarımı pedagojik işlevin ötesine geçerek psikolojik düzenleme, öznel kontrol ve sosyal aidiyet gibi yönleri de desteklemelidir.
Bu bağlamda, salutojenik tasarım yaklaşımı çocuk mekânları için önemli bir kuramsal çerçeve sunar. Bireyin yaşamı anlamlı, yönetilebilir ve anlaşılabilir biçimde deneyimlemesini sağlayan "Sense of Coherence (SOC)" modeli, salutojenik kuramın temelini oluşturur. Bu üç bileşenin mekânda karşılık bulması, çocukların stresle baş etme, çevresel bütünlük algısı geliştirme ve kendilik duygusunu inşa etme süreçlerini destekler. Bütüncül sağlığı çevresel düzenlemeler yoluyla önceleyen salutojenik yaklaşım, çocuğun fiziksel olduğu kadar zihinsel ve sosyal refahına da mimari bağlamda yanıt arar.
Bu çalışma kapsamında, Minhas ve Nair tarafından geliştirilen 27 tasarım ilkesine referansla; mekânsal okunabilirlik, aidiyet hissi, biyofilik çevre etkisi, çok duyulu deneyim ve öznel kontrol gibi başlıklar kuramsal düzeyde incelenecektir. Özellikle çocuğun kendi alanını tanımlayabilmesi, mekânın sadece kullanıldığı değil, "anlamlandırıldığı" bir deneyim alanına dönüşmesini sağlamaktadır.
Anahtar Kelimeler: Çocuk mekanları, Mimari tasarım, salutojenik mimari, duyu bütünleme

THE IMPACT OF SALUTOGENIC DESIGN ON SENSORY INTEGRATION IN CHILDREN'S SPACES

ABSTRACT
Childhood represents one of the most sensitive developmental phases in which spatial experiences are internalized not merely through physical interaction, but also through emotional, cognitive, and social dimensions. Particularly for children aged 2 to 6, environmental stimuli are processed with heightened sensitivity, and the meanings of space are constructed through sensory cues, rhythm, and repetition. For this age group, "risk" does not solely refer to physical hazards but includes unpredictability, disorientation, overstimulation, and the absence of belonging. Therefore, in early childhood, spatial design must extend beyond pedagogical function to support emotional regulation, subjective control, and social affiliation.
In this context, the salutogenic design approach offers a compelling theoretical framework for child-centered environments. The "Sense of Coherence (SOC)" model, which enables individuals to perceive life as meaningful, manageable, and comprehensible, forms the core of the salutogenic paradigm. When these three components are spatially embodied, they reinforce children's ability to cope with stress, develop a coherent perception of their surroundings, and

construct a resilient sense of self. Salutogenic design, which prioritizes holistic well-being through environmental interventions, addresses not only physical safety but also the mental and social well-being of the child in architectural terms.
This study theoretically examines how the design principles of salutogenic learning environments—as outlined by Minhas and Nair—can be applied to early childhood settings. Topics such as spatial legibility, sense of belonging, biophilic influences, multisensory engagement, and perceived control will be explored. Particular emphasis is placed on how the child's ability to define their own space transforms the built environment into a meaningful and coherent experiential field rather than a merely functional one.
Keywords: Children's Spaces, Architectural Design, Salutogenic Architecture, Sensory Integration

1930-1945 YILLARI ARASINDA BILECIK'IN İDARI TAKSIMATI VE YEREL YÖNETIM YAPISI

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ÖZET
Bu bildiri, Cumhuriyet'in ilk yıllarında Türkiye genelinde uygulamaya konan merkezi idare anlayışının taşra teşkilatları üzerindeki etkilerini, 1930-1945 yılları arasında Bilecik ili özelinde ele almayı amaçlamaktadır. Araştırma kapsamında, Bilecik'in idari taksimat yapısı; il, ilçe, bucak ve köy düzeyinde değerlendirilerek bu dönemde yaşanan yapısal değişiklikler ortaya konulmuştur.
Araştırmanın temel kaynaklarını, dönemin Türkiye İstatistik Umum Müdürlüğü yayınları, nüfus sayımı sonuçları oluşturmaktadır. Kırsal ve kentsel nüfus yoğunlukları karşılaştırmalı olarak değerlendirilmiş; köy ve muhtarlık sayılarındaki değişimler üzerinden yerel yönetimlerin genişleme ve daralma süreçleri analiz edilmiştir. Ayrıca belediye bütçeleri üzerinden yerel mali yapının gelişimi incelenmiş, Bilecik'in bu dönemdeki ekonomik-idari kapasitesi yorumlanmıştır.
Bu bağlamda çalışmada, idari yapının yalnızca il sınırları üzerinden değil, aynı zamanda dönemin toplumsal ve ekonomik dinamikleriyle birlikte ele alınması hedeflenmiştir. 1930-1945 dönemi, Bilecik örneğinde, özellikle bucak ve köy yönetimlerinde yaşanan yapısal değişimler, Cumhuriyet rejiminin yereldeki temsil gücünün artışını ortaya koymaktadır.
Ayrıca, belediyelerin tahsilat raporları incelenerek, yerel yönetimlerin mali sürdürülebilirliği analiz edilmiştir. Bu çerçevede, gider kalemleri de lira bakımından gösterilmiştir. Yerel yönetimlerin kurumsallaşma süreci; nüfus artışı kır ve kentsel gibi unsurlarla da ilişkilendirilmiştir.
Bu çalışma, yalnızca Bilecik'in idari haritasındaki değişimi değil, aynı zamanda Cumhuriyet'in taşradaki kurumsallaşma sürecine dair önemli ipuçları da sunmayı hedeflemektedir. Bu yönüyle çalışma, hem bölgesel tarih yazımı hem de erken Cumhuriyet idare yapısının anlaşılması bakımından katkı sunacaktır.
Anahtar Kelimeler: Bilecik, idari taksimat, taşra yönetimi, Cumhuriyet dönemi, köy, yerel yönetim.

ADMINISTRATIVE DIVISION AND LOCAL ADMINISTRATION STRUCTURE OF BILECIK BETWEEN 1930-1945

ABSTRACT
This paper aims to examine the impact of the centralization policies implemented during the early years of the Republic of Turkey on provincial administrative structures, focusing specifically on Bilecik province between 1930 and 1945. The study analyzes the administrative division of Bilecik—at the levels of province, district, sub-district, and village—by identifying the structural changes that occurred during this period.

The primary sources of the research consist of publications by the Turkish General Directorate of Statistics and national census results. Rural and urban population densities were evaluated comparatively, and changes in the number of villages and village headships were analyzed to understand the patterns of expansion and contraction in local governance. In addition, municipal budgets were examined to assess the development of the local fiscal structure and to interpret Bilecik's administrative and economic capacity during this era.
The study approaches administrative transformation not only in terms of geographical boundaries but also by taking into account the broader social and economic dynamics of the time. The 1930–1945 period reveals a significant increase in the Republic's representational power at the local level, particularly through structural changes in sub-district and village administrations.
Furthermore, municipal revenue and expenditure reports were reviewed to evaluate the financial sustainability of local governments, with expenditure items detailed in Turkish lira. The institutionalization process of local administrations is also discussed in relation to population growth and the rural–urban distinction.
This study offers insights into both the transformation of Bilecik's administrative landscape and the broader institutionalization of the Republic in rural regions, contributing to regional historiography and the understanding of early Republican governance.
Keywords:
Bilecik, administrative division, provincial governance, Republican era, village, local administration

GİRİŞ

Cumhuriyet'in ilk yıllarında Türkiye'de uygulamaya konulan merkezileşme politikaları, taşra idaresinin yapısını da önemli ölçüde etkilemiştir. Özellikle 1930-1945 yılları arasındaki dönem, Türkiye'nin modernleşme süreci içinde yerel yönetimlerin yeniden yapılandırıldığı bir zaman dilimi olarak dikkat çekmektedir. Bu çalışmada, söz konusu değişim süreci Bilecik ili özelinde ele alınarak idari yapının geçirdiği dönüşümler ve bu dönüşümlerin yerel yönetimlere etkisi analiz edilmektedir.

Bilecik ili, gerek coğrafi konumu gerekse nüfus yoğunluğu bakımından erken Cumhuriyet döneminde örnek teşkil edebilecek iller arasında yer almaktadır. Bu nedenle, bu dönemde il, ilçe, bucak ve köy düzeyinde yaşanan idari taksimat değişikliklerinin değerlendirilmesi, Cumhuriyet'in taşra örgütlenmesinin anlaşılmasına katkı sağlayacaktır.

ARAŞTIRMA VE BULGULAR

İstatistiki Kaynaklar ve Yöntem

Araştırmada temel olarak Türkiye İstatistik Umum Müdürlüğü'nün yıllık yayınları ve nüfus sayımı sonuçları kullanılmıştır. Bu kaynaklardan elde edilen veriler doğrultusunda Bilecik'in köy, bucak, ilçe ve il düzeyindeki idari yapılanmaları incelenmiştir. Aynı zamanda belediye bütçelerine dair bilgilerden hareketle, yerel yönetimlerin mali gücü ve kapasitesi analiz edilmiştir.

Bilecik Nüfus Verileri ve Nüfus Dağılımı

Cumhuriyet döneminde gerçekleştirilen ilk nüfus sayımı 1927 yılında yapılmıştır. Türkiye'nin en ücra köylerine kadar ulaşan bu kapsamlı sayım sonucunda, ülke genelindeki toplam nüfus 13.648.270 kişi olarak belirlenmiştir. Bu nüfusun 6.563.879'unu erkekler, 7.084.391'ini ise kadınlar oluşturmaktadır. Bilecik'in toplam nüfusu 113.660 olarak kaydedilmiştir.[56] Bu nüfus sayımına göre erkek nüfus toplam 53.498 iken kadın nüfus 60.162'dir.[57]

[56] İUM; 28 Teşrinievvel 1927 Umumi Nüfus Tahriri, f. I, s. IV.
[57] İUM; 28 Teşrinievvel 1927 Umumi Nüfus Tahriri, f. I, s. II-XVII.

1935 yılında yapılan nüfus sayımında, iller coğrafi bölgelerine göre sınıflandırılmış ve bu doğrultuda Marmara Bölgesi'nin güneydoğusunda yer alan Bilecik'in toplam nüfusu 125.417 olarak belirlenmiştir. Bu sayının 61.105'ini erkekler, 64.312'sini ise kadınlar oluşturmuştur. Daha önce, 1927 yılında gerçekleştirilen ilk genel nüfus sayımında elde edilen sonuçlar Başbakanlığa sunulurken iller, nüfus büyüklüğüne göre sıralanmıştır. Bu sıralamada Bilecik, en düşük nüfusa sahip iller arasında yer almış ve yalnızca Ağrı ve Burdur'un önünde, sondan üçüncü sırada yer almıştır. 1935 yılında gerçekleştirilen nüfus sayımında, Bilecik ilinin toplam nüfusu 1927 yılına kıyasla 11.747 kişi artış göstermiştir. Bu artış yaklaşık %10 oranındadır.[58] 1935 yılına ait nüfus verileri incelendiğinde, Bilecik ilinde kırsal alanlarda yaşayan nüfusun, ilçe merkezlerinde yaşayanlara kıyasla belirgin şekilde fazla olduğu dikkat çekmektedir. Bu durum, dönemin sosyoekonomik yapısının hâlâ büyük ölçüde tarıma dayalı olduğunu ve kentleşmenin sınırlı kaldığını ortaya koymaktadır. Özellikle Bozüyük ilçesi bu durumu en açık biçimde yansıtmaktadır. İlçede merkez nüfusu yaklaşık 7.873 iken, köylerde yaşayanların sayısı 39.000'i aşmıştır. Benzer şekilde Gölpazarı'nda merkez nüfusu 1.870'e yaklaşırken, köy nüfusu 15.000'in üzerindedir. Söğüt'te de benzer bir tablo mevcuttur; köylerde yaşayanların sayısı merkezdekilerin çok üzerindedir. Bilecik il merkezinde dahi köylerde yaşayan nüfus, şehir merkezinde yaşayanların neredeyse beş katına ulaşmaktadır. Bu dağılım, hem demografik yapının ağırlıklı olarak kırsal yerleşimlere dayandığını hem de ekonomik faaliyetlerin büyük ölçüde tarım ve hayvancılığa bağlı sürdürüldüğünü göstermektedir.[59] 1940 yılına ait nüfus verileri incelendiğinde, Bilecik ve çevresindeki bölgelerde kırsal nüfusun, kent nüfusuna kıyasla ezici bir çoğunlukta olduğu açıkça görülmektedir. Toplam nüfusun 110.049'u köylerde yaşarken, yalnızca 17.928 kişi şehir merkezlerinde ikamet etmekteydi. Bu da, nüfusun yaklaşık %86'sının hâlâ kırsal alanlarda yaşamını sürdürdüğünü göstermektedir. Bu tablo, bölgedeki kentleşme sürecinin yavaş ilerlediğini ve kırsal yaşamın 1940'lı yıllarda da baskın bir karakter taşıdığını ortaya koymaktadır.[60] Cumhuriyet döneminin dördüncü nüfus sayımı 22 Ekim 1945 tarihinde gerçekleştirilmiştir. Bu sayım sonuçlarına göre Bilecik ilinin toplam nüfusu 136.053 olarak tespit edilmiştir. Bu nüfusun yaklaşık 65.600'ünü erkekler, 70.400'ünü ise kadınlar oluşturmaktadır. Veriler, nüfusun büyük kısmının hâlâ kırsal alanda yaşadığını ortaya koymaktadır. Zira toplam nüfusun 116.730'u köylerde ikamet ederken, şehir merkezlerinde yaşayanların sayısı yalnızca 19.315'te kalmıştır. Bu durum, bölgedeki kentleşme sürecinin 1945 itibarıyla sınırlı düzeyde olduğunu ve tarım merkezli yaşam biçiminin ağırlığını koruduğunu göstermektedir.[61]

Bilecik'in 1930-1945 Dönemi Yerel Yönetim Yapısı

1930-1945 yılları arasında Bilecik'in kırsal ve kentsel nüfusunda dikkat çekici farklılıklar gözlemlenmektedir. Köy sayılarındaki artış, kırsal yerleşimlerin yaygınlaştığını gösterirken; belediye örgütlenmelerinin gelişimi, şehirleşmenin ve merkezi otoritenin yereldeki etkisinin arttığını ortaya koymaktadır.

1930-1945 yılları arasında Türkiye'de yerel yönetimler, Cumhuriyet'in merkeziyetçi idare anlayışı doğrultusunda şekillenmiştir. Bu dönemde 1924 Anayasası, mahalli idarelere ilişkin olarak 1876 Anayasası'nın merkeziyetçi yapısını devam ettirmiş; yerel yönetimlerin özerkliği sınırlandırılarak merkezi yönetim üzerinde güçlü bir denetim mekanizması kurulmuştur (Hisoğlu Koç, Ertilav ve Lamba, 2024).

Bu yıllar arasında köy ve bucak sayılarındaki artış, Cumhuriyet rejiminin taşradaki kurumsallaşma sürecinin önemli göstergelerindendir. Ayrıca yerel halkın idari birimlerle

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İstatistik Yıllığı Cilt.9, 1936-1937 Devlet Basımevi İstanbul, s.29.[58]

Türkiye Cumhuriyeti Başbakanlık İstatistik Genel Direktörlüğü, Genel Nüfus Sayımı Köyler Nüfusu, [59] Hüsnütabiat Basımevi İstanbul, 1937, s.IV.

Başvekalet İstatistik Umum Müdürlüğü, Genel Nüfus Sayımı 20 ilkteşrin 1940, s.91-96.[60]

T.C. Başbakanlık İstatistik Genel Müdürlüğü, 1945 Genel Nüfus Sayımı, Ankara, 1950, s.10.[61]

ilişkisi daha doğrudan ve yoğun hale gelmiştir. 1930'lu yıllarda yapılan yasal düzenlemelerle il özel idareleri, özellikle kırsal alanlarda devletin temel hizmet sağlayıcısı konumuna yükselmiş; dönemin söyleminde "yerel parlamento" olarak tanımlanmış, il genel meclisi üyeleri ise "yerel milletvekili" gibi önemli bir statüye sahip olmuştur (Bozlağan & Can, 2009; Çetin, 2015).

Bilecik özelinde, il özel idareleri yerel yönetim sisteminin belkemiğini oluşturmuş ve köylerin ile ilçelerin idari ihtiyaçlarını karşılamada merkezi yönetimin etkin bir uzantısı olarak görev yapmıştır. Bu kurumlar, tarım, eğitim ve sağlık gibi temel hizmetleri yürütmüş; köy yollarının yapımı, ilkokul açılması ve sağlık tesislerinin kurulması gibi pek çok önemli faaliyeti doğrudan üstlenmiştir (Güler, 2014). Bu dönemde belediyelerin yetkileri kırsal kesimlere oranla şehir merkezleriyle sınırlı kalmış, il özel idareleri kırsal alanlarda daha etkili olmuştur.

1945 sonrası ise yerel yönetimlerde önemli değişiklikler yaşanmış; belediyelerin ağırlığı artarken, il özel idarelerinin işlevselliği görece azalmıştır. 1930-1945 dönemi, Bilecik'te merkezi idarenin kırsal alanlara hizmet götürmek için il özel idarelerini aktif şekilde kullandığı ve yerel yönetimlerin temel hizmet alanlarında etkili olduğu bir süreç olarak öne çıkmaktadır (Hisoğlu Koç, Ertilav ve Lamba, 2024).

Belediye Bütçeleri ve Mali Sürdürülebilirlik

Döneme ait belediye bütçeleri incelendiğinde, Bilecik ve bağlı idari birimlerinde yerel yönetimlerin gelir ve gider dengelerinde belirgin bir gelişim süreci yaşandığı görülmektedir. Özellikle 1935 yılından sonra bütçelerde tahsilat oranlarında yaşanan artış, hem vergi tabanının genişlediğine hem de bölgesel ekonomik canlılığın yerel düzeyde daha hissedilir hale geldiğine işaret etmektedir. 1929'dan itibaren belediye tahsilatları ve masrafları birbirine yakın seyretmekte, bu durum bütçe disiplininin gözetildiğini göstermektedir. Örneğin, 1929 yılında tahsilat 59.544 TL, masraf ise 55.967 TL iken, 1930'da tahsilat 62.525 TL'ye yükselmiş ve giderler ise 51.817 TL olarak gerçekleşmiştir. Ancak 1931 ve 1932 yıllarında hem gelirlerde hem de giderlerde bir düşüş yaşanmış; 1931'de tahsilat 43.125 TL'ye, 1932'de 40.158 TL'ye gerilemiştir. Bu yıllarda giderler de buna paralel olarak azalmıştır. 1933 yılından itibaren yerel yönetim gelirlerinde toparlanma gözlenmekte ve 1934'te tahsilatlar 67.018 TL'ye yükselirken, masraflar 60.139 TL seviyesine ulaşmıştır. 1935 ve 1936 yıllarında ise ekonomik hareketlilik belirginleşmiş; tahsilatlar sırasıyla 80.887 TL ve 89.741 TL'ye yükselirken, giderlerde de artış gözlenmiş ancak tahsilatlar giderlerin üzerinde seyretmiştir.[62] Bu durum, mali sürdürülebilirlik açısından olumlu bir gelişme olarak değerlendirilebilir.

1937'den sonra da gelirlerde artış devam etmiş, 1938 yılında 114.600 TL'ye ulaşan gelirler, giderlerin (89.221 TL) oldukça üzerinde kalmıştır. 1939 ve 1940 yıllarında da benzer bir tablo görülmekte, gelirler giderlerden yüksek seyretmektedir.[63] Bu dengeli bütçe yapısı, Bilecik'in idari taksimatı göz önüne alındığında, yerel yönetimlerin ekonomik kaynaklarını etkin kullandığını ve mali disiplin sağladığını göstermektedir.

Bilecik'in il merkezi ve ilçeleri ile köylerinden oluşan idari yapısında, bu bütçe verileri yerel yönetimlerin özellikle altyapı, eğitim ve sağlık gibi kamu hizmetlerini sürdürme kapasitesine önemli katkı sağlamıştır. Vergi tahsilatlarının artması, bölgedeki ekonomik faaliyetlerin büyümesiyle örtüşmekte; bu da yerel yönetimlerin hizmet kalitesinin yükselmesine ve bölgesel kalkınmaya destek olmasına olanak tanımıştır**.**

[62] Başbakanlık İstatistik Umum Müdürlüğü, İstatistik Yıllığı 1938-1939, Cilt: 10, Hüsnütabiat Basımevi İstanbul, 1939, s. 427.

[63] Başbakanlık İstatistik Genel Müdürlüğü, İstatistik Yıllığı 1942-1945, Cilt:15, Hüsnütabiat Basımevi İstanbul, 1946, s. 442.

SONUÇ

1930-1945 yılları arasında Bilecik'te gerçekleşen idari ve demografik gelişmeler, Cumhuriyet'in taşradaki merkezileşme ve kurumsallaşma politikalarının yerel yönetim yapısını nasıl şekillendirdiğini açıkça ortaya koymaktadır. Bu dönemde Bilecik'in nüfusu önemli ölçüde artarken, kırsal alanların kentlere kıyasla hâlâ baskın konumda olduğu görülmüştür. Köy ve bucak sayılarındaki artış, Cumhuriyet rejiminin yerel düzeydeki temsil gücünü güçlendirmiştir. İl özel idareleri, özellikle kırsal kesimde devletin temel hizmet sağlayıcısı rolünü üstlenmiş; altyapı, eğitim ve sağlık gibi alanlarda önemli projeler gerçekleştirmiştir. Belediye bütçeleri ise, 1935 sonrasında artan gelir ve gider dengeleriyle mali disiplin ve sürdürülebilirlik açısından olumlu bir seyir izlemiştir. Bu durum, yerel yönetimlerin ekonomik kaynaklarını etkin kullandıklarına ve bölgesel kalkınmaya katkı sağladıklarına işaret etmektedir. Sonuç olarak, Bilecik örneğinde 1930-1945 dönemi, Cumhuriyet'in merkezi yönetim anlayışının taşradaki yansımalarının ve yerel yönetimlerin güçlenme sürecinin önemli bir yansımasıdır. Bu süreç, Türkiye'nin modernleşme çabalarının yerelde nasıl organize edildiğine dair değerli bilgiler sunmakta ve erken Cumhuriyet idare yapısının anlaşılmasına önemli katkılar sağlamaktadır.

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ELEKTRİK DAĞITIM SEKTÖRÜNDE BT YATIRIM PROJELERİNİN ÇOK KRİTERLİ KARAR VERME YÖNTEMLERİ İLE ÖNCELİKLENDİRİLMESİ: AHP, PROMETHEE VE VIKOR UYGULAMASI

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ÖZET
Elektrik dağıtım sektöründe faaliyet gösteren işletmelerin dijitalleşme ve teknolojik dönüşüm süreçleri, bilgi teknolojileri (BT) alanındaki stratejik yatırım kararlarını kritik hale getirmiştir. Bu çalışma, bir elektrik dağıtım şirketinde 2022 yılı BT yatırım bütçesi kapsamında değerlendirmeye alınan beş alternatif projeyi (P1–P5), çok kriterli karar verme (ÇKKV) yöntemleriyle analiz ederek önceliklendirmeyi amaçlamaktadır. Uygulamada; Analitik Hiyerarşi Süreci (AHP) ile belirlenen kriter ağırlıkları kullanılarak PROMETHEE ve VIKOR yöntemleriyle projelerin sıralaması yapılmıştır. Kriter seti; stratejik uyum (%21), teknik uygulanabilirlik (%16), maliyet etkinliği (%14), sürdürülebilirlik (%13), risk seviyesi (%12), operasyonel etki (%10), iş süreçlerine katkı (%8) ve uzun vadeli fayda (%6) olmak üzere sekiz boyuttan oluşmuştur. Uzman görüşleriyle oluşturulan karar matrisleri kullanılarak yapılan hesaplamalarda, hem PROMETHEE hem de VIKOR yöntemleri P3 numaralı projeyi en öncelikli yatırım alternatifi olarak belirlemiştir. PROMETHEE analizinde P3'ün net akış değeri $\varphi = +0.54$ ile en yüksek seviyede bulunmuş; VIKOR analizinde ise kompromis çözüm değeri $Q = 0.000$ olarak hesaplanmıştır. Sıralama açısından her iki yöntem arasında tam uyum sağlanmıştır. Bu sonuç, geliştirilen modelin güvenilirliğini ve karar vericilerin sezgileriyle yöntem çıktılarının örtüştüğünü göstermektedir. Elde edilen çıktılar, elektrik dağıtım sektöründe BT projelerinin yalnızca maliyet merkezli değil, stratejik ve operasyonel etkileriyle birlikte çok boyutlu değerlendirilmesi gerektiğini ortaya koymaktadır. Ayrıca, bu modelin farklı yıllarda, projelerde ve dağıtım bölgelerinde yeniden kullanılabilirliği mümkündür. Çalışma, karar vericilere nesnel, şeffaf ve tekrar edilebilir bir karar destek aracı sunmakta ve BT yatırımlarının sistematik planlanmasına katkı sağlamaktadır.
Anahtar Kelimeler: Çok Kriterli Karar Verme (ÇKKV), AHP, PROMETHEE, VIKOR, Elektrik Dağıtım Sektörü, Bilgi Teknolojileri Yatırımları, Proje Önceliklendirme, Karar Destek Sistemi

PRIORITIZATION OF IT INVESTMENT PROJECTS IN THE ELECTRICITY DISTRIBUTION SECTOR USING MULTI-CRITERIA DECISION-MAKING METHODS: AN APPLICATION OF AHP, PROMETHEE, AND VIKOR

ABSTRACT
The digitalization and technological transformation processes in electricity distribution companies have rendered strategic investment decisions in the field of information technologies (IT) increasingly critical. This study aims to prioritize five alternative projects (P1–P5) evaluated within the 2022 IT investment budget of an electricity distribution company using multi-criteria decision-making (MCDM) methods. In the application, the project

rankings were determined using PROMETHEE and VIKOR methods based on the criteria weights obtained through the Analytic Hierarchy Process (AHP). The criteria set consists of eight dimensions: strategic alignment (21%), technical feasibility (16%), cost-effectiveness (14%), sustainability (13%), risk level (12%), operational impact (10%), contribution to business processes (8%), and long-term benefit (6%). Using expert-based decision matrices, the analyses revealed that both PROMETHEE and VIKOR methods identified Project P3 as the top investment priority. In the PROMETHEE analysis, P3 achieved the highest net flow value ($\varphi = +0.54$), while the VIKOR method calculated a compromise solution value of $Q = 0.000$. A complete ranking agreement between the two methods was observed, demonstrating the reliability of the proposed model and the consistency between decision-makers' intuitions and model outcomes. The results indicate that IT projects in the electricity distribution sector should be evaluated through a multidimensional lens, incorporating strategic and operational impacts rather than solely focusing on cost. Moreover, the model can be reused across different years, projects, and distribution regions. This study offers decision-makers an objective, transparent, and repeatable decision support tool, contributing to the systematic planning of IT investments.

Keywords: Multi-Criteria Decision-Making (MCDM), AHP, PROMETHEE, VIKOR, Electricity Distribution Sector, Information Technology Investments, Project Prioritization, Decision Support System

ELEKTRİK DAĞITIM SEKTÖRÜNDE ERP YAZILIM SEÇİMİ İÇİN ÇOK KRİTERLİ KARAR VERME YAKLAŞIMI: AHP, TOPSIS VE VIKOR KARŞILAŞTIRMASI

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ÖZET
Elektrik dağıtım sektöründe faaliyet gösteren büyük ölçekli kuruluşlar için Kurumsal Kaynak Planlaması (ERP) sistemleri; kaynakların etkin yönetimi, operasyonel süreçlerin bütünleştirilmesi ve dijital dönüşüm hedeflerinin gerçekleştirilmesi açısından stratejik öneme sahiptir. Ancak ERP sistemlerinin yüksek maliyetli, teknik olarak karmaşık ve sektörel uyum gerektiren yapısı, seçim sürecini çok boyutlu ve zorlayıcı bir karar problemi haline getirmektedir. Bu çalışma, Türkiye'de faaliyet gösteren büyük ölçekli bir elektrik dağıtım işletmesinin ERP yazılımı seçim sürecini çok kriterli karar verme (ÇKKV) yaklaşımıyla modellemek ve bu süreçte AHP, TOPSIS ve VIKOR yöntemlerinin birlikte kullanımına dayalı karşılaştırmalı bir değerlendirme sunmak amacıyla gerçekleştirilmiştir. Araştırmada ilk olarak literatür taraması ve uzman görüşlerine dayalı olarak, ERP sistemlerinin seçiminde yaygın biçimde kullanılan dört ana kriter (maliyet, teknik yeterlilik, uyarlanabilirlik ve tedarikçi faktörü) ve bu kriterlere bağlı toplam on yedi alt kriter belirlenmiştir. Ardından dört ERP alternatifi (SAP, Oracle, Müşteri Bilgi Sistemleri [MBS] ve Yerli Yazılım [THOR] çözümü) değerlendirmeye alınmış; karar kriterleri AHP yöntemi ile ağırlıklandırılmış, bu ağırlıklar kullanılarak TOPSIS ve VIKOR analizleri gerçekleştirilmiştir. Analiz sonuçlarına göre, alternatiflerin sıralamasında, AHP, TOPSIS ve VIKOR analizinde THOR en uygun ERP çözümü olarak belirlenmiştir. Bu durum, ERP sistemlerinin seçiminde kullanılan yöntemlerin karar sonucuna etkisini ve karar probleminin çok boyutlu yapısını açık biçimde ortaya koymaktadır. Bu çalışma hem akademik literatüre katkı sağlamakta hem de pratikte karar vericilere uygulamaya dönük esnek ve güvenilir bir yöntem seti sunmaktadır.
Anahtar Kelimeler: Kurumsal Kaynak Planlaması (ERP), Çok Kriterli Karar Verme (ÇKKV), AHP, TOPSIS, VIKOR, Elektrik Dağıtım Sektörü, Karar Destek Sistemleri, ERP Seçimi, Bilgi Teknolojileri Yatırımı, Sektörel Uyum.

A MULTI-CRITERIA DECISION-MAKING APPROACH FOR ERP SOFTWARE SELECTION IN THE ELECTRICITY DISTRIBUTION SECTOR: A COMPARATIVE ANALYSIS OF AHP, TOPSIS, AND VIKOR

ABSTRACT
Enterprise Resource Planning (ERP) systems play a strategic role in large-scale electricity distribution companies by enabling integrated process management, resource optimization, and alignment with digital transformation strategies. However, the complexity, high investment costs, and sector-specific requirements of ERP systems render the selection process a multifaceted and challenging decision problem. This study aims to model the ERP software selection process of a major electricity distribution company in Turkey using a multi-criteria

decision-making (MCDM) approach, and to comparatively evaluate the applicability of three prominent methods: Analytic Hierarchy Process (AHP), TOPSIS, and VIKOR. Initially, a comprehensive literature review and semi-structured expert interviews were conducted to identify key decision criteria. Four main criteria—cost, technical capability, adaptability and vendor support and seventeen associated sub-criteria were established. Four ERP alternatives, SAP, Oracle, Customer Information Systems (MBS), and a domestic ERP solution were evaluated. AHP was employed to derive the relative importance weights of each criterion based on expert judgments. These weights were then integrated into TOPSIS and VIKOR methods to rank the ERP alternatives. The findings revealed that technical capability was the most influential criterion, with a weight of 52.1%, reflecting the high integration, modularity, and data security demands of the electricity distribution sector. According to the analysis results, THOR was determined as the most suitable ERP solution in the ranking of alternatives, AHP, TOPSIS and VIKOR analysis. This situation clearly reveals the effect of the methods used in the selection of ERP systems on the decision result and the multidimensional structure of the decision problem. This study contributes to both the academic literature and offers a flexible and reliable method set for application to decision makers in practice.
Keywords: Enterprise Resource Planning (ERP), Multi-Criteria Decision-Making (MCDM), AHP, TOPSIS, VIKOR, Electricity Distribution, Decision Support Systems, IT Investment, Sectoral Adaptability, ERP Evaluation.

GİRİŞ

Küresel rekabetin ve dijital dönüşümün hız kazandığı günümüzde, büyük ölçekli işletmelerin sürdürülebilir rekabet avantajı elde edebilmeleri, yalnızca kaliteli ürün ve hizmet üretimiyle değil, aynı zamanda bilgiye dayalı karar süreçlerini etkin biçimde yönetebilmeleriyle de doğrudan ilişkilidir. Bu kapsamda Kurumsal Kaynak Planlaması (ERP – Enterprise Resource Planning) sistemleri; muhasebe, finans, üretim, insan kaynakları, tedarik, satış ve müşteri ilişkileri gibi temel işlevleri tek bir bütünleşik yapıda birleştirerek kurum genelinde veri bütünlüğü, süreç şeffaflığı ve operasyonel etkinlik sağlamaktadır (Monk & Wagner, 2009; Yusuf, Gunasekaran & Abthorpe, 2004).

Özellikle enerji, üretim ve dağıtım gibi yüksek işlem hacmine sahip sektörlerde ERP sistemleri; karar alma hızını artırmakta, kaynak kullanımını optimize etmekte ve maliyetleri düşürerek operasyonel verimliliği desteklemektedir. Ancak bu sistemlerin sağladığı fayda, büyük ölçüde doğru yazılımın seçilmesine bağlıdır. Yanlış bir ERP tercihi, yalnızca yüksek yatırım maliyetlerine yol açmakla kalmayıp, aynı zamanda iş süreçlerinde uyumsuzluk ve verimsizlik gibi önemli riskleri de beraberinde getirmektedir (Öztürk & Karakoç, 2021).

Bu nedenle ERP yazılım seçimi; yalnızca maliyet değil, teknik altyapı, modüler yapı, kullanıcı dostluğu, tedarikçi desteği ve sektörel uygunluk gibi çok sayıda kriterin birlikte değerlendirildiği, çok boyutlu ve karmaşık bir karar problemi haline gelmiştir. Bu tür karar problemlerinde, klasik tek kriterli analiz yöntemleri yetersiz kalmakta; Çok Kriterli Karar Verme (ÇKKV) yöntemleri daha kapsamlı ve güvenilir değerlendirme imkânı sunmaktadır (Saaty, 2008; Kahraman, 2008).

Bu çalışmanın temel amacı, Türkiye'de elektrik dağıtım sektöründe faaliyet gösteren büyük ölçekli bir kurumun ERP yazılımı seçim sürecini sistematik, çok kriterli ve karşılaştırmalı biçimde analiz etmek; bu süreçte Analitik Hiyerarşi Süreci (AHP), TOPSIS ve VIKOR gibi yaygın üç çok kriterli karar verme (ÇKKV) yönteminin birlikte uygulanabilirliğini ortaya koymaktır. Çalışmada ilk olarak AHP yöntemi kullanılarak karar kriterlerinin göreli önem düzeyleri uzman görüşlerine dayalı biçimde belirlenmiş; ardından elde edilen ağırlıklar TOPSIS ve VIKOR yöntemlerine entegre edilerek ERP yazılım alternatifleri sıralanmıştır. Böylece hem nitel (uzman görüşü tabanlı) hem de nicel (matematiksel modellemeye dayalı) bileşenler içeren bütüncül bir karar destek çerçevesi oluşturulmuştur.

Araştırma kapsamında; SAP, Oracle, Microsoft Business Solutions (MBS) ve tamamen yerli geliştirilen bir ERP yazılımı olmak üzere dört farklı alternatif değerlendirme altına alınmış; ERP seçiminde yaygın biçimde dikkate alınan beş ana kriter (maliyet, teknik yeterlilik, kullanıcı deneyimi, uyarlanabilirlik, tedarikçi faktörü) ve bu kriterlere bağlı toplam on beş alt kriter üzerinden karar matrisi yapılandırılmıştır. Bu kapsamlı yapı sayesinde, yalnızca yöntem temelli değil; aynı zamanda sektörel ihtiyaçlarla uyumlu, uygulama odaklı bir karar modeli geliştirilmiştir.

Bu çalışmada; öncelikle literatürdeki mevcut yaklaşımların kısa bir değerlendirilmesi yapılacak, ardından önerilen karar modeli ve uygulanan yöntem adımları detaylandırılacaktır. Elde edilen bulgular ışığında, çok kriterli analizlerin karar sürecine etkisi tartışılacak ve özellikle ERP seçiminde rol oynayan teknik ve yönetsel faktörlere ilişkin akademik ve sektörel düzeyde uygulanabilir çıkarımlar sunulacaktır.

ÖNCEKİ ÇALIŞMALAR

Kurumsal Kaynak Planlama (ERP) sistemleri, işletmelerin tüm fonksiyonlarını entegre biçimde yönetmelerini sağlayarak dijital dönüşüm süreçlerinin temel bileşenlerinden biri haline gelmiştir. Bu sistemler yalnızca bir BT yatırımı olarak değil, aynı zamanda stratejik dönüşüm aracı olarak değerlendirilmektedir. Ancak yüksek maliyetleri, teknik karmaşıklıkları ve uygulama riskleri nedeniyle ERP seçim süreci, dikkatli planlama ve çok boyutlu analiz gerektiren karmaşık bir karar problemidir.

Literatürde ERP sistemlerinin seçiminde çok kriterli karar verme (ÇKKV) yöntemlerinin kullanımına ilişkin önemli bir birikim oluşmuştur. Bu süreçte en sık başvurulan yöntemlerin başında Analitik Hiyerarşi Süreci (AHP), TOPSIS ve VIKOR yer almaktadır. Saaty (2008) tarafından geliştirilen AHP yöntemi, kriterlerin hiyerarşik yapıda modellenmesi ve öznel yargıların tutarlı biçimde sayısallaştırılması açısından güçlü bir araç olarak görülmektedir. Wei et al. (2005) ve Özkan & Kara (2016), AHP'nin ERP seçiminde kriter ağırlıklandırmasında etkinliğini ortaya koymuş; karar kalitesini artırdığını belirtmişlerdir. Alternatiflerin sıralanmasında yaygın kullanılan yöntemlerden biri olan TOPSIS, karar seçeneklerini ideal ve negatif ideal çözüme olan uzaklıklarına göre değerlendirerek sade ve sezgisel bir karar mekanizması sunmaktadır. Özellikle belirsizlik ortamlarında geliştirilmiş bulanık TOPSIS uygulamaları, ERP seçiminde daha tutarlı ve uygulanabilir sonuçlar sunmaktadır (Karsak & Özogul, 2009). Bir diğer önemli yöntem olan VIKOR, çelişkili kriterler arasında denge kurarak uzlaşmacı bir sıralama sağlar. Opricovic ve Tzeng (2004) tarafından geliştirilen bu yöntem, karar vericiler arasında ortak bir payda oluşturması bakımından ERP seçiminde avantaj sağlamaktadır (Öztürk & Karakoç, 2021; Yazgan et al., 2009). Rouyendegh ve Erkan (2012) tarafından önerilen bulanık VIKOR uygulamaları ise, özellikle belirsizliklerin yoğun olduğu durumlarda daha dengeli sonuçlar üretmiştir. Ngai et al. (2008) tarafından yapılan sistematik literatür taraması, AHP ve TOPSIS'in ERP seçiminde en sık tercih edilen yöntemler olduğunu göstermiştir. Literatürde ERP seçiminde sektörel farklılıklar da dikkat çekmektedir. Sağlık, inşaat ve kamu sektörlerinde güvenlik, mevzuata uyum ve özel süreç modülleri gibi kriterlerin ön plana çıktığı gözlemlenmiştir. Ancak Türkiye'de elektrik dağıtım sektörü özelinde ERP seçim sürecini inceleyen çalışmalar sınırlı sayıdadır. Bu durum, veri yoğunluğu ve regülasyon bağımlılığı yüksek olan bu sektörde özgün ve bütüncül karar modellerine olan ihtiyacı ortaya koymaktadır.

Bu çalışma, söz konusu boşluğu doldurmayı amaçlamakta; AHP, TOPSIS ve VIKOR yöntemlerini entegre biçimde kullanarak elektrik dağıtım sektörüne özgü kriterlerle çok kriterli bir karar modeli önermektedir. Böylece hem akademik literatüre katkı sağlanmakta hem de uygulayıcılar için sistematik ve uygulanabilir bir çerçeve sunulmaktadır.

GEREÇ VE YÖNTEM

Bu çalışma, Türkiye'de faaliyet gösteren büyük ölçekli bir elektrik dağıtım işletmesinin kurumsal kaynak planlaması (ERP) sistemine geçiş sürecinde karşılaştığı yazılım seçimi problemini çok kriterli karar verme (ÇKKV) yaklaşımlarıyla çözmeyi amaçlamaktadır. Araştırma, hem nitel hem nicel veri toplama yöntemlerini bütünleştiren betimsel-analitik bir vaka çalışması olarak kurgulanmış ve üç temel fazda yürütülmüştür: (1) karar probleminin tanımlanması ve kriterlerin belirlenmesi, (2) çok kriterli karar verme yöntemlerinin uygulanması, (3) sonuçların yorumlanması ve karşılaştırmalı değerlendirilmesi.

3.1. Karar Probleminin Tanımlanması

İlgili elektrik dağıtım işletmesi, artan operasyonel ihtiyaçlar ve dijitalleşme stratejisi doğrultusunda mevcut süreçlerini bütünleşik biçimde yönetmek üzere ERP sisteminde değişiklik kararı almıştır. Ancak, pazarda yer alan farklı ERP çözümleri; modüler yapı, maliyet, esneklik, kullanıcı deneyimi ve tedarikçi desteği gibi çok sayıda farklı kriter açısından çeşitlilik göstermektedir. Bu nedenle seçim süreci çok boyutlu ve karmaşık bir karar problemine dönüşmüştür.

Bu bağlamda araştırma kapsamında ele alınan karar problemi şu şekilde tanımlanmıştır:

"Elektrik dağıtım sektöründe faaliyet gösteren bir kuruluşun ERP sistemine geçiş sürecinde, teknik, yönetsel ve sektörel gereksinimlerine en uygun yazılım alternatifinin seçilmesi."

Problemin doğası gereği, çok sayıda alternatifin ve farklı öneme sahip çok sayıda kriterin yer aldığı çok kriterli bir karar yapısı söz konusudur.

3.2. Veri Toplama ve Kriter Belirleme Süreci

Kriter belirleme süreci hem literatür taraması hem de sektörel uzman görüşmeleri yoluyla yürütülmüştür. Saha verileri; bilgi işlem yöneticileri, ERP danışmanları ve teknik kullanıcılarla yapılan yarı yapılandırılmış mülakatlar aracılığıyla toplanmıştır. Bu süreç sonunda ERP seçiminde öncelikli olarak değerlendirilen dört ana kriter ve bunlara bağlı toplam 20 alt kriter tanımlanmıştır:

- Maliyet:
  - Yazılım maliyeti
  - Donanım maliyeti
  - EPDK desteği
  - Bakım maliyeti.
- Teknik Yeterlilik:
  - Arayüz ve veritabanının hılzı olması
  - Özelleştirilebilir iş akışları
  - Kullanım kolaylığı & kullanıcı dostu
  - Kullanıcıların sistemden esnek ve etkileşimli raporlar alabilmesi
  - Yazılımın web tabanlı olması.
- Uyarlanabilirlik:
  - Yazılımı oluşturan modüllerin tam entegrasyonu
  - Kurum içerisindeki diğer uygulamalar ile entegrasyonu
  - Yazılımın uyarlama ve işletme içerisinde kurulma süresi
  - Sisteme eski verilerin aktarılabilmesi.
- Tedarikçi Özellikleri:
  - Eğitim ve danışmanlık hizmetlerinin yazılım firması tarafından verilmesi
  - Tedarikçinin bölgede yerleşik olması
  - Yazılım firmasının yurt içi ve yurt dışı referanslarının olması ve güvenirliği

- Yazılımın firmasının ürünlerini sürekli olarak geliştirmesi ve yeni teknolojileri bu ürünlere aktarması.

Kriterlerin göreli önem düzeylerinin belirlenmesinde Saaty'nin 1–9 ölçekli karşılaştırma sistemi kullanılmış ve uzmanlardan elde edilen veriler ışığında ikili karşılaştırma matrisleri oluşturulmuştur.

3.3. ERP Alternatiflerinin Belirlenmesi

Uygulama kapsamında, sektörde sık tercih edilen ve farklı teknik-mali profillere sahip dört ERP yazılımı değerlendirmeye alınmıştır. Bu alternatifler aşağıda tanımlanmıştır:

- ERP A – SAP: Uluslararası çapta bilinen, güçlü modüler yapıya sahip ancak yüksek maliyetli çözüm.
- ERP B – Oracle: Geniş modül çeşitliliği ve yüksek teknik kapasite sunan, orta seviyede kullanıcı deneyimi sağlayan sistem.
- ERP C – MBS: Mevcutta kullanılan ve kullanıcalın da adapte olduğu çözüm.
- ERP D – Milli Yazılım (THOR): Tamamen open-source(açık kaynak) kodları ile yazılan yerli çözüm, düşük maliyetli ancak modüler kapasitesi ve teknik altyapısı sınırlı.

Bu yazılım seçenekleri, belirlenen kriterlere göre ÇKKV yöntemleriyle çok boyutlu olarak analiz edilmiştir.

3.4. Kullanılan Karar Verme Yöntemleri

Çalışmada, karar kalitesini artırmak ve duyarlılık analizine olanak tanımak amacıyla üç farklı ÇKKV yöntemi birlikte kullanılmıştır: AHP, TOPSIS ve VIKOR. Bu bütünleşik yöntem seti, hem kriter ağırlıklandırması hem de alternatif sıralaması açısından karşılaştırmalı analiz imkânı sunmaktadır.

AHP (Analitik Hiyerarşi Prosesü)

AHP yöntemi, karar vericilerin sübjektif değerlendirmelerini nicel ağırlıklara dönüştürerek kriterlerin önem düzeylerini belirlemede kullanılmıştır. İkili karşılaştırma matrisleri, Saaty (1980) tarafından önerilen 1–9 puanlama ölçeğine göre oluşturulmuş; her matrisin tutarlılık oranı (CR) %10'un altında kalacak şekilde kontrol edilmiştir. Elde edilen kriter ağırlıkları, diğer sıralama yöntemlerinde kullanılmak üzere normalize edilmiştir.

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution)

TOPSIS yöntemi, her alternatifin ideal çözüme olan yakınlığı ve negatif-ideal çözüme olan uzaklığı esas alınarak değerlendirilmiştir. İlk olarak karar matrisi normalize edilmiş; ardından AHP yöntemiyle elde edilen kriter ağırlıklarıyla ağırlıklandırılmış karar matrisi oluşturulmuştur. Bu matris üzerinden her bir ERP alternatifi için Ci (yakınlık katsayısı) hesaplanarak tercih sıralaması elde edilmiştir.

VIKOR (Vise Kriterijumska Optimizacija I Kompromisno Resenje)

VIKOR yöntemi, uzlaşmaya dayalı karar verme yaklaşımı ile, grup faydası ve bireysel pişmanlık kriterlerini birlikte dikkate alarak alternatifleri değerlendirmiştir. Her bir alternatif için S (toplam uzaklık), R (maksimum bireysel kriter uzaklığı) ve Q (uzlaşma indeksi) değerleri hesaplanmıştır. Karar verici tercih ağırlığı v = 0,5 olarak alınmış ve sıralama Q değerine göre yapılmıştır.

Bu yöntemlerin birlikte kullanımı, karar modellerinin çıktılarının karşılaştırılmasını ve yöntemler arası tutarlılık ve sapma analizinin yapılmasını sağlamış; böylece ERP seçim sürecinde daha güvenilir, esnek ve çok yönlü bir karar destek ortamı oluşturulmuştur.

BULGULAR

Bu çalışmada çok kriterli karar verme (ÇKKV) yöntemleri olan Analitik Hiyerarşi Süreci (AHP), TOPSIS ve VIKOR kullanılarak dört farklı ERP yazılım alternatifi sistematik biçimde değerlendirilmiştir. Elektrik dağıtım sektörüne özgü ihtiyaçlar doğrultusunda belirlenen kriterler ve alt kriterler, uzman görüşlerine dayalı olarak AHP yöntemiyle ağırlıklandırılmış, ardından bu ağırlıklar TOPSIS ve VIKOR yöntemlerinde kullanılarak ERP alternatiflerinin başarı sıralamaları elde edilmiştir. Bulgular hem karar kriterlerinin önem derecelerine hem de yazılım seçeneklerinin bütüncül performansına ilişkin anlamlı çıktılar sunmaktadır.

4.1. AHP Sonuçları: Kriter Ağırlıkları

AHP yöntemiyle gerçekleştirilen ikili karşılaştırmalar sonucunda dört ana kriterin göreli önem düzeyleri belirlenmiştir. Bu kapsamda, karar matrisinin normalize edilmesi ve öncelik vektörlerinin hesaplanması ile elde edilen ağırlıklar Tablo 1'de sunulmuştur.

Tablo 1. AHP **Yöntemiyle Belirlenen Ana Kriter Ağırlıkları ve Tutarlılık Sonuçları**

Ana Kriter	**Ağırlık (%)**	**Açıklama**
Teknik Özellikler	30,86	Sistem modülerliği, entegrasyon, veri güvenliği
Uyarlanabilirlik	34,65	Kurulum süresi, uyarlama kolaylığı
Tedarikçi Özellikleri	14,94	Referans, destek, yerel işbirliği
Maliyet	19,56	Yazılım, donanım, teşvik ve bakım maliyeti
Toplam	**100**	
Tutarlılık Oranı (CR)	**0,48**	AHP analizine göre tutarlılık sağlanmıştır

AHP analizine göre en yüksek öneme sahip kriter “Uyarlanabilirlik” (%34,65) olarak öne çıkmaktadır. Bu durum, elektrik dağıtım sektöründe ERP sistemlerinden beklenen işlevsellik, esneklik ve veri entegrasyonuna verilen önemi göstermektedir. Diğer kriterler arasında Teknik Özellikler (%30,86) ve Maliyet (%19,56) orta düzeyde etkili olurken, Tedarikçi Özellikler (%14,94) en düşük ağırlığa sahip olmuştur. Bu dağılım, karar vericilerin ERP yatırımlarında sadece ekonomik faktörlere değil, sistemin teknik yeterliliğine ve kurumsal uyuma öncelik verdiğini göstermektedir.

4.2. TOPSIS Sonuçları: ERP Alternatiflerinin İdeal Çözüme Yakınlığına Göre Sıralanması

TOPSIS yöntemi, ağırlıklandırılmış karar matrisinden ideal ve negatif ideal çözümlere olan uzaklıkları hesaplayarak alternatiflerin yakınlık derecelerini (Ci) belirler. Bu analiz sonucunda elde edilen skorlar ve sıralama Tablo 2'de gösterilmektedir.

Tablo 2. TOPSIS Yöntemine Göre ERP Alternatiflerinin Ci Skorları ve Sıralaması

ERP Alternatifi	**Ci Değeri**	**Sıralama**
THOR	0,177	1
MBS	0,170	2
ORACLE	0,126	3
SAP	0,092	4

TOPSIS analizi sonucunda, en yüksek Ci değeri olan THOR ideal çözüme en yakın seçenek olarak belirlenmiştir. THOR’un teknik özelliklerdeki yüksek performansının yanı sıra uyarlama kolaylığı ve kabul edilebilir maliyet düzeyi bu sonucu desteklemektedir. MBS, düşük maliyet ve uyarlanabilirlik sayesinde ikinci sıraya yerleşmiştir. ORACLE, güçlü teknik kapasitesine rağmen yüksek maliyeti nedeniyle bir sıra geride kalmıştır. SAP ise özellikle yüksek maliyetli oluşu ve uyarlama süresi sebebiyle son sırada kalmıştır. Bu sıralama, kriter bazlı denge arayışının toplam performansa olan etkisini yansıtmaktadır.

4.3. VIKOR Sonuçları: Uzlaşma Temelli Sıralama Yaklaşımı

VIKOR yöntemi, fayda ve pişmanlık kriterlerini dengeleyerek alternatiflerin ideal çözüme yakınlıklarını belirler. Bu analiz sonucunda her bir ERP alternatifi için S (toplam uzaklık), R (en kötü kriter performansı) ve Q (uzlaşma indeksi) değerleri hesaplanmıştır. Elde edilen sonuçlar Tablo 3'te verilmiştir.

Tablo 3. VIKOR Yöntemine Göre ERP Alternatiflerinin Q Değerleri ve Sıralaması

ERP Alternatifi	**Q Değeri**	**Sıralama**
THOR	0,0000	1
ORACLE	0,50493	2
MBS	0,50505	3
SAP	1,0000	4

VIKOR analizinde de Oracle, grup faydası ve bireysel pişmanlık ölçütleri bakımından en uygun alternatif olarak değerlendirilmiştir. Bu sonuç, THOR'un teknik açıdan güçlü olmasının yanı sıra düşük maliyet-performans ilişkisi kurabilmesinden kaynaklanmaktadır. MBS ve ORACLE birbirine yakın değerler vermektedir.THOR ile kıyaslandığında maliyet ve performans kaleminden kaynaklı THOR, MBS ve ORACLE'dan daha güçlü görünmektedir. SAP bu analizde de benzer nedenlerle son sırada kalmaktadır.

4.4. Yöntemlerin Karşılaştırmalı Değerlendirmesi

AHP yöntemi, doğrudan bir sıralama sunmasa da, kriter ağırlıklarının belirlenmesinde temel veri kaynağı olmuştur. TOPSIS ve VIKOR yöntemleri ise bu ağırlıkları kullanarak ERP alternatiflerini sıralamıştır. Yöntemlerin sunduğu sıralamalar genel olarak benzer eğilim göstermekte, ancak yöntemlerin yapısal farkları nedeniyle kısmi sapmalar görülmektedir.

- TOPSIS analizinde THOR > MBS > ORACLE > SAP şeklinde bir sıralama oluşmuştur.
- VIKOR analizinde ise THOR > ORACLE > MBS > SAP sıralaması ortaya çıkmış ve THOR her iki yöntemde de tutarlı biçimde ilk sırada yer almıştır.

Bu uyum, karar modellerinin güvenilirliğini ve ERP seçim sürecinde nesnel analizlerin önemini ortaya koymaktadır. SAP'nin tüm yöntemlerde son sırada yer alması ise özellikle maliyet ve uyarlanabilme kriterlerinden kaynaklı dezavantajlı ERP yazılımları olduğunu göstermektedir.

TARTIŞMA

Bu çalışmada geliştirilen çok kriterli karar verme (ÇKKV) modeli, Türkiye'de elektrik dağıtım sektöründe faaliyet gösteren bir kuruluşun ERP yazılımı seçim sürecini bilimsel temellere dayalı biçimde sistematikleştirmeyi amaçlamış ve uygulamada Analitik Hiyerarşi Süreci (AHP), TOPSIS ve VIKOR yöntemlerinin birlikte kullanılabilirliğini başarıyla göstermiştir. Elde edilen sonuçlar, ERP seçim sürecinin yalnızca teknik değerlendirmelerden ibaret olmadığını; aynı zamanda maliyet, kullanıcı deneyimi, yerel destek gibi yönetsel ve operasyonel unsurları da kapsayan çok katmanlı bir yapıya sahip olduğunu ortaya koymuştur. Bu çok boyutlu yapı, karar modellerinin stratejik planlama süreciyle uyumlu biçimde kurgulanmasının karar kalitesini doğrudan etkilediğini göstermektedir.

AHP yöntemiyle yapılan analizde, "Uyarlanabilirlik" kriterinin %34,65 gibi yüksek bir oranla en önemli faktör olarak belirlenmesi, özellikle maliyet, veri güvenliği, sistem entegrasyonu ve modüler yapı gibi unsurların öncelikli olduğu elektrik dağıtım sektörünün dinamikleriyle büyük ölçüde örtüşmektedir. Bu bulgu, Büyüközkan ve Öztürkcan (2010) tarafından üretim sektöründe yapılan çalışmalarda da benzer şekilde teknik kriterlerin en yüksek önceliğe sahip olduğunun belirtilmesiyle literatürel uyum içindedir. Ayrıca, Karaarslan & Gündoğar (2008) tarafından yapılan modüler ERP sistem seçimi üzerine çalışmada teknik yeterliliğin karar

sürecinde en belirleyici unsur olarak ön plana çıkması, bu çalışmanın hem metodolojik sağlamlığını hem de sektörel geçerliliğini desteklemektedir.

ERP yazılım alternatiflerinin sıralanmasında kullanılan TOPSIS ve VIKOR yöntemlerinin farklı sonuçlar üretmesi, bu yöntemlerin altında yatan matematiksel prensiplerin karar sürecine olan etkisini açıkça göstermektedir. TOPSIS yöntemi, ideal çözüme olan yakınlığı esas alarak MBS ERP'yi en uygun seçenek olarak belirlemiştir. Buna karşılık, VIKOR yöntemi, bireysel pişmanlığı minimize eden ve grup faydasını maksimize eden uzlaşma temelli yapısı ile Oracle ERP'yi birinci sırada değerlendirmiştir. Bu farklılık, Sarı (2018) tarafından gerçekleştirilen karşılaştırmalı analizlerde de vurgulandığı üzere, karar vericilere farklı perspektiflerden analiz yapma ve karar tutarlılığını sınama fırsatı sunmakta, yöntemlerin birlikte kullanımının güvenilirliği artırdığını göstermektedir.

Bu çalışmanın özgün katkılarından biri de sektörel bağlamda oluşturduğu modelleme yaklaşımıdır. ERP seçim literatüründe, genellikle üretim, sağlık, kamu veya hizmet sektörlerine odaklanan çalışmalar yaygınken, elektrik dağıtım sektörüne özgü karar kriterlerinin çok sınırlı biçimde ele alındığı görülmektedir. Bu bağlamda çalışma, sektörün kendine özgü regülasyon yoğunluğu, yüksek veri güvenliği ihtiyacı, SCADA ve enerji yönetim sistemleriyle entegrasyon gereksinimi gibi spesifik kriterleri modeline entegre etmesi bakımından öncü bir örnek sunmaktadır. Bu yaklaşım, Karsak ve Özogul'un (2009) ERP seçiminde bulanık TOPSIS yöntemiyle geliştirdiği sektörel duyarlılığı yüksek karar modelleriyle de örtüşmekte; klasik TOPSIS yönteminin bu çalışmada uygulanmasıyla elde edilen sonuçlar ise sektör pratiğine uygun ve uygulanabilir çıktılar üretmektedir.

Ayrıca, bu çalışmada kullanılan yöntemlerin karşılaştırmalı yapısı, sadece en uygun ERP yazılımının belirlenmesini değil, aynı zamanda duyarlılık analizi yapılmasına da olanak sağlamıştır. AHP ile belirlenen ağırlıkların farklı yöntemlere entegre edilmesi, karar vericilerin farklı senaryolarda nasıl sonuçlar elde edilebileceğini test etmesine imkân tanımış ve bu yönüyle sadece teorik değil, pratik yönetim kararları açısından da uygulanabilirlik sağlamıştır.

Sonuç olarak, bu çalışmada ÇKKV yöntemlerinin bütünleşik biçimde kullanılmasıyla ERP seçim sürecine ilişkin daha bütüncül, duyarlı ve esnek bir karar destek sistemi geliştirilebileceğini açık biçimde göstermiştir. Özellikle, farklı yöntemlerin birlikte uygulanması sayesinde karar vericilere çok yönlü analiz, karşılaştırmalı değerlendirme ve metodolojik esneklik sunulmuş; böylece karar kalitesinde önemli bir artış sağlanmıştır. Bu yönüyle çalışma, yalnızca akademik katkı sunmakla kalmamış; aynı zamanda kamu ve özel sektörde dijital dönüşüm süreçlerine stratejik yön verme potansiyeline sahip uygulanabilir bir model önermektedir.

SONUÇLAR

Bu çalışma kapsamında, elektrik dağıtım sektöründe faaliyet gösteren bir kurumun ERP sistemi seçim süreci, çok kriterli karar verme (ÇKKV) yaklaşımlarıyla yapılandırılmış ve sistematik bir biçimde analiz edilmiştir. Kuruluşun teknik, yönetsel ve mali ihtiyaçları doğrultusunda belirlenen karar kriterleri, Analitik Hiyerarşi Süreci (AHP) yöntemi ile ağırlıklandırılmış; elde edilen kriter ağırlıkları, ERP yazılım alternatiflerinin değerlendirilmesinde TOPSIS ve VIKOR yöntemlerinde kullanılmıştır. Bu bütünleşik analiz çerçevesinde, her bir yöntemin ürettiği sıralamalar karşılaştırılarak tutarlılık ve karar güvenilirliği açısından değerlendirilmiştir.

AHP yöntemi ile yapılan analizlerde "Uyarlanabilirlik" kriteri %34,65 oranla en önemli faktör olarak öne çıkmıştır. Bu bulgu, özellikle maliyet, veri güvenliği, sistem entegrasyonu, SCADA uyumluluğu gibi teknik yeteneklerin ön planda olduğu enerji sektöründe ERP başarısının doğrudan entegrasyon, uyarlama süresi, maliyet gibi kriterlere bağlı olduğunu göstermektedir. Bu kriteri sırasıyla teknik yeterlilik (%30,86), maliyet (%19,56) ve tedarikçi özellikleri (%14,94) izlemiştir. Söz konusu ağırlıklandırma, karar sürecinin sadece finansal değil, çok boyutlu bir yapıda yürütülmesi gerektiğini göstermektedir.

TOPSIS yöntemiyle yapılan analizde, ideal çözüme en yakın ERP alternatifi THOR olarak belirlenmiş; bu yazılım, özellikle maliyet ve uyarlanabilirlik açısından dengeli bir performans sergilemiştir. Diğer yandan, VIKOR yöntemi, grup faydası ile bireysel pişmanlık dengesi üzerinden yürütülen analizde THOR ERP'yi en uygun çözüm olarak önermiştir. Her iki yöntemin aynı karar problemine uygulandığında ilk alternatifin aynı olup, sonraki sırlamanın farklı sonuçları üretmesi, çoklu yöntem kullanımının karar duyarlılığı ve güvenilirliği açısından önemini ortaya koymuştur. Bu yöntemsel çeşitlilik sayesinde, sadece tekil bir modelin sonuçlarına bağlı kalınmadan, daha kapsamlı ve sağlam bir değerlendirme yapılması mümkün olmuştur.

Yabancı referansları fazla ve uluslararası çapta yaygın olarak kullanılan alternatif olan SAP, teknik yeterlilik avantajına sahip olmasına rağmen yüksek maliyet ve uyarlama süresinden kaynaklı zayıf kalmış, hem TOPSIS hem de VIKOR analizlerinde son sırada yer almıştır. Bu sonuç, yalnızca performans temelli karar vermenin yetersiz olduğunu, özellikle maliyet, stratejik öneme sahip yazılım yatırımlarında işlevsellik, entegrasyon kabiliyeti ve kurumsal destek gibi niteliksel kriterlerin öncelikli olarak değerlendirilmesi gerektiğini ortaya koymuştur.

Bu bağlamda çalışmanın temel katkısı, ERP gibi stratejik bilgi teknolojileri yatırımlarında, çok boyutlu karar destek sistemlerinin kullanılmasının gerekliliğini açık biçimde göstermesidir. ERP sistemleri yalnızca yazılım seçiminden ibaret olmayan, organizasyonun dijital dönüşüm stratejisini doğrudan etkileyen kritik yapılardır. Bu nedenle karar vericilerin yalnızca fiyat, marka bilinirliği ya da geçmiş deneyimlere dayalı tercihler yerine; sektörel, teknik ve organizasyonel gerçekliklerle uyumlu çok kriterli modellerle desteklenen kararlar alması, yatırımın başarısını ve sürdürülebilirliğini büyük ölçüde artırmaktadır.

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İÇ ANADOLU BÖLGESİ'NE AİT GELENEKSEL VE UNUTULMAYA YÜZ TUTMUŞ LEZZETLER

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ÖZET
İç Anadolu Bölgesi, tarih boyunca pek çok medeniyete ev sahipliği yapmış, göçebe kültürden yerleşik düzene geçişin izlerini taşıyan bir coğrafyada yer almaktadır. Bu köklü tarihsel geçmiş, bölge mutfağına da zengin bir çeşitlilik ve kültürel derinlik kazandırmıştır. Ancak günümüzde, geleneksel yemeklerin büyük bir kısmı unutulmuş ya da yalnızca sınırlı yerel çevrelerde bilinir haldedir. Bu çalışmada, İç Anadolu Bölgesi'ndeki unutulmaya yüz tutmuş geleneksel yemeklere ait bilgilerin derlenmesi ve kültürel bağlamlarının ortaya konulması amaçlanmıştır. Ankara'ya özgü Entekke Böreği, Konya mutfağının önemli örneklerinden Etli Topalak, Kayseri'nin karakteristik mezesi Fırın Çemeni, Sivas'ın Divriği ilçesine has Divriği Pilavı, Yozgat mutfağının özgün lezzeti Cırma, Nevşehir'in geleneksel tatlarından Dolaz, Aksaray'da yaygın olarak hazırlanan Etli Çalma ile Kırşehir'in yerel yemeği Gılik, bölgenin tarihsel ve kültürel dokusuyla şekillenen, ancak günümüzde unutulma riski taşıyan değerli mutfak lezzetleri arasında yer almaktadır. Söz konusu yemekler sadece beslenme aracı değil, aynı zamanda gelenek, ritüel ve sosyal aidiyet taşıyıcısıdır. Çalışmanın sonucu, bazı geleneksel yemek tariflerinin kuşaktan kuşağa aktarılamadığı için tamamen yok olma tehlikesiyle karşı karşıya olduğunu göstermektedir. Sözkonusu reçetelerin yazılı hale getirilerek arşivlenmesi, sadece yemek kültürünün değil, aynı zamanda bölgesel kimliğin de yaşatılmasına katkı sağlayacaktır.
Anahtar Kelimeler: Geleneksel yemekler, İç Anadolu Bölgesi, kültürel miras, gastronomi, unutulmuş tarifler.

TRADITIONAL AND NEARLY FORGOTTEN TASTES OF THE CENTRAL ANATOLIA REGION

ABSTRACT
The Central Anatolia Region has hosted many civilizations throughout history and is located in a geography that bears the traces of the transition from nomadic culture to settled life. This deep-rooted historical past has also given the regional cuisine a rich variety and cultural depth. However, today, a large part of the traditional dishes have been forgotten or are only known in limited local circles. This study aims to compile information on traditional dishes that are on the verge of being forgotten in the Central Anatolia Region and to reveal their cultural contexts. Entekke Borek, unique to Ankara, Etli Topalak, an important example of Konya cuisine, Fırın Çemeni, a characteristic appetizer of Kayseri, Divriği Pilaf, unique to the Divriği district of Sivas, Cırma, an original flavor of Yozgat cuisine, Dolaz, a traditional flavor of Nevşehir, Etli Çalma, widely prepared in Aksaray, and Gılik, a local dish of Kırşehir, are among the valuable culinary flavors that have been shaped by the historical and cultural texture of the region, but are currently at risk of being forgotten. The meals in question are not only a means of nutrition, but also a carrier of tradition, ritual and social belonging. The results of the study show that some traditional recipes are in danger of extinction because they cannot be passed down from

generation to generation. Archiving these recipes in writing will contribute to the survival of not only the food culture but also the regional identity.
Keywords: Traditional dishes, Central Anatolia Region, cultural heritage, gastronomy, forgotten recipes.

GİRİŞ

Gastronomi yalnızca beslenme pratiklerini değil; aynı zamanda toplumların kültürel mirasını, yaşam biçimlerini ve tarihsel birikimlerini yansıtan çok disiplinli bir alandır. Tarih boyunca kuşaktan kuşağa aktarılan geleneksel yemekler, bir toplumun kimliğini oluşturan temel kültürel öğelerden biri olarak kabul edilmektedir. Ancak günümüzde küreselleşme, kentleşme, göç hareketleri ve modern yaşam biçimlerinin etkisiyle bu geleneksel yemek kültürü dönüşüme uğramakta; bazı yemekler ise zamanla unutulmakta ya da tamamen yok olma tehlikesiyle karşı karşıya kalmaktadır.

Bu çalışma, Türkiye'nin kültürel açıdan zengin bölgelerinden biri olan İç Anadolu Bölgesi'ne (Aksaray, Niğde, Yozgat, Kayseri, Sivas, vb.) ait unutulmuş ya da unutulmaya yüz tutmuş geleneksel yemeklerin tespit edilmesini ve bu yemeklerin kaybolma nedenlerinin araştırılmasını amaçlamaktadır. Araştırma kapsamında hem yazılı kaynaklardan hem de sözlü görüşmelerden yararlanılmış; geçmişten günümüze kadar varlığını sürdüren ancak günümüzde yaygın olarak bilinmeyen veya üretilmeyen yemekler belirlenmiştir. Elde edilen veriler doğrultusunda bu yemeklerin tarihsel ve kültürel bağlamları irdelenmiştir. Bu araştırma ile İç Anadolu mutfağının özgün ve yerel tatlarını kayıt altına alarak gün yüzüne çıkarılıp gastronomi literatürüne katkı sağlanacak ve geleneksel yemeklerin korunmasına yönelik farkındalık oluşturulacaktır.

İÇ ANADOLU BÖLGESİ'NİN KÜLTÜREL VE GASTRONOMİK YAPISI

İç Anadolu Bölgesi'nin Coğrafi ve Tarihî Özellikleri

İç Anadolu Bölgesi, Türkiye'nin tam merkezinde yer alması sayesinde tarih boyunca pek çok medeniyete ev sahipliği yapmış, bu da bölgenin kültürel çeşitliliğini artırmıştır. Bozkırlarla kaplı yapısı ve sert karasal iklimi nedeniyle tarım ve hayvancılık, halkın temel geçim kaynakları olmuş; bu durum mutfak kültürüne de yansımıştır. Köy ve kasaba yaşamının hâkim olduğu bu bölgede geleneksel değerler güçlü şekilde yaşatılmakta, gastronomik alışkanlıklar kuşaktan kuşağa aktarılmaktadır. Düğün, bayram ve dini törenler gibi toplumsal etkinlikler yemek kültürünün en yoğun yaşandığı alanlardır. İç Anadolu mutfağı, kıtlık dönemlerinin etkisiyle sadelik, dayanıklılık ve doyuruculuk esasına dayanır. Un, bulgur, kuru baklagiller, yoğurt ve et gibi gıdalar öne çıkar (Açıkalın, 2018).

Yemek yapımı genellikle kolektif şekilde gerçekleştirilir. Özellikle kadınların erişte kesme, salça yapma, turşu kurma gibi becerileri, kültürel mirasın aktarımında önemli yer tutar. Son yıllarda şehirleşme ve hazır gıdalar nedeniyle bu kültür değişime uğrasa da, kırsal bölgelerde geleneksel yapısını korumaktadır. Ayrıca yerel yönetimler, festivaller ve kadın kooperatifleri sayesinde unutulmaya yüz tutmuş lezzetler yeniden hatırlatılmakta, kültürel hafıza canlı tutulmaktadır (Aşçıoğlu, 2020).

Bölge Halkının Mutfak Kültürü

İç Anadolu Bölgesi'nin mutfak kültürü, tarihsel birikimin, coğrafi koşulların ve sosyal yapının etkisiyle şekillenmiş köklü bir geleneğe sahiptir. Bölge mutfağı, öncelikli olarak kendi kendine yetme kuralına dayalıdır. Yani, yemeklerde kullanılan malzemelerin önemli bir kısmı evde üretilen veya yerelden temin edilen ürünlerden oluşur. Tarım ürünleri arasında özellikle buğday, arpa, mercimek ve nohut gibi tahıl ve bakliyat ürünleri ön plana çıkarken, hayvancılık faaliyetleri sayesinde süt, yoğurt, peynir, tereyağı ve et gibi ürünler mutfağın temel yapı taşlarını oluşturur. Bu durum, bölge halkının yemek tercihlerinin aynı zamanda ekonomik ve coğrafi zorunluluklarla da şekillendiğini göstermektedir (Yüce, 2016).

İç Anadolu halkı için yemek yalnızca bir beslenme aracı değil; aynı zamanda toplumsal iletişimin ve kültürel aktarımın bir parçasıdır. Özellikle kırsal alanlarda yemek hazırlama ve tüketme eylemleri, önemli bir nitelik taşır. Geleneksel köy yaşamında kadınlar, sabah erken saatlerde başlayarak gün boyu mutfak işleriyle ilgilenir, kışlık yiyeceklerin hazırlanması gibi süreçler ise kalabalık bir şekilde yürütülür. Erişte kesme, salça yapma, tarhana hazırlama, kurutmalık sebze ve meyve işlemleri hazırlıkları yapar hem üretime katılım hem de kültürel bağları güçlendiren etkinliklerdir. Fazla emek çeşitliliği, bölgedeki yaşam döngüsüne göre değişkenlik gösterir. Örneğin, kış aylarında daha çok saklamaya uygun, kalorisi yüksek yemekler tercih edilirken, yaz aylarında yoğurtlu ve sebzeli yemeklere yoğunluk verildiği gözlemlenir. Çorba kültürü, İç Anadolu'da oldukça gelişmiştir; özellikle mercimek, tarhana, düğü (ince bulgur) ve arabaşı gibi çorbalar hemen her sofrada yer bulur. Arabaşı, bölgede yalnızca bir yemek değil, aynı zamanda sosyal bir etkinlik olarak kabul edilir ve genellikle kalabalık aile grupları ile tüketilir (Gürsoy & Öztürk, 2020).

Özellikle keşkek, etli pilav, kavurma ve tandır eti gibi yemekler, bölgenin geleneksel tören yemekleri arasında yer alır. Bu yemeklerin hazırlanışı ise yalnızca mutfak pratiği değil, aynı zamanda bir süreç olarak değerlendirilir. Keşkek örneğinde olduğu gibi, yemeğin pişirme süreci kalabalık biçimde yürütülür; kazanlar kurulur, saatler süren pişirme işlemi gerçekleştirilir ve yemek toplulukla paylaşılır (Sönmez & Yıldırım 2021). Tatlılar ise çoğunlukla şerbetli hamur tatlıları ya da sütlü tatlılar şeklinde karşımıza çıkar. Bununla birlikte, özel günlere özgü tatlılar arasında üzüm pekmezinden yapılan bastık, cevizli sucuk, un helvası gibi yerel ürünler de önemli yer tutar. Tatlıların hazırlanışı ve sunumu, misafirperverlik kültürüyle de doğrudan ilişkilidir. Bölge halkının mutfak kültürü, geçmişten günümüze aktarılan sözlü bilgi, deneyim ve geleneklerle yaşatılmaktadır. Ancak günümüzde kentleşme, hazır gıda tüketimi ve yaşam tarzlarındaki değişim gibi faktörler, bu geleneksel kültürün sürdürülebilirliğini tehdit edip, bizlerden uzaklaştırmaktadır. Buna rağmen, hâlâ birçok köyde ve kasabada geleneksel yöntemlerle yemek yapılmakta; annelerden kızlara, ninelerden torunlara bu kültürel miras aktarılmaya devam etmektedir (Kaya, 2017).

Geleneksel Saklama ve Pişirme Teknikleri

İç Anadolu'da şekillenen saklama ve pişirme teknikleri yalnızca besinlerin fiziki dayanıklılığını artırmakla kalmamış; aynı zamanda bölgenin kültürel hafızasında derin izler bırakan, kuşaktan kuşağa aktarılan birer yaşam pratiği haline gelmiştir. Bölgedeki geleneksel saklama yöntemleri, doğrudan üretim takvimine ve mevsimsel döngülere bağlı olarak gelişmiştir (Karabağ & Durmaz, 2019). Öte yandan, pişirme yöntemleri ise bölge halkının toplumsal yapısını, yaşam ritmini ve yemekle kurduğu ilişkiyi açıkça yansıtan pratikler olarak dikkat çeker (Açıkgenç & Tunçel, 2021).

Saklama Teknikleri

a) Kurutma: Kurutma, İç Anadolu'da en yaygın kullanılan geleneksel saklama yöntemlerinden biridir. Kurutulacak ürünler genellikle yaz aylarında toplanır ve güneşli yerlerde, çoğu zaman evlerin damlarında ya da avlularında ipler üzerine asılarak doğal yollarla kurutulur. Domates, biber, patlıcan, fasulye gibi sebzelerin yanı sıra, erişte, tarhana, yufka ve meyve kuruları da aynı yöntemle saklanır. Kurutulan gıdalar hem küçülür hem de ürünlerin raf ömrü uzar; bu da onları kış aylarında kolay erişilebilir hâle gelir.

b) Tuzlama: Tuzlama yöntemi, özellikle et ve peynir gibi hayvansal gıdaların saklanmasında kullanılır. Kış öncesi yapılan kavurma, tuzla muhafaza edilen etlerin uzun süre saklanmasına neden olur. Aynı şekilde, beyaz peynir tuzlu su dolu küplerde bekletilerek hem lezzet kazanır hem de aylarca bozulmadan kalabilir.

c) Salamura: Sebze ve bazı süt ürünlerinin korunmasında kullanılan salamura yöntemi, su ve tuz karışımından oluşur. Özellikle lahana, biber, salatalık, yeşil domates gibi sebzeler turşu hâline getirilerek kışa hazırlanır. Salamura, gıda güvenliği açısından mikroorganizma

gelişimini engellediği için, halk arasında güvenilir bir yöntem olarak kabul görmüştür ve hala yaygın bir şekilde kullanılan bir yöntemdir.

d) Fermente Ürünler: İç Anadolu'da, özellikle süt ürünlerinin korunması için mayalama ve yoğurtlaştırma yöntemleri öne çıkar. Yoğurt, çökelek ve ayran gibi ürünler, genellikle ev yapımıdır ve uzun ömürlü olacak şekilde hazırlanır. Yoğurttan elde edilen tarhana, hem besleyici hem de uzun süre saklanabilen bir ürün olarak kış aylarının vazgeçilmezidir .

e) Kavanozlama ve Ezme Yöntemi: Modern saklama yöntemlerinin yaygınlaşmadığı dönemlerde, halk domates ezmesi, biber salçası, pekmez ve reçel gibi ürünleri büyük ölçülerde hazırlayıp cam kavanozlarda saklamıştır. Bu uygulama günümüzde de sürmekte olup geleneksel yapısıyla hâlâ yaygın bir şekilde kullanılmaktadır(Karabağ & Durmaz, 2019).

Pişirme Teknikleri: İç Anadolu Bölgesi'nde pişirme teknikleri, yakıt, iklim şartları vb. faktörlere bağlı olarak gelişmiştir. Özellikle tandır, ocak, sac, taş fırın ve toprak kaplar, geleneksel pişirme araçlarının başında gelir .

a) Tandırda Pişirme: Tandır, özellikle kırsal alanlarda hâlâ kullanılan geleneksel bir pişirme aracıdır. Toprağın içine açılan silindir kuyulara benzer şekliyle bilinen tandırda, ekmek, bazlama, gözleme ve et yemekleri hazırlanır. Tandır ateşi yavaş ve uzun süreli pişirme sağladığı için, özellikle etlerin lokum kıvamına gelmesi ve hamur işlerinin içinin iyi pişmesi sağlanır. Ayrıca, tandırın başında geçen zaman kadınlar arasında sosyal etkileşimin de bir parçasıdır.

b) Sacda Pişirme: Sac, demirden yapılmış, geniş ve yayvan bir pişirme yüzeyidir. Yufka ekmeği, katmer, gözleme gibi unlu mamuller bu yüzeyde hazırlanır. Genellikle sac altına odun ateşi yakılır, bu da hızlı pişirme sağlar. Sac pişirme hem ekonomik hem de pratik olması nedeniyle yaygın biçimde kullanılmaktadır.

c) Taş Fırında Pişirme: Evlerin ya avlularında ya da mahalle içinde bulunan taş fırınlar, özellikle büyük miktarda yapılan yemeklerin ya da hamur işlerinin pişirilmesinde kullanılır. Fırınlar genellikle köy halkı arasında paylaşımlı şekilde kullanılır. Özellikle tandır böreği, fırın yemeği (etli patates, kuru fasulye gibi) ve baklava gibi tatlılar taş fırında pişirilerek daha lezzetli hâle gelir.

d) Toprak Kap Kullanımı: Toprak kaplar (güveç), yemeğin düşük sıcaklıkta uzun süre pişmesini sağlar. Özellikle güveçte et yemekleri, kuru fasulye, nohut gibi bakliyat yemekleri bu yöntemde sıkça tercih edilir. Toprak kabın doğal yapısı, yemeğin aromasını korur ve ısıyı dengeli dağıtarak sağlıklı ve lezzetli bir pişirme sağlar (Akyol & Yıldız, 2019).

İÇ ANADOLU BÖLGESİ'NİN İLLERİNE AİT UNUTULMUŞ TARİFLER

İç Anadolu mutfağının temel özellikleri arasında buğday ve türevlerinin yoğun kullanımı dikkat çeker. Hamur işleri, unlu mamuller ve tahıl bazlı çorbalar bölge mutfağının belkemiğini oluşturur. Bölgedeki sert karasal iklim, uzun süre saklanabilen yemeklerin ve kurutma, kavurma, salamura gibi geleneksel muhafaza yöntemlerinin yaygınlaşmasına neden olmuştur. Aynı zamanda tarhana, bulgur, erişte, kuru sebze ve meyveler gibi saklamaya uygun ürünler de günlük beslenmede önemli yer tutar. Tarihi süreç içerisinde, İç Anadolu'ya özgü birçok tarif günlük sofralardan çekilmiş, modern yaşam tarzı ve hızlı tüketim alışkanlıklarıyla birlikte unutulma tehlikesiyle karşı karşıya kalmıştır (Yıldız, 2018).

Bu unutulmuş tarifler, yalnızca lezzet açısından değil; aynı zamanda kültürel, tarihî ve toplumsal birer belge niteliğindedir. Tariflerin içerikleri, pişirme yöntemleri ve sunum şekilleri; geçmişin yaşam tarzı, sosyal yapısı ve coğrafi koşulları hakkında fikir verir. Bu nedenle geleneksel yemeklerin yalnızca lezzet olarak değil, kültürel miras kapsamında da değerlendirilmesi gerekmektedir. Günümüzde gastronomi alanında yapılan çalışmalar, bu eski tariflerin kayıt altına alınması, belgelenmesi ve modern mutfağa adapte edilmesi yönünde artmaktadır. Bu kapsamda yapılan araştırmalar, bölgenin mutfak hafızasını diri tutmak ve bu eşsiz yemekleri gelecek nesillere aktarmak adına oldukça değerlidir. Ayrıca geleneksel

tariflerin günümüz tüketici alışkanlıklarına uygun hale getirilerek yeniden mutfaklara kazandırılması, yerel turizmi ve kültürel farkındalığı da desteklemektedir (Güleç, 2021).

İç Anadolu Bölgesi'nin illerine göre unutulmuş yemekleri aşağıdaki tabloda verilmiştir.

Tablo 3.1: İller ve Unutulmuş Yemekleri[64]

İl	**Unutulmuş Yemekler**
Ankara	Entekke Böreği, Bastırma, Cızlak, Öllüğün Körü
Konya	Düğün Tiridi, Tutmaç Çorbası, Etli Topalak, Zülbiye
Kayseri	Yağlama, İncik Aşı, Fırın Çemeni
Sivas	Hıngel, Divriği Pilavı, Madımak Kavurması, Kelle Tatlısı, Gömme Tatlısı, Sızgıt, Hasıda, Katıklı Dolma, Erişte Çorbası, Sabüra
Yozgat	Parmaksız Böreği, Cırma, Teneşir Böreği, Arabaşı, Yarma Aşı, Kavurma Dolması
Nevşehir	Düğürcük Çorbası, Tandır Böreği, Soğanlama, Dolaz, Köfter
Aksaray,	Katıklı Dolma, Düğü Çorbası
Niğde	Cımbar
Kırşehir	Gılik

Ankara

Ankara iline ait unutulmaya yüz tutmuş yemekler aşağıda verilmiştir.

Entekke Böreği

Coğrafi Dağılımı: Ankara'nın özellikle Beypazarı ve Ayaş ilçelerinde geçmişte yaygın olarak hazırlanan bir börektir.

Tarihsel Arka Plan: Ramazan aylarında ve bayram sabahlarında geleneksel olarak yapılan bu börek, ince katmanlı hamuru ve özgün iç harcıyla bilinir. Özellikle kırsal alanlarda, evde açılan hamurun kat kat dizilmesiyle elde edilen yapısı, yemeğe ismini vermiştir.

Temel İçerikler: Un, su, tuz (hamur için); yeşil mercimek, tereyağı, karabiber

Hazırlık Süreci: Yoğrulan hamur bezeler halinde açılır. Haşlanmış mercimek ve ev eriştesiyle hazırlanan iç harç, kat kat serilen yufkaların arasına konur. Katmer formunda sarılarak fırında pişirilir.

Kültürel Önemi: Dayanıklılığı ve besleyiciliği nedeniyle özellikle tarım mevsimlerinde tercih edilirdi.

Günümüzdeki Durumu: El açması böreklerin zahmetli oluşu, hazır yufka ve pratik tariflerin yaygınlaşması nedeniyle bu tarif unutulma riski altındadır (Gökçe & Turgut, 2020).

Bastırma

Coğrafi Dağılımı: Ankara'nın Polatlı ilçesi başta olmak üzere kırsal bölgelerinde geçmişte sıklıkla tüketilmiştir.

[64]Halıcı, M. N., 2007; Artun, E., 2006; T.C. Kültür ve Turizm Bakanlığı Yayınları, 2021.

Tarihsel Arka Plan: Kışa hazırlık döneminde tuzlanarak kurutulan etlerin kullanımı, besin muhafaza tekniklerinin gelişmediği dönemlerde yaygın bir yöntemdi. Bu tarif, kurutulmuş etin sıcak yemek formuna dönüştürülmesinin güzel bir örneğidir.
Temel İçerikler: Kurutulmuş dana/koyun eti, soğan, yağ, biber salçası
Hazırlık Süreci: Kurutulmuş et önce ılık suda bekletilerek yumuşatılır. Ardından soğan ve salçayla birlikte kavrularak pişirilir. Sade pilav veya ekmekle servis edilir.
Kültürel Önemi: Etin bozulmadan uzun süre saklanmasını sağlayan bu yöntem, Ankara kırsal mutfağının kendine özgü bir çözümüdür.
Günümüzdeki Durumu: Soğuk zincirli et dağıtımının yaygınlaşması ve market ürünlerine yönelim nedeniyle ev tipi bastırma yapılmamaktadır (Çelik & Uysal, 2021).

Cızlak
Coğrafi Dağılımı: Elmadağ ve çevresindeki köylerde, sabah kahvaltılarının geleneksel bir parçası olmuştur.
Tarihsel Arka Plan: Sac üzerinde pişirilen, sade veya haşhaşlı şekilde tüketilen bu ince hamur işi, özellikle tandır kültürünün olduğu evlerde yaygındı.
Temel İçerikler: Un, su, tuz (hamur); haşhaş ezmesi veya çökelek
Hazırlık Süreci: Hamur, oklavayla çok ince açılır ve kızgın sac üzerinde pişirilir. Piştikten sonra haşhaş ezmesi ya da çökelek ile tatlandırılır ve katlanarak servis edilir.
Kültürel Önemi: Pratik hazırlanışı ve doyuruculuğu nedeniyle özellikle sabah erken saatlerde çalışan çiftçiler için idealdir (Özdemir, 2019).
Günümüzdeki Durumu: Sac kullanımının evlerde azalması ve kahvaltı alışkanlıklarının değişmesiyle bu yemek büyük oranda unutulmuştur.
Ankara kırsal mutfağı, sade ama fonksiyonel tariflerle donatılmış zengin bir mirasa sahiptir. Ancak modern yaşamın getirdiği hız, geleneksel tariflerin çoğunun kuşaktan kuşağa aktarımını kesintiye uğratmıştır. Bu üç yemek, Ankara'nın yerel mutfak belleğinde yer alan fakat unutulmaya yüz tutmuş önemli örneklerdir.

Konya
Konya iline ait unutulmaya yüz tutmuş yemekler aşağıda verilmiştir.

Düğün Tiridi
Coğrafi Dağılımı: Konya merkez ve çevresindeki kırsal ilçelerde (özellikle Karapınar ve Ilgın) düğün yemekleri arasında öne çıkmıştır.
Tarihsel Arka Plan: Eskiden düğünlerde kurban edilen hayvanların etiyle yapılan bu yemek, sade malzemelere dayanmasına rağmen zengin bir lezzet sunar. "Tirit" genel olarak et suyu ile bayat ekmeklerin buluştuğu bir yemeği ifade ederken, Konya versiyonu etin kendisinin de ön planda olduğu özel bir yorumdur.
Temel İçerikler: Parça et (genellikle kuzu veya dana), et suyu, bayat ekmek, sarımsaklı yoğurt, tereyağı
Hazırlık Süreci: Et haşlanarak suyuyla birlikte ayrılır. Bayat ekmek dilimleri tepsiye yerleştirilir, üzerine et suyu gezdirilir ve didiklenmiş et konur. Son olarak sarımsaklı yoğurt ve eritilmiş tereyağı eklenerek servis edilir.
Kültürel Önemi: Düğün yemeklerinin baş tacı olan bu yemek, köylerde toplulukla birlikte tüketilen bir ritüel öğünüydü.
Günümüzdeki Durumu: Düğünlerin lokantalarda yapılması ve büyük kazanlarda yapılan geleneksel tariflerin zorlaşması nedeniyle unutulmuştur (Karakaya & Yılmaz, 2019).

Tutmaç Çorbası
Coğrafi Dağılımı: Konya'nın Akşehir, Beyşehir ve Ereğli çevresinde özellikle kış aylarında sıkça hazırlanırdı.

Tarihsel Arka Plan: Orta Asya'dan Anadolu'ya uzanan göç sürecinde gelen bir çorba çeşididir. Selçuklu saray mutfağında da yer aldığı bilinir. Konya'da bu çorba yöreye özgü erişte, nohut ve yoğurtla yapılır.
Temel İçerikler: Ev yapımı erişte, haşlanmış nohut, süzme yoğurt, un, sarımsak, nane, tereyağı
Hazırlık Süreci: Erişte ve nohut haşlanır. Yoğurt, un ve yumurta sarısıyla terbiyesi hazırlanır. Kaynayan erişte-nohut karışımına yavaşça eklenir. Sarımsaklı tereyağında nane yakılarak üzerine gezdirilir.
Kültürel Önemi: Hem besleyici hem de ekonomik bir yemek olan tutmaç çorbası, dayanıklı ve kolay malzemelerle geniş aileleri doyurmak için tercih edilirdi.
Günümüzdeki Durumu: Hazır çorbaların ve hızlı yemek kültürünün yaygınlaşmasıyla bu geleneksel tarif evlerde nadiren yapılır hâle gelmiştir (Demirtaş & Akıncı, 2020).

Etli Topalak

Coğrafi Dağılımı: Konya'nın Bozkır ve Hadim çevresi başta olmak üzere kırsal kesimde bilinen bir yemektir.
Tarihsel Arka Plan: Bu yemek, kıtlık dönemlerinde az etle çok kişiyi doyurmak üzere geliştirilen pratik ama lezzetli bir çözümdür. Bulgurun başrolde olduğu yemek, Konya halk mutfağının sade ama doyurucu doğasını yansıtır.
Temel İçerikler: İnce bulgur, un, yumurta, dana kıyma, salça, soğan, baharatlar
Hazırlık Süreci: Bulgura yumurta ve un eklenerek küçük yuvarlak köfteler hazırlanır. Ayrı bir tencerede soğan ve salça kavrulur, su ilavesiyle köfteler içine atılır. Kıymalı sosla birlikte pişirilerek sıcak servis edilir.
Kültürel Önemi: Özellikle kış aylarında yapılan bu yemek, az malzeme ile doyurucu ve tok tutan bir alternatif olmuştur.
Günümüzdeki Durumu: Hazırlık aşamasının zahmetli olması ve geleneksel köfte yapımının genç kuşaklarca bilinmemesi nedeniyle evlerde artık çok nadir yapılmaktadır (Karakaya & Yılmaz, 2019).
Konya mutfağı, köklü tarihsel geçmişiyle birlikte hem saray hem halk mutfağının izlerini taşıyan zengin bir repertuara sahiptir. Ancak teknolojik gelişmeler, hazır gıdaların artması ve geleneksel bilgilerin aktarımındaki kopukluk, bu tür tariflerin unutulmasına neden olmuştur. Bu çalışma, söz konusu yemeklerin kayda geçirilmesi ve kültürel belleğin korunması açısından önemlidir (Yüce, 2021).

Kayseri

Kayseri iline ait unutulmaya yüz tutmuş yemekler aşağıda verilmiştir.

Yağlamak

Coğrafi Dağılımı: Özellikle Kayseri şehir merkezi ve çevresindeki mahallelerde yaygın olarak tüketilirdi.
Tarihsel Arka Plan: Yağlama, Kayseri mutfağında önemli bir yer tutan mantının yanında sıklıkla yapılan doyurucu bir ana yemektir. Ancak geleneksel formu, evde elle açılan yufka ve taş fırında pişirme yöntemine dayanır (Altuntaş & Demir, 2019).
Temel İçerikler: Mayalı hamur, kıyma, domates salçası, soğan, sıvı yağ veya tereyağı, baharatlar
Hazırlık Süreci: Hamur ince yuvarlaklar halinde açılıp sacda veya fırında pişirilir. Aynı anda kıymalı sos hazırlanır. Pişen yufkaların her katı, bu sosla yağlanır. Üst üste dizilip sıcak olarak, yanında yoğurtla servis edilir.
Kültürel Önemi: Özellikle misafir sofralarında, ev hanımlarının hünerlerini gösterdiği bir tarif olarak öne çıkmıştır.
Günümüzdeki Durumu: Pratik tariflerin ve dışarıdan hazır ürünlerin tercih edilmesiyle geleneksel ev tipi yağlama, giderek daha az yapılmaktadır (Altuntaş & Demir, 2019).

İncik Aşı
Coğrafi Dağılımı: Kayseri merkez ve Develi, Tomarza gibi ilçelerde geçmişte bayram yemekleri arasında yer alırdı.
Tarihsel Arka Plan: Koyun veya kuzu inciklerinin sebzelerle uzun sürede pişirilmesiyle oluşan bu yemek, daha çok özel günlerde hazırlanırdı. Etin kemikle birlikte pişmesi, yemeğe yoğun lezzet kazandırır.
Temel İçerikler: Kuzu incik, patates, havuç, kuru soğan, domates salçası, karabiber, defne yaprağı
Hazırlık Süreci: İncikler önce mühürlenir, ardından doğranmış sebzelerle birlikte güvece yerleştirilir. Salçalı su eklenip uzun sürede, tercihen tandır fırınında pişirilir.
Kültürel Önemi: Etin her parçasına saygı duyulan kırsal mutfak anlayışının tipik örneğidir.
Günümüzdeki Durumu: Uzun pişirme süresi ve geleneksel fırın olanaklarının azalması nedeniyle unutulmaya yüz tutmuştur (Koçak & Erol, 2020).
Fırın Çemeni
Coğrafi Dağılımı: Kayseri merkez ve Bünyan ilçesi başta olmak üzere çemenin yoğun kullanıldığı bölgelerde yapılırdı.
Tarihsel Arka Plan: Bu tarif, pastırmanın çemeninden esinlenerek hazırlanmış bir fırın yemeğidir. Etin üzerine çemen harcı sürülüp fırında kurutularak pişirilir. Kayseri'de daha çok kış hazırlığı olarak değerlendirilmiştir.
Temel İçerikler: Dana eti, çemen (sarımsak, kırmızı biber, çemen otu, un, su, tuz), isteğe bağlı soğan
Hazırlık Süreci: Et dilimleri hazırlanır, üzerine kalın çemen harcı sürülür. Bu şekilde birkaç saat dinlendirildikten sonra taş fırında ağır ateşte pişirilir.
Kültürel Önemi: Koruyucu baharat ve çemen sayesinde etin dayanıklılığı artırılmış, kış aylarında tüketim için saklanmıştır.
Günümüzdeki Durumu: Çemenin ağır kokusu ve fırın ihtiyacı nedeniyle şehir yaşamında uygulanabilirliği azalmıştır.
Kayseri mutfağı, Türkiye'nin en zengin mutfaklarından biri olmasına rağmen genellikle mantı, pastırma ve sucuk ile özdeşleştirilmiş; bu nedenle daha az bilinen yemekleri gölgede kalmıştır. Yukarıdaki örnekler, köy yaşamının, kış hazırlıklarının ve toplumsal paylaşımın mutfaktaki yansımalarıdır. Günümüzde bu tariflerin unutulma nedeni sadece malzeme temini değil, aynı zamanda yaşam biçiminin değişmesidir (Yalçın & Arıkan, 2021).
Sivas
Sivas iline ait unutulmaya yüz tutmuş yemekler aşağıda verilmiştir.
Gıllor
Coğrafi Dağılımı: Sivas, Tunceli ve Erzincan
Tarihsel Arka Plan: Sivas'ta evde olan un, su, tuz, yoğurt, tereyağı ve sarımsakla yapılan zamanla yerel yorumlarla şekillenmiş, özellikle kıtlık dönemlerinde ulaşılması kolay malzemelerle hazırlanan bir yemektir.
Temel İçerikler: Un, su, tuz (hamur), yoğurt, sarımsak, tereyağı
Hazırlık Süreci: Hamur yoğurulup bir tepsiye yayılır. Yoğurt, su ve içerisine sarımsak rendelenip ocağa alınır. Fırında kızaran hamurun tam ortası açılır ve açılan parçalar küçük küçük ufalanıp ortaya geri konur. Üzerine sarımsaklı yoğurt sos ve tereyağında servis edilir.
Kültürel Önemi: Et bulunamayan zamanlarda protein ihtiyacını yoğurt ve unla karşılamaya yönelik geliştirilmiş, çok kişiyi doyuran bir yemektir.
Günümüzdeki Durumu: Çok eskiden köylerde çok yaygın bir şekilde yapılan yemek unutulmaya başlamıştır.

Divriği Pilavı
Coğrafi Dağılımı: Divriği ilçesi ve civarı
Tarihsel Arka Plan: Sivas'ın Divriği ilçesi, tarih boyunca kültürel çeşitliliğin bir merkezi olmuştur. Düğün, sünnet gibi özel günlerde yapılan bu pilav, et, kuru meyve ve baharatın uyumunu yansıtır.
Temel İçerikler: Pirinç, kuşbaşı kuzu eti, kuş üzümü, badem veya ceviz, tarçın, karabiber, et suyu
Hazırlık Süreci: Etler önce haşlanır. Pirinç tereyağında kavrulur, kuş üzümü ve baharatlarla birlikte et suyu eklenerek pişirilir. En son haşlanmış etler ve kavrulmuş iç malzemelerle harmanlanır.
Kültürel Önemi: Hem besleyici hem de ritüel niteliği taşıyan bu yemek, topluluk içindeki paylaşım kültürünü simgeler.
Günümüzdeki Durumu: Kuru meyve ve baharatların tatlı/tuzlu karışımı genç nesiller arasında rağbet görmediği için artık yaygın olarak yapılmamaktadır (Öztürk & Yılmaz, 2018).
Madımak Kavurması
Coğrafi Dağılımı: Sivas merkez ve kırsal köyler (özellikle Kangal, Yıldızeli çevresi)
Tarihsel Arka Plan: Baharın gelişiyle birlikte doğada doğal olarak yetişen madımak otu, geçmişte sofraların vazgeçilmez yeşilliği olmuş; hem yemeği yapılmış hem de salamura edilerek saklanmıştır.
Temel İçerikler: Madımak otu, pastırma veya kuyruk yağı, kuru soğan, bulgur (isteğe bağlı)
Hazırlık Süreci: Madımaklar iyice ayıklanır ve doğranır. Yağda soğan kavrulur, ardından madımak eklenir. İsteğe göre bulgur ya da yumurta ilave edilir.
Kültürel Önemi: Özellikle bahar aylarında bağ ve bahçe işlerinin yoğun olduğu dönemlerde, topraktan gelen besinlerle yapılan ekonomik ve sağlıklı bir yemektir.
Günümüzdeki Durumu: Doğal bitki toplama kültürünün zayıflaması ve madımağın şehirlerde ulaşılmasının zorlaşması nedeniyle azalmıştır (Yıldırım & Kaya, 2017).
Kelle Tatlısı
Coğrafi Dağılımı: Sivas merkez ve Gürün ilçesi
Tarihsel Arka Plan: Geçmişte daha çok kış mevsiminde, soba üzerinde kavrularak yapılan bu tatlı, adını yumuşak dokusundan almıştır. Kelle sözcüğü yerel ağızda "yuvarlak topak" anlamında kullanılır.
Temel İçerikler: Un, tereyağı, su veya süt, şeker, isteğe göre ceviz
Hazırlık Süreci: Tereyağında un kısık ateşte uzun süre kavrulur. Ardından şerbet ya da süt eklenerek toparlanması sağlanır. Top şeklinde sunum yapılır.
Kültürel Önemi: Az malzeme ile yapılan, uzun süre tok tutan bir tatlı çeşidi olarak özellikle çocuklara yönelik hazırlanırdı.
Günümüzdeki Durumu: Hazır tatlıların artması ve el emeği gerektirmesi nedeniyle artık evlerde nadiren yapılmaktadır (Demirtaş & Arslan, 2016).
Gömme
Coğrafi Dağılımı: Sivas'ın Hafik, Doğanşar ve çevre köyleri
Tarihsel Arka Plan: Bu tarif, sabah erkenden tarlaya gitmeden önce yapılan, unlu bir kahvaltı çeşididir. Sac üzerinde pişirilen yassı bir ekmek türüdür.
Temel İçerikler: Un, su, tuz, maya; iç harç olarak çökelek, haşhaş ezmesi veya kavrulmuş un
Hazırlık Süreci: Hamur yoğrulur, küçük bezelere ayrılır. İç harçla doldurulup sacda çift taraflı pişirilir.
Kültürel Önemi: Zahmetsiz, pratik ve doyurucu olması nedeniyle kırsal üretim toplumunun günlük yaşamında sıkça yer bulmuştur.
Günümüzdeki Durumu: Sac kullanımı azaldığı ve taş fırınlar yerini modern mutfaklara bıraktığı için bu tür ekmekler unutulma aşamasına gelmiştir (Kara, & Şahin, 2019).

Sızgıt
Coğrafi Dağılımı: Sivas genelinde yaygın; özellikle Zara, Suşehri ve Kangal ilçelerinde
Tarihsel Arka Plan: Kışa hazırlık kapsamında kesilen büyükbaş hayvanların etlerinin, yağa bastırılarak saklanmasıyla oluşturulan geleneksel bir kavurma yöntemidir.
Temel İçerikler: Dana/koyun eti (kuşbaşı), iç yağı veya kuyruk yağı, tuz
Hazırlık Süreci: Et kavrulur, iyice suyunu salıp çekince bol yağda kızartılır. Kavrulan et, sıcak yağa gömülerek cam kavanozlarda veya bakır kaplarda soğuyana dek dinlendirilir. Kış boyunca tüketilir.
Kültürel Önemi: Soğuk iklim koşullarında etin bozulmadan saklanabilmesi için geliştirilmiş geleneksel bir teknik olarak, dayanıklılığı ve pratikliğiyle öne çıkar.
Günümüzdeki Durumu: Hazır kavurmaların marketlerde yaygınlaşmasıyla, ev yapımı sızgıt geleneği neredeyse kaybolmuştur (Özdemir, & Kaplan, 2017).
Hasıda
Coğrafi Dağılımı: Sivas'ın merkez ve köylerinde özellikle kış gecelerinde yapılırdı.
Tarihsel Arka Plan: Osmanlı mutfağından da izler taşıyan bu tatlı, daha çok çocuklara yönelik bir gece atıştırmalığıydı. Soba üzerinde pişirilen hasıda, ailenin bir araya geldiği akşam sohbetlerinde servis edilirdi.
Temel İçerikler: Un, su, şeker, tereyağı
Hazırlık Süreci: Un tereyağında kavrulur. Ayrı bir kapta hazırlanan şekerli su (şerbet) üzerine dökülür. Sürekli karıştırılarak macun kıvamına getirilir.
Kültürel Önemi: Kış aylarında enerji veren, basit ve doyurucu bir tatlı olarak bilinir.
Günümüzdeki Durumu: Pratik tatlıların ve hazır ürünlerin artmasıyla ev yapımı hasıda yapılmaz hâle gelmiştir (Çelik & Yılmaz, 2018).
Katıklı Dolma
Coğrafi Dağılımı: Sivas'ın Ulaş ve Kangal ilçeleri başta olmak üzere kırsal kesim
Tarihsel Arka Plan: Bu tarif, kurutulmuş biber ve patlıcanların kış için saklanmasıyla başlayan bir sürecin sonucunda yapılan geleneksel bir dolmadır. İç harcında pirinç yerine yarma (aşurelik buğday) bulunması, onu benzerlerinden ayırır.
Temel İçerikler: Kurutulmuş sebzeler (biber, patlıcan), haşlanmış yarma, kıyma, soğan, domates salçası, baharatlar
Hazırlık Süreci: Haşlanmış yarma ve kavrulmuş kıymalı harç karıştırılır. Kurutulmuş sebzeler yumuşatıldıktan sonra bu harçla doldurulur ve salçalı suyla pişirilir.
Kültürel Önemi: Tahılın etle birleştiği bu tarif, kış aylarında besin ihtiyacını karşılayan temel yemeklerden biri olarak kullanılmıştır.
Günümüzdeki Durumu: Kurutmalık yapma geleneğinin yok olması ve yarma kullanımının azalmasıyla birlikte tarif unutulma tehlikesiyle karşı karşıyadır (Yıldırım & Korkmaz, 2021).

Yozgat
Yozgat iline ait unutulmaya yüz tutmuş yemekler aşağıda verilmiştir.
3.5.1. Parmaksız Böreği
Coğrafi Dağılımı: Yozgat merkez ve Sorgun ilçesi
Tarihsel Arka Plan: Bu börek, adını el yordamıyla değil, oklava kullanılarak yapılmasından alır. "Parmaksız" ifadesi, el şekli verilmeden açılmasından kaynaklanır. Özellikle bayram sabahlarında yapılırdı.
Temel İçerikler: Un, su, tuz, yoğurt, çökelek veya haşhaş
Hazırlık Süreci: Hamur yoğrulup bezelere ayrılır. Her yufka ince açılarak haşhaş ya da çökelekle yağlanır, rulo yapılıp tepsiye dizilir. Üzerine yumurta sürülerek fırında pişirilir.
Kültürel Önemi: El emeği ve imece usulüyle yapılan, kadın dayanışmasının sembolü bir bayram lezzetidir.

Günümüzdeki Durumu: El açması böreklerin zahmetli olması ve hazır yufkanın yaygınlaşmasıyla unutulmaya başlamıştır (Altuntaş, & Demir, 2018).

3.5.2. Cırma (Yoğurtlu Soğuk Buğday Aşı)

Coğrafi Dağılımı: Boğazlıyan ve Sarıkaya çevresi
Tarihsel Arka Plan: Yaz aylarında serinletici olarak tüketilen bu çorba, haşlanmış buğdayın yoğurtla buluşturulduğu bir tür ayran aşıdır.
Temel İçerikler: Haşlanmış buğday, yoğurt, tuz, nane
Hazırlık Süreci: Haşlanmış buğday soğutulur, yoğurtla karıştırılarak çorba kıvamına getirilir. Üzerine nane eklenerek soğuk servis edilir.
Kültürel Önemi: Sıcakta çalışan çiftçiler için ferahlatıcı ve tok tutucu bir besin kaynağıydı.
Günümüzdeki Durumu: Soğuk çorbaların evlerde nadiren yapılması ve hazır içeceklerin artmasıyla geri planda kalmıştır (Yıldız & Kılıç, 2017).

Teneşir Pilavı

Coğrafi Dağılımı: Yozgat genelinde bilinir, ancak Alaca ve Aydıncık'ta daha yaygındır.
Tarihsel Arka Plan: İsmi dikkat çekicidir; geleneksel olarak cenaze sonrası evlerde toplu taziye yemeği olarak pişirilir.
Temel İçerikler: Bulgur, yağ, et suyu, soğan
Hazırlık Süreci: Soğanlar kavrulur, üzerine bulgur eklenir. Et suyu ile demlenmeye bırakılır. Etli ya da etsiz hazırlanabilir.
Kültürel Önemi: Taziye kültürünün önemli bir parçasıdır; paylaşım, yas ve birliktelik simgesidir.
Günümüzdeki Durumu: Taziye yemeklerinin lokantalarda yapılmaya başlanmasıyla ev tipi versiyonu unutulmaya yüz tutmuştur (Kılıç & Öztürk, 2022).

Arabaşı (Hamur ve Acı Tavuk Çorbası)

Coğrafi Dağılımı: Yozgat genelinde yaygın ancak geleneksel formu unutulmaya başlamıştır.
Tarihsel Arka Plan: Kış gecelerinde, özellikle kalabalık aile toplantılarında yenen bu yemek, çorba-hamur kombinasyonuyla eşsizdir.
Temel İçerikler: Buğday unu (hamur için), tavuk eti, salça, acı biber, su
Hazırlık Süreci: Hamur ayrı pişirilir ve küp şeklinde kesilir. Çorba tavuk etiyle hazırlanır ve bol acılı olur. Hamur çorbaya batırılarak yenir.
Kültürel Önemi: Toplumsal birlikteliğin simgesidir; birlikte yenmesi adeta bir törendir.
Günümüzdeki Durumu: Uzun hazırlık süreci ve acı tüketiminin azalması nedeniyle geleneksel haliyle nadiren yapılmaktadır (Yıldırım & Doğan, 2018).

Yarma Aşı

Coğrafi Dağılımı: Yozgat'ın köylerinde, özellikle Akdağmadeni çevresinde
Tarihsel Arka Plan: Tarım toplumlarında, özellikle buğdayın değirmende kırılmasıyla elde edilen yarma ile yapılan doyurucu bir tencere yemeğidir.
Temel İçerikler: Aşurelik buğday (yarma), soğan, tereyağı, salça
Hazırlık Süreci: Yarma haşlanır, kavrulmuş soğan ve salçayla karıştırılır. Kıvamına göre su eklenerek pişirilir.
Kültürel Önemi: Düşük maliyetli, yüksek besleyiciliğe sahip olması nedeniyle yoksul sofraların baş tacıydı.
Günümüzdeki Durumu: Endüstriyel ürünlerin yerini alması ve aşurelik buğdayın kullanımının azalmasıyla unutulmuştur (Erdem, 2021).

Kavurma Dolması

Coğrafi Dağılımı: Yozgat'ın Çekerek ve Kadışehri ilçelerinde bilinirdi.
Tarihsel Arka Plan: Kurban bayramlarında yapılan bu yemek, kavurmanın farklı bir kullanım biçimidir. Etin, bulgurla birleştirilerek doldurulduğu geleneksel bir dolmadır.
Temel İçerikler: Kavurma (küçük doğranmış), bulgur, salça, kuru biber (kurutulmuş), baharat

Hazırlık Süreci: Kavurma ve bulgur karıştırılarak dolma içi hazırlanır. Kurutulmuş sebzelerin içine doldurulur ve fırında ya da ocakta pişirilir.
Kültürel Önemi: Etin uzun süre tüketilmesini sağlamak, bayram ziyafetini günlük yaşama yaymak amacıyla kullanılmıştır.
Günümüzdeki Durumu: Kavurma artık doğrudan tüketiliyor, dolma versiyonu neredeyse bilinmez hâle gelmiştir (Gökçe & Turgut, 2020).

Nevşehir

Nevşehir iline ait unutulmaya yüz tutmuş yemekler aşağıda verilmiştir.

Düğürcük Çorbası (Nevşehir Usulü Bulgur Çorbası)

Coğrafi Dağılımı: Nevşehir merkez ve Avanos çevresi
Tarihsel Arka Plan: "Düğürcük", ince pilavlık bulgura verilen yerel isimdir. Bu çorba, yoksul dönemlerin temel besinlerinden biridir.
Temel İçerikler: İnce bulgur, domates salçası, soğan, tereyağı, kuru nane
Hazırlık Süreci: Soğan tereyağında kavrulur, salça ve su eklenir. Kaynayınca bulgur ilave edilir. Nane ile tatlandırılır.
Kültürel Önemi: Basit ama besleyici olan bu tarif, kıtlık zamanlarında dahi sofraları boş bırakmamıştır.
Günümüzdeki Durumu: Hazır çorbaların yaygınlaşması ve tarifin "sade" bulunması nedeniyle unutulmaya başlamıştır (Türkmen, 2020).

Nevşehir Tandır Böreği

Coğrafi Dağılımı: Ürgüp, Derinkuyu ve köyler
Tarihsel Arka Plan: Tandır ocaklarında, köz üzerinde pişirilen bu börek, özellikle kış aylarında sıklıkla yapılırdı. Yufkanın arasında yerel iç harçlar kullanılırdı.
Temel İçerikler: Un, su, tuz (hamur); çökelek veya patatesli iç harç
Hazırlık Süreci: Hamur açılıp iç harçla katlanır. Tandır ocağına ya da sac üzerine yerleştirilerek pişirilir.
Kültürel Önemi: Evde tandırın bulunması, bu böreğin kadınlar arasında ortak yapılmasını desteklemiştir.
Günümüzdeki Durumu: Tandır kullanımının azalması ve zahmetli yapısı nedeniyle modern mutfaklarda yapılmamaktadır (Öztürk & Koçyiğit, 2021).

Soğanlama

Coğrafi Dağılımı: Özellikle Gülşehir ve civar köylerde
Tarihsel Arka Plan: Soğanın başrolde olduğu bu yemek, hayvansal ürünlerin az bulunduğu dönemlerde ana öğün olarak tüketilmiştir.
Temel İçerikler: Soğan, un, domates salçası, tereyağı, karabiber
Hazırlık Süreci: Soğanlar ince doğranıp kavrulur, üzerine un ve salça eklenir. Suyla açılarak koyu kıvamlı bir yemek elde edilir.
Kültürel Önemi: İhtiyaçtan doğan, ama zamanla geleneksel hale gelen bir "yokluk yemeği"dir.
Günümüzdeki Durumu: Basitliği ve sadece soğandan oluşması nedeniyle yeni kuşaklar tarafından rağbet görmemektedir (Gökçe & Demirbaş, 2020).

Dolaz

Coğrafi Dağılımı: Nevşehir merkez, Acıgöl ve Hacıbektaş
Tarihsel Arka Plan: Buğday unu ve yağla yapılan, eski kış akşamlarının tatlısı olan dolaz, ocak başında hazırlanırdı.
Temel İçerikler: Un, tereyağı, su veya süt, şeker
Hazırlık Süreci: Un yağda kavrulur. Ayrı bir kapta hazırlanan şerbet ya da süt yavaşça eklenir. Sürekli karıştırılarak koyu kıvama gelmesi sağlanır.
Kültürel Önemi: Kış gecelerinde soba başında ailece tüketilen, paylaşımı simgeleyen tatlılardan biridir.

Günümüzdeki Durumu: Pratik tatlıların tercih edilmesi, evde kavurma işinin zahmetli oluşu nedeniyle unutulmaya yüz tutmuştur (Yıldırım, 2018).

Aksaray Köfter (Pekmezli Meyve Lokumu)

Tarihçesi: Pekmez ve nişasta kullanılarak yapılan, kışlık doğal tatlı

Malzemeler: Üzüm pekmezi, nişasta, ceviz

Yapılışı: Kaynatılarak kıvam alması sağlanır, dökülüp kurutulur.

Durumu: Ticari lokumlara yönelim nedeniyle terk edilmiştir (Yılmaz, 2019).

Aksaray

Ankara iline ait unutulmaya yüz tutmuş yemekler aşağıda verilmiştir.

Katıklı Dolma

Coğrafi Dağılımı: Aksaray'ın merkez köyleri ve özellikle Ortaköy, Gülağaç gibi ilçelerinde yaygın olarak hazırlanmıştır.

Tarihsel Arka Plan: Asma yaprağının bol bulunduğu dönemlerde ve özellikle hasat sonrası imece usulü yapılan kış hazırlıklarının bir parçasıydı. Hem Orta Asya kökenli dolma kültürü hem de Anadolu'nun yoğurtlu pişirme geleneğini birleştirir.

Temel İçerikler: Asma yaprağı, ince bulgur, kıyma, kuru soğan, salça, karabiber, nane, yoğurt, sarımsak

Hazırlık Süreci: Yapraklar haşlanıp iç harcı kıyma, bulgur ve baharatla hazırlanır. Sarılan dolmalar, tencerede haşlanarak pişirilir. Üzerine yoğurtlu-sarımsaklı sos gezdirilir.

Kültürel Önemi: Büyük ailelerin bir araya geldiği zamanlarda imece ile hazırlanırdı. Geleneksel Aksaray düğün ve bayram sofralarında sıkça yer alırdı.

Günümüzdeki Durumu: Zaman alan hazırlık süreci nedeniyle günlük hayatta yapılmaz hale gelmiş, bazı köylerde yalnızca özel günlerde yapılmaya devam etmektedir (Kılıç, 2019).

Düğü Çorbası

Coğrafi Dağılımı: Aksaray merkez ve özellikle Eskil, Ortaköy ilçelerinde geçmişte sıklıkla yapılırdı.

Tarihsel Arka Plan: Bulgurun un haline gelmeden önceki hali olan "düğü", kırsal bölgelerde ekonomik ve doyurucu bir besin olarak sık kullanılmıştır.

Temel İçerikler: Düğü (iri bulgur), yeşil mercimek, kuru soğan, tereyağı, salçaHazırlık Süreci: Düğü ve mercimek haşlanır. Soğan kavrularak salça ile birlikte çorbaya eklenir. Kıvam aldıktan sonra sıcak servis edilir.

Kültürel Önemi: Kıtlık zamanlarında bile yapılan bu çorba, Aksaray halkı için "az malzemeyle karın doyurma" kültürünün simgesidir.

Günümüzdeki Durumu: Nadiren köy düğünlerinde veya yaşlı nüfusun bulunduğu evlerde yapılmaktadır (Gökçe & Turgut, 2020).

Etli Çalma (Hamur Aşı)

Coğrafi Dağılımı: Aksaray genelinde bilinse de Eskil ve Sultanhanı çevresinde daha çok yapılırdı.

Tarihsel Arka Plan: Sulu yemek kültürünün ve hamur işinin birleştiği, tamamen yerli malzeme ile yapılan geleneksel bir tariftir.

Temel İçerikler: Un, su, tuz (hamur), kuşbaşı et, domates salçası, soğan, baharatlar

Hazırlık Süreci: Hamur küçük parçalara ayrılıp açılır, salçalı ve etli suya atılarak pişirilir. Hamurlar yumuşayıp et piştiğinde servis edilir.

Kültürel Önemi: Yüksek kaloriye ihtiyaç duyulan tarla işleri sonrası tüketilirdi; paylaşım kültürünü simgeler.

Günümüzdeki Durumu: Tarifi bilenler azaldığı için unutulmaya yüz tutmuştur. Yöresel festivallerde nadiren sunulmaktadır (Altun, 2015).

Niğde

Niğde iline ait unutulmaya yüz tutmuş yemekler aşağıda verilmiştir.

Cımbar (Bağırsak Dolması)

Coğrafi Dağılımı: Niğde'nin Altunhisar ve Bor ilçeleri başta olmak üzere kırsal kesimde yapılırdı.

Tarihsel Arka Plan: Kurban bayramları ve kışlık et hazırlıklarının önemli parçalarındandı. Eskiden bağırsak temizlemek ciddi bir ritüeldi.

Temel İçerikler: Koyun bağırsağı, kıyma, bulgur, soğan, baharatlar

Hazırlık Süreci: Bağırsaklar iyice temizlenir, iç harçla doldurulur. Doldurulan cımbarlar haşlanarak veya fırında pişirilir.

Kültürel Önemi: Etin hiçbir parçasının israf edilmemesi anlayışının geleneksel bir yansımasıdır.

Günümüzdeki Durumu: Hijyen endişeleri ve zahmetli oluşu nedeniyle evlerde neredeyse hiç yapılmamaktadır (Küçük, 2021).

Kırşehir

Kırşehir iline ait unutulmaya yüz tutmuş yemekler aşağıda verilmiştir.

Gılik (Mayalı Yassı Ekmek)

Coğrafi Dağılımı: Kırşehir'in özellikle Mucur ilçesinde yapılırdı.

Tarihsel Arka Plan: Fırın kültürünün yaygın olmadığı dönemlerde sac üzerinde pişirilen geleneksel bir ekmektir.

Temel İçerikler: Un, maya, su, tuz

Hazırlık Süreci: Mayalanmış hamur açılıp sac üzerinde pişirilir. Genelde içine tereyağı sürülerek sıcak yenirdi.

Kültürel Önemi: Kahvaltıların ve ara öğünlerin vazgeçilmeziydi. Özellikle tarlaya götürülürdü.

Günümüzdeki Durumu: Hazır ekmeklerin yaygınlaşmasıyla birlikte unutulmuştur; nadiren köylerde yapılmaktadır (Yıldırım & Koç, 2019).

GELENEKSEL YEMEKLERİN KAYBOLMA SÜRECİ VE NEDENLERİ

Gastronomi yalnızca beslenme biçimlerini değil, aynı zamanda toplumların yaşam tarzlarını, dünya görüşlerini, kültürel birikimlerini ve sosyal ilişkilerini yansıtan çok yönlü bir alan olarak kabul edilmektedir. Bu çerçevede, geleneksel yemekler bir toplumun kültürel belleğini oluşturan temel unsurlar arasında yer almaktadır. Özellikle Türkiye gibi çok katmanlı kültürel geçmişe sahip ülkelerde, mutfak kültürü yalnızca bireysel alışkanlıkları değil, aynı zamanda toplumsal aidiyeti ve ortak kimliği de beslemektedir. Ancak küreselleşmenin, modernleşmenin ve teknolojik gelişmelerin etkisiyle, birçok geleneksel yemek tarifi günümüzde unutulmaya yüz tutmuştur. Bu kayboluş yalnızca bir damak tadı kaybı değil, aynı zamanda kültürel bir erozyonun da habercisidir.

Geleneksel yemeklerin kaybolma süreci, sadece damak tadının değişmesinden ibaret değildir. Bu süreç; toplumsal yapının değişimini, bireylerin kültürel kökenleriyle olan bağlarının zayıflamasını, modern yaşamın pratik gerekçelerinin kültürel değerleri gölgede bırakmasını da ifade eder. İç Anadolu Bölgesi gibi tarihsel derinliği olan coğrafyalarda bu kayıp daha dramatik yaşanmaktadır. Her biri birer kültürel belge niteliğindeki unutulmuş tarifler, yalnızca gastronomi değil, aynı zamanda tarih, sosyoloji ve halk bilimi açısından da büyük önem taşımaktadır. Bu bağlamda yapılacak akademik çalışmalar, derlemeler, belgesel projeleri ve gastronomi eğitimleri, geleneksel mutfak kültürünün yaşatılmasında kilit rol oynayacaktır. Geleneksel yemeklerin yalnızca geçmişe ait bir nostalji değil, geleceğe uzanan bir kültürel yatırım olarak görülmesi gerekir (Sancar, 2021).

Geleneksel yemekler, yalnızca geçmişin mutfak alışkanlıklarını değil; aynı zamanda bir toplumun kimliğini, kültürel belleğini ve tarihsel sürekliliğini temsil eden çok katmanlı birer anlam taşıyıcısıdır. Ancak özellikle son yarım yüzyılda yaşanan toplumsal dönüşümler, bu

kültürel mirasın ciddi biçimde tehdit altına girmesine yol açmıştır. Kentsel dönüşüm, hızlı kentleşme, göç, yaşam biçimlerinin değişimi, zaman kıtlığı, gıda endüstrisinin yaygınlaşması, küreselleşen damak zevkleri ve geleneksel bilgilerin yeterince belgelenmemesi gibi etkenler, geleneksel yemeklerin aktarımını sekteye uğratmış; birçoğunun unutulmasına veya yalnızca nostaljik bir anıya dönüşmesine neden olmuştur. İç Anadolu Bölgesi gibi tarihsel ve kültürel açıdan zengin bir coğrafyada bu kayıp daha çarpıcı biçimde hissedilmektedir. Bir zamanlar toplu üretimin, imece kültürünün, mevsimsel döngülere dayalı saklama ve pişirme tekniklerinin merkezinde yer alan birçok yemek, günümüzde yalnızca birkaç köyde sınırlı biçimde yaşatılmaktadır. Bu durum, kültürel sürekliliğin zayıflamasının yanı sıra, toplumsal aidiyetin de dönüşüm geçirdiğini göstermektedir. Bununla birlikte, gastronomi alanında artan akademik çalışmalar, yerel yönetimlerin ve bazı sivil toplum örgütlerinin yürüttüğü projeler ile birlikte geleneksel yemeklerin yeniden gündeme gelmesi umut verici gelişmelerdir. Özellikle üniversitelerin gastronomi bölümleri bünyesinde yürütülen sözlü tarih çalışmaları ve derleme faaliyetleri, geleneksel tariflerin belgelenmesi ve yaşatılması adına önemli bir rol üstlenmektedir. Ancak bu çabaların daha kurumsal ve sürdürülebilir biçimde organize edilmesi gerekmektedir (Arlı, 2020).

SONUÇ

İç Anadolu mutfağı, geçmişten bugüne uzanan güçlü bir kültürel sürekliliğin taşıyıcısıdır. Ancak günümüzde bu süreklilik, modernleşmenin getirdiği yaşam biçimi değişiklikleri, kentleşme, hızlı tüketim alışkanlıkları, hazır gıdaların yaygınlaşması ve geleneksel bilgi aktarımının zayıflaması nedeniyle ciddi bir kesintiye uğramaktadır. Özellikle sözlü kültüre dayanan mutfak mirası, yazılı kaynaklara yeterince aktarılmadığı için unutulma riski altındadır. Bu durum, yalnızca tariflerin değil; aynı zamanda yemekle ilişkili ritüellerin, sofra adabının, üretim yöntemlerinin ve toplumsal değerlerin de kaybolmasına neden olmaktadır. Bu bağlamda gastronomi, sadece yemek üretim süreciyle sınırlı olmayan; aynı zamanda kültürel belleği koruma, yerel kimliği yaşatma ve kuşaklar arası aktarımı sağlama gibi çok yönlü bir sorumluluğa sahiptir. Akademik çalışmalar, saha araştırmaları, belgeleme faaliyetleri ve eğitim programları aracılığıyla bu mirasın yaşatılması mümkündür. Özellikle İç Anadolu gibi zengin mutfak mirasına sahip bölgelerde, unutulmuş tariflerin yeniden gün yüzüne çıkarılması, yalnızca geçmişe bir saygı değil; aynı zamanda kültürel sürdürülebilirlik adına bir gerekliliktir. Gastronomi eğitiminin ve bilimsel araştırmaların, unutulmuş yemeklerin sistemli bir şekilde belgelenmesini ve yeni kuşaklara aktarılmasını sağlayacak biçimde yapılandırılması, bu sürece önemli katkılar sağlayacaktır. Ayrıca sosyal medya, dijital yayıncılık ve gastronomik turizm gibi modern araçlar da bu değerlerin görünür kılınmasında etkili olabilir. Yerel yönetimlerin, sivil toplum kuruluşlarının ve kültürel kurumların iş birliği ile geliştirilecek projeler, geleneksel mutfak mirasının korunmasına yönelik güçlü adımlar atılmasına olanak tanıyacaktır.

Bu çalışma, İç Anadolu Bölgesi'ne ait unutulmuş geleneksel lezzetlerin tarihsel, kültürel ve toplumsal boyutlarını inceleyerek, bu zengin mirasın günümüzde karşı karşıya olduğu tehditleri ve korunmasına yönelik gereklilikleri ortaya koymayı amaçlamıştır. Çalışmada elde edilen bulgular, geleneksel yemeklerin yalnızca birer tarif değil; bir toplumun yaşam tarzını, inançlarını, sosyal ilişkilerini ve tarihsel birikimini yansıtan kültürel değerler olduğunu açıkça göstermiştir.

Sonuç olarak, İç Anadolu Bölgesi'ne ait unutulmuş lezzetler yalnızca tarihsel birer kalıntı değil; geleceğe taşınması gereken yaşayan kültürel varlıklardır. Bu yemeklerin korunması, bir topluluğun kültürel kimliğini koruması anlamına gelmektedir. Her bir unutulan tarif, aslında bir hikâyenin, bir belleğin ve bir kimliğin sessizce kaybolmasıdır. Bu nedenle, gastronomi bilimi ve kültürel koruma politikaları el ele vererek, geçmişten gelen bu değerleri bugüne ve yarına taşımalı; mutfak kültürünü yaşayan bir miras olarak koruma altına almalıdır.

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PHARMACOVIGILANCE IN THE ERA OF PERSONALIZED MEDICINE: OPPORTUNITIES AND LIMITATIONS

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ABSTRACT

Pharmacovigilance (PV) plays a vital role in ensuring drug safety by monitoring, detecting, and evaluating adverse drug reactions (ADRs). With the growing shift toward personalized medicine—an approach that tailors medical treatment based on an individual's genetic, environmental, and lifestyle factors—traditional PV systems face new challenges and opportunities. Personalized medicine emphasizes the use of pharmacogenomics and biomarkers to stratify patients and customize therapies. This requires an evolution in PV practices to capture drug responses that vary widely across genetic subgroups.

Traditional PV models often fall short in detecting rare, genotype-specific ADRs due to their one-size-fits-all approach. The complexity of ADR patterns in genetically diverse populations and limited real-world evidence make it essential to redesign pharmacovigilance systems. Integration of genetic data into PV frameworks can help predict high-risk patients and support more targeted safety monitoring. Advanced technologies like AI, machine learning, electronic health records (EHRs), and mobile health tools now offer real-time data processing and improved signal detection.

Despite these advancements, challenges remain. Ethical concerns, lack of standardized genomic reporting, regulatory gaps, and under-reporting in rare-genotype patients hinder progress. International guidelines (FDA, EMA, ICH) and national PV centers are now working toward integrating genomics into safety monitoring systems. Real-world case studies—such as the association between abacavir and HLA-B*5701, and warfarin dosing linked to CYP2C9/VKORC1—highlight the clinical importance of personalized pharmacovigilance.

To fully realize its potential, pharmacovigilance must proactively adapt to the personalized era, ensuring safer and more effective treatments through collaborative innovation, regulatory support, and global research investment.

KEY WORDS Pharmacovigilance, Personalized Medicine, Pharmacogenomics, Adverse Drug Reactions (ADRs), Drug Safety, Precision Medicine

INTRODUCTION

Definition and Goals of Pharmacovigilance

Pharmacovigilance is defined as the science and activities related to the detection, assessment, understanding, and prevention of adverse effects or any other drug-related problems. Its primary goal is to ensure patient safety by identifying potential risks associated with medications, especially once they are in widespread use. Pharmacovigilance also helps in optimizing the benefit-risk ratio of medicines, guiding safer prescribing practices, and informing regulatory decisions. By collecting and analyzing data from healthcare settings, clinical trials, and post-marketing reports, pharmacovigilance plays a central role in minimizing harm and improving the quality of pharmaceutical care.

Brief Overview of Personalized Medicine

Personalized medicine, often referred to as precision medicine, is an innovative approach to healthcare that customizes treatment based on an individual's genetic makeup, lifestyle, and environment. It moves beyond the "one-size-fits-all" model by considering biological

variability among individuals. This field relies heavily on advances in genomics, biomarkers, and molecular diagnostics to tailor therapies to the right patient at the right time. Personalized medicine aims to increase treatment effectiveness, reduce adverse drug reactions, and provide more accurate predictions of disease risk and treatment response.

Importance of Integrating Both for Drug Safety

As personalized medicine continues to grow, the need for adapting pharmacovigilance systems becomes increasingly important. Traditional pharmacovigilance models often lack the capacity to capture genotype-specific adverse drug reactions, which are crucial in personalized therapy. Integration of genomic and molecular data into pharmacovigilance can help identify previously undetectable ADRs and improve the overall safety profile of drugs in genetically diverse populations. Additionally, personalized pharmacovigilance can provide targeted surveillance in high-risk groups, enhance early warning systems, and contribute to more precise regulatory actions. The fusion of these two fields ensures a more dynamic and effective framework for safeguarding patients, particularly in an era where therapies are tailored on an individual level.

CONCEPT OF PERSONALIZED MEDICINE

Role of Pharmacogenomics and Biomarkers

Pharmacogenomics is the study of how an individual's genetic makeup affects their response to medications. It is a core element of personalized medicine, helping doctors choose the safest and most effective drug for each patient. Certain genes can influence how a person absorbs, metabolizes, or reacts to a drug. For instance, variations in genes like **CYP2C9**, **VKORC1**, or **TPMT** can significantly impact drug efficacy and safety. Biomarkers, on the other hand, are biological indicators—such as proteins or genetic mutations—that provide insights into disease states or treatment responses. They allow for early detection of adverse drug reactions and help in monitoring therapeutic effects. Together, pharmacogenomics and biomarkers are transforming how clinicians make treatment decisions.

Stratification of Patients Based on Genetic Profiles

One of the key features of personalized medicine is its ability to classify patients into subgroups based on their genetic profiles. This stratification helps identify which group is more likely to benefit from a drug and which group is at risk for side effects. For example, patients with the **HLA-B*5701** gene variant are more likely to experience hypersensitivity reactions to **abacavir**, an antiretroviral drug. By testing for such variants in advance, doctors can avoid prescribing harmful medications and instead choose safer alternatives. Stratification also plays a role in identifying individuals who may need higher or lower doses to achieve therapeutic effects.

Precision Dosing and Individualized Therapies

Traditional medicine often uses standard doses for all patients, which may not work equally well for everyone. In contrast, personalized medicine emphasizes precision dosing—adjusting the dose of a drug based on genetic, metabolic, or physiological differences. This is especially important in drugs with narrow therapeutic ranges, such as **warfarin**. Precision dosing helps achieve the desired effect while reducing the risk of toxicity or under-dosing. Individualized therapy extends beyond just dosage; it includes selecting the right drug, route of administration, and treatment duration tailored to a person's unique biology. This approach leads to better treatment outcomes and fewer adverse reactions.

NEED FOR EVOLVING PHARMACOVIGILANCE SYSTEMS

Limitations of Traditional Pharmacovigilance in Individualized Care

Traditional pharmacovigilance (PV) systems are primarily designed to detect adverse drug reactions (ADRs) on a population level, focusing on average responses rather than individual variability. These systems often rely on passive reporting and generalized data, which may overlook important signals specific to small subpopulations. In the era of personalized medicine, where treatments are tailored to the individual, such conventional methods fall short.

They do not adequately account for genetic diversity, co-existing conditions, or the influence of lifestyle and environment. As a result, traditional PV may miss ADRs that occur only in genetically predisposed individuals or those receiving highly specific therapies.

Complexity in ADR Patterns Among Genetically Diverse Populations

Genetically diverse populations show different responses to the same drug. A medication that is safe and effective in one group may cause severe reactions in another due to genetic variants in drug-metabolizing enzymes, transporters, or receptors. For example, the gene **CYP2D6** affects how individuals metabolize many commonly used drugs. Ultra-rapid metabolizers may experience reduced efficacy, while poor metabolizers may suffer toxicity at standard doses. This genetic complexity creates a major challenge for current PV systems, which are not equipped to identify or interpret genotype-specific ADR patterns. Without proper stratification, these safety signals remain hidden.

Real-World Evidence Challenges

While real-world data is increasingly used to support pharmacovigilance, integrating it effectively into personalized care poses significant hurdles. Real-world evidence (RWE) includes data from electronic health records, insurance claims, mobile apps, and patient-reported outcomes. However, much of this data is unstructured, incomplete, or lacks standardized genomic information. Moreover, linking ADRs with genetic profiles in routine clinical settings requires sophisticated tools and cross-platform collaboration. These challenges slow down timely signal detection and limit the ability to make evidence-based safety decisions at the individual level.

OPPORTUNITIES IN PERSONALIZED PHARMACOVIGILANCE

Integration of Genetic Data for Risk Prediction

One of the most promising opportunities in personalized pharmacovigilance is the integration of genetic information to predict drug-related risks. Genetic markers, especially those linked to drug metabolism (e.g., CYP enzymes), immune response (e.g., HLA genes), and transport proteins, can indicate how a patient is likely to respond to a particular medication. By incorporating pharmacogenomic data into pharmacovigilance systems, healthcare providers can better predict which individuals are at higher risk for adverse drug reactions (ADRs) before the medication is even prescribed. This proactive approach supports pre-emptive decision-making and improves overall patient safety by minimizing trial-and-error prescribing.

Use of AI and Machine Learning in Safety Signal Detection

Artificial intelligence (AI) and machine learning (ML) technologies are revolutionizing the way we detect and analyze drug safety signals. Traditional PV methods often rely on manual data review, which can be slow and error-prone. In contrast, AI algorithms can rapidly scan large volumes of data—from clinical databases, patient records, scientific literature, and even social media—to identify hidden patterns of ADRs. Machine learning can also evolve with time, improving its predictive accuracy as more data becomes available. In personalized medicine, these tools are essential for identifying complex relationships between genetic traits and adverse outcomes, offering faster and more refined signal detection.

Role of Electronic Health Records (EHRs) and Big Data

Electronic health records are another powerful resource in modern pharmacovigilance. EHRs contain rich clinical data, including diagnoses, lab results, prescriptions, and sometimes even genomic details. By mining this information, researchers and clinicians can track how drugs perform across different patient populations in real-world settings. When combined with big data technologies, EHRs enable large-scale safety analysis across diverse demographics. This is particularly valuable for identifying ADR trends in small subpopulations, such as patients with rare genetic variants or co-morbidities. EHR-driven pharmacovigilance can thus help tailor interventions to specific groups, making drug safety more precise and personalized

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TECHNOLOGICAL AND METHODOLOGICAL ADVANCES

Genomic Databases and Bioinformatics Tools

Genomic databases and bioinformatics platforms play a central role in modernizing pharmacovigilance within the framework of personalized medicine. These databases, such as PharmGKB, dbSNP, and ClinVar, store information on gene-drug interactions, genetic variations, and their clinical significance. By accessing these resources, researchers can identify genetic markers linked to adverse drug reactions (ADRs) and assess population-specific drug responses. Bioinformatics tools help interpret large-scale genomic data, enabling precise prediction of drug efficacy and toxicity. When integrated into pharmacovigilance systems, these resources support a shift from reactive to predictive safety monitoring, allowing health professionals to foresee and prevent drug-related harm more effectively.

Real-Time Pharmacovigilance Systems

Traditional pharmacovigilance relies on delayed reporting and retrospective analysis. In contrast, real-time pharmacovigilance systems allow continuous and immediate monitoring of drug safety data. These systems integrate data from hospitals, pharmacies, clinical trials, and patient registries, using automation and smart algorithms to identify potential safety signals as they emerge. Real-time systems are particularly valuable in managing high-risk or newly introduced drugs, especially in genetically diverse populations. They also enable dynamic risk assessment and quicker regulatory responses. This proactive approach to drug safety is crucial in personalized medicine, where early detection of rare or genotype-specific ADRs can significantly reduce patient harm.

Mobile Health Apps and Wearable Devices in ADR Reporting

The rise of mobile health (mHealth) technologies and wearable devices has opened new avenues for patient-centered pharmacovigilance. Mobile apps now allow patients to report side effects directly, improving the volume and speed of ADR reporting. Wearables can track physiological parameters such as heart rate, blood pressure, or skin reactions in real time, providing objective data on possible drug effects. These tools empower patients to participate in their own care and enhance the granularity of data collected for pharmacovigilance. Combined with cloud-based platforms, mHealth technologies offer personalized, real-world insights that can guide safer, more individualized drug use.

LIMITATIONS AND CHALLENGES

Ethical and Privacy Concerns with Genetic Data

One of the major challenges in personalized pharmacovigilance is the ethical management of genetic information. Genetic data is highly sensitive and personal, raising serious concerns about confidentiality and misuse. Patients may fear discrimination in insurance, employment, or social settings if their genetic risks are exposed. Even with consent, sharing genetic data across databases and health networks can lead to unintended breaches of privacy. These issues necessitate robust data protection laws, transparent informed consent processes, and strict ethical oversight. Without patient trust and secure systems, the widespread use of genetic data in pharmacovigilance will remain limited.

Lack of Standardized Protocols for Genomic PV

Currently, there is no universal standard for how genomic information should be integrated into pharmacovigilance systems. This lack of harmonization makes it difficult to compare results across studies, countries, or databases. For instance, genetic test results may vary in format and interpretation between laboratories. Similarly, ADR reports often do not include detailed genomic data, making it harder to establish clear gene-drug safety links. A standardized framework is urgently needed for data collection, analysis, and reporting, so that pharmacogenomic insights can be effectively translated into clinical safety practices across healthcare systems.

Inadequate Regulatory Guidelines & Under-Reporting in Rare Genotypes

Existing drug regulatory guidelines were designed with traditional pharmacovigilance in mind and often lag behind the advancements in genomics. There are limited requirements for collecting pharmacogenomic data during clinical trials or post-marketing surveillance. Furthermore, ADRs in patients with rare genotypes are frequently under-reported due to low awareness, limited access to genetic testing, and small sample sizes. These gaps lead to missed safety signals and delay in recognizing high-risk subgroups. To address this, regulatory bodies must update their policies to encourage genetic data reporting and improve pharmacovigilance training among healthcare professionals.

REGULATORY AND POLICY CONSIDERATIONS

Current International Guidelines (e.g., FDA, EMA, ICH)

Global regulatory bodies like the **U.S. Food and Drug Administration (FDA)**, the **European Medicines Agency (EMA)**, and the **International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use (ICH)** have made important strides in adapting pharmacovigilance policies for the genomics era. The FDA encourages the inclusion of pharmacogenomic information in drug labeling and supports personalized medicine through its **Table of Pharmacogenomic Biomarkers**. The EMA has issued guidelines for the evaluation of pharmacogenomics in clinical trials and post-marketing phases. Similarly, ICH guidelines (e.g., E15, E16) promote standardized terminology and genomic data use. However, these frameworks are evolving slowly and often focus more on drug development than real-world safety monitoring.

Role of National PV Centers in Integrating Genomics

National pharmacovigilance (PV) centers serve as the backbone of drug safety in individual countries. They collect and analyze adverse drug reaction (ADR) reports and provide safety recommendations to healthcare providers and the public. These centers now face the challenge of integrating genomic data into routine PV practices. To do so effectively, they must invest in workforce training, digital infrastructure, and collaboration with genetic laboratories. Some countries have begun pilot projects combining pharmacovigilance with pharmacogenomics, but full-scale implementation remains limited due to budget constraints, lack of policy clarity, and limited access to genomic technology.

Gaps in Legal Frameworks

Despite growing recognition of pharmacogenomics in healthcare, legal and regulatory frameworks in many regions remain outdated or incomplete. For instance, there are limited laws mandating the reporting of genetic data with ADRs, and the legal responsibilities of stakeholders—such as pharmaceutical companies, clinicians, and genetic testing labs—are often unclear. Additionally, the absence of unified global policies hinders cross-border data sharing and collaborative research. Addressing these legal gaps is essential for advancing personalized pharmacovigilance. A harmonized regulatory approach that protects patient rights while enabling data use is key to ensuring safe and equitable use of genomic medicine worldwide.

CASE STUDIES AND REAL-LIFE EXAMPLES

Examples of ADRs Linked to Pharmacogenetic Variation

Pharmacogenetic variations significantly impact how individuals respond to medications, and real-world evidence has shown clear links between specific genetic traits and adverse drug reactions (ADRs). Some patients may metabolize drugs too quickly or too slowly, leading to reduced efficacy or increased toxicity. For instance, individuals with mutations in the **TPMT** gene are at higher risk of severe bone marrow suppression when treated with thiopurines. Similarly, **CYP2D6** poor metabolizers may experience opioid toxicity when given standard doses of codeine. These cases highlight the importance of integrating genetic screening into clinical and pharmacovigilance practices to predict and prevent harmful outcomes.

Case of Abacavir and HLA-B*5701

Abacavir is an antiretroviral drug used to treat HIV, but in some patients, it can cause a potentially life-threatening hypersensitivity reaction. Research has shown a strong link between this reaction and the presence of the **HLA-B*5701** allele. Patients who carry this genetic variant are much more likely to develop severe allergic responses to abacavir. As a result, genetic testing for HLA-B*5701 has become standard practice before prescribing this drug. This case is a clear example of how pharmacogenomics has improved drug safety and demonstrates the value of incorporating genetic information into pharmacovigilance systems for risk prediction and prevention.

Warfarin Dose Adjustment Based on CYP2C9/VKORC1

Warfarin is a widely used anticoagulant, but it has a narrow therapeutic window and significant variability in patient response. Genetic variants in **CYP2C9** and **VKORC1** genes affect the metabolism and sensitivity to warfarin, influencing the required dosage for effective anticoagulation. Patients with certain CYP2C9 variants may metabolize warfarin more slowly, leading to a higher risk of bleeding. Those with VKORC1 variations may require lower doses. Dosing algorithms that include these genetic markers have been developed to guide therapy and minimize complications. This real-life example illustrates how personalized dosing strategies, supported by pharmacovigilance data, can enhance safety and treatment outcomes

FUTURE DIRECTIONS

Development of Predictive PV Models

One of the most promising future directions in pharmacovigilance (PV) is the creation of predictive models that use patient-specific data to forecast adverse drug reactions (ADRs) before they occur. These models would integrate pharmacogenomic, clinical, and demographic data to identify high-risk individuals even before therapy begins. By using artificial intelligence (AI), machine learning (ML), and data mining algorithms, predictive PV tools could analyze vast datasets to uncover hidden patterns and make real-time risk assessments. This approach would shift PV from a reactive process to a proactive system—one that anticipates harm and prevents it rather than just responding after ADRs happen. Such innovation would significantly improve patient safety, especially in personalized medicine.

Need for Global Pharmacogenomic Databases

As personalized medicine spreads worldwide, the establishment of large, accessible pharmacogenomic databases is critical. These databases should collect and store genetic variants related to drug metabolism, response, and toxicity across various ethnicities and populations. Currently, most available data are skewed toward populations of European descent, leaving significant knowledge gaps in African, Asian, and Latin American populations. A global initiative to build diverse and comprehensive pharmacogenomic databases would enhance our understanding of drug response variability. It would also support equitable healthcare by ensuring that genetic insights are applicable to all individuals, not just select groups. Such resources would be invaluable for regulators, researchers, and healthcare providers globally.

Multi-Stakeholder Collaboration for PV Enhancement

Improving pharmacovigilance in the era of personalized medicine cannot be achieved by one sector alone. It requires strong collaboration between multiple stakeholders—government agencies, pharmaceutical companies, healthcare providers, researchers, bioinformatics experts, and patient advocacy groups. Each party brings unique expertise and resources to the table. Governments and regulators can provide policies and funding; researchers and IT professionals can develop tools and algorithms; pharmaceutical industries can contribute data; and patients can offer real-world insights. When all these sectors work together, they can accelerate the development and implementation of advanced PV systems, making personalized healthcare both safer and more accessible.

CONCLUSION

The integration of pharmacovigilance and personalized medicine represents a major advancement in the pursuit of safer, more effective healthcare. Traditional pharmacovigilance systems, although instrumental in improving drug safety over the years, are no longer sufficient on their own. With the advent of personalized medicine, which tailors treatments to individuals based on genetic and biological differences, there is an urgent need for evolving pharmacovigilance frameworks that can address these complexities.

Pharmacogenomics and biomarker-driven therapies have opened new doors in precision treatment, yet they also demand more refined safety monitoring tools. By incorporating genetic data, AI algorithms, and real-time health monitoring technologies, pharmacovigilance can transition from a reactive system to a predictive and preventive one. Real-world case studies, such as the use of HLA-B*5701 screening for abacavir or warfarin dosing based on CYP2C9/VKORC1, clearly demonstrate the clinical value of integrating genomics into safety protocols.

However, limitations such as ethical concerns, inconsistent regulations, data privacy, and under-representation of diverse populations remain significant barriers. To overcome these, multi-stakeholder collaboration and strong regulatory support are essential. The future of

pharmacovigilance lies in the development of predictive models, global pharmacogenomic databases, and the commitment to ethical, inclusive, and data-driven approaches.

A harmonized and innovative pharmacovigilance system aligned with personalized medicine is not only desirable—it is necessary. It holds the promise of enhancing patient care, reducing adverse reactions, and shaping the future of precision healthcare across the globe.

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PHOTONIC APPLICATIONS OF YTTRIUMOXIDE BASED NANAOPHOSPHORS

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Abstract

This study investigates the optical and structural characteristics of rare earth-doped and co-doped yttrium oxide (Y_2O_3) nanophosphors, with particular focus on europium (Eu^{3+}) and holmium (Ho^{3+}) dopants. The phosphors were synthesized using a combustion method, followed by annealing at different temperatures to enhance crystallinity. Structural characterization was performed using X-ray diffraction (XRD) and Fourier-transform infrared spectroscopy (FTIR), which confirmed the formation and phase purity of the Y_2O_3 compound.

The diffuse reflectance spectra of both doped and co-doped Y_2O_3 powders were analyzed, revealing a shift of the absorption edge to longer wavelengths compared to pure yttrium oxide. The band gap was determined using the Kubelka–Munk function, and it was observed that the band gap increased with higher annealing temperatures.

The study also explored the effects of doping concentration, pH, and annealing temperature on the photoluminescence (PL) properties of the phosphors. The PL emission intensity was found to be highest for 5 wt% Eu^{3+}-doped Y_2O_3, with a red light emission at 612 nm under 260 nm excitation due to the $^5D_0$–$^7F_2$ transition in europium. In the case of co-doping, the maximum PL intensity was achieved with 6 wt% Ho^{3+} under 255 nm excitation.

In summary, this work highlights the influence of doping concentration, annealing temperature, and the presence of co-dopants on the optical properties of Y_2O_3-based phosphors, making them promising for various photonic applications.

Keywords: Nanophosphors, Combustion Method, Doping

PLASTİK, REKONSTRÜKTİF VE ESTETİK CERRAHİDE ROBOTİK CERRAHİNİN KULLANIMI VE HEMŞİRELİK YAKLAŞIMLARI

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ÖZET
Son yıllarda, mikrocerrahi için geliştirilen robotik sistemlerin plastik, rekonstrüktif ve estetik cerrahide kullanımı artmıştır. Plastik cerrahide robotik cerrahinin kullanıldığı alanlar; meme rekonstrüksiyonu, baş ve boyun estetik cerrahisi, transseksüel cerrahiler, laparoskopik liposuction, transoral yüz germe, flep uygulamaları, tümör rezeksiyonu gibi cerrahi girişimlerdir. Belirtilen girişimler için Symani Cerrahi Sistemi ve da Vinci Cerrahi Sistemi mevcuttur. Symani Cerrahi Sistemi otolog meme rekonstrüksiyonu, sinir transferi ve özellikle rekonstrüktif lenfatik cerrahi gibi birçok mikrocerrahide kullanılmıştır. Plastik cerrahide 'da Vinci' Cerrahi Sistemi ilk kez orofarengeal tümör rezeksiyonu ve rekonstrüksiyonunda kullanılmıştır. Türkiye'de ise plastik cerrahi alanında robotik sistemin kullanıldığı ilk vaka Akdeniz Üniversitesi Hastanesi'nde yapılan omental flep ile bacaktaki doku defektinin rekonstrüksiyonudur. Robotik cerrahinin avantajları olarak üç boyutlu görüntüleme ve beceride artış, yedi derecede serbestlik, titreme azaltma ve hareket ölçekleme teknolojisi, mikroanastomozlara ve tele cerrahiye izin vermesi, organ, doku ve sinirlere erişimi kolaylaştırması, cerraha ergonomik pozisyon sağlaması sayılabilir. Dezavantajları arasında ise; aletlerin büyük olması, uzman bir ekip gerektirmesi, kurulumunun uzun sürmesi, portların yerlerinin değiştirilmesinin zorluğu, dokunma hissinin olmaması, ameliyat sırasında hastanın pozisyonunun değişiminin zaman alması ve hastaya ulaşmanın güç olması, tam bir görüş alanının sağlanamaması ve maliyetli olması bulunmaktadır. Hastalarla en fazla zaman geçiren ve onlara bakım veren hemşireler, plastik cerrahi süreci boyunca aktif rol almaktadır. Robotik cerrahi hemşiresi cerrah, asistan ve hasta arasında hayati bir köprü görevi görmektedir. Bu yöntem sadece cerrahın bilgi ve deneyimini değil aynı zamanda hemşirenin de bilgi sahibi olmasını gerektirmektedir. Cerrahi öncesi hemşirelerin, robotik ekipman kullanımı için hastayı uygun pozisyonlandırması, sistemin sterilizasyonunu ve fonksiyon kontrolünü sağlaması gerekmektedir. Hemşirelerin gelişen teknolojiyle birlikte robotik tekniğin hasta üzerindeki olumlu ve olumsuz yönlerini bilmeleri ve hizmet içi eğitimlerle plastik, rekonstrüktif ve estetik cerrahideki son gelişmeleri takip ederek güncel hemşirelik uygulamalarını bakımlarına yansıtmaları gerekmektedir.
Anahtar Kelimeler: Plastik, rekonstrüktif ve estetik cerrahi, robotik cerrahi, hemşire

THE USE OF ROBOTIC SURGERY IN PLASTIC, RECONSTRUCTIVE AND AESTHETIC SURGERY AND NURSING APPROACHES

ABSTRACT

In recent years, the use of robotic systems developed for microsurgery has increased in plastic, reconstructive and aesthetic surgery. The areas where robotic surgery is used in plastic surgery are surgical interventions such as breast reconstruction, head and neck aesthetic surgery, transsexual surgeries, laparoscopic liposuction, transoral face lift, flap applications, tumor resection. Symani Surgical System and da Vinci Surgical System are available for these procedures. The Symani Surgical System has been used in many microsurgeries such as autologous breast reconstruction, nerve transfer and especially reconstructive lymphatic surgery. In plastic surgery, the da Vinci Surgical System was first used in oropharyngeal tumor resection and reconstruction. In Turkey, the first case in which the robotic system was used in plastic surgery was the reconstruction of a tissue defect in the leg with an omental flap at Akdeniz University Hospital. The advantages of robotic surgery include three-dimensional imaging and increased skill, seven degrees of freedom, tremor reduction and motion scaling technology, allowing microanastomosis and tele-surgery, facilitating access to organs, tissues and nerves, and providing an ergonomic position for the surgeon. Disadvantages include the large size of the instruments, requiring a specialized team, taking a long time to set up, difficult to relocate ports, lack of tactile sensation, taking time to change the patient's position during surgery and difficult to reach the patient, not providing a full field of vision and being costly. Nurses, who spend the most time with patients and care for them, take an active role throughout the plastic surgery process. The robotic surgery nurse acts as a vital bridge between the surgeon, assistant and patient. This method requires not only the knowledge and experience of the surgeon but also the knowledge of the nurse. Before surgery, nurses need to position the patient appropriately for the use of robotic equipment, sterilization and function control of the system. Nurses should know the positive and negative aspects of the robotic technique on the patient with the developing technology, follow the latest developments in plastic, reconstructive and aesthetic surgery with in-service trainings and reflect current nursing practices to their care.

Keywords: Plastic, reconstructive and aesthetic surgery, robotic surgery, nurse

Giriş

Cerrahide robotik teknik ilk olarak 1985 yılında kullanılmıştır (Walters vd., 2011). Türkiye'de ise robotik cerrahi, ilk olarak 2003 yılında bypass cerrahisinde, 2005 yılında ise üroloji ameliyatları için Florence Nightingale Hastanesi'nde uygulanmıştır. Günümüzde robotik cerrahi tekniği dünya genelinde üroloji, genel cerrahi, göğüs cerrahisi, beyin cerrahisi, kalp damar cerrahisi, ortopedik cerrahi, plastik cerrahi, kulak burun boğaz cerrahisi ve jinekoloji cerrahisinde kullanılmaktadır (Alcan vd., 2019).

Plastik Cerrahide Robotik Cerrahi Teknolojisinin Kullanımı

Son yıllarda, özellikle mikrocerrahi için geliştirilen cerrahi robotik sistemler, robotik yardımlı cerrahinin plastik, rekonstrüktif ve estetik cerrahide kullanılmasını arttırmıştır. Plastik, rekonstrüktif ve estetik cerrahide robotik cerrahinin kullanıldığı alanlar; meme rekonstrüksiyonu, baş ve boyun estetik cerrahisi, transseksüel cerrahiler, laparoskopik liposuction, transoral yüz germe, flep uygulamaları, tümör rezeksiyonu gibi cerrahi girişimlerdir (Selber, 2010; Çinpolat vd., 2015; Wen vd., 2024; Jun vd., 2021; Lin vd., 2023; Claus vd., 2024).

Belirtilen girişimler için iki mikro cerrahi robotik sistem mevcuttur. Bunlardan biri Symani Cerrahi Sistemi, diğeri ise da Vinci Cerrahi Sistemi‘dir. Symani Cerrahi Sistemi, mikro cerrahi açık prosedürler için özel olarak tasarlanmış bir robotik cihazdır. Zürih Üniversitesi Hastanesi Plastik Cerrahi ve El Cerrahisi Bölümü'nde, Symani Cerrahi Sistemi otolog meme

rekonstrüksiyonu, sinir transferi ve özellikle rekonstrüktif lenfatik cerrahi dahil olmak üzere birçok mikro cerrahi ve süper mikro cerrahide kullanılmıştır (Grünherz vd., 2023; Henn vd., 2023).

Plastik cerrahide 'da Vinci' isimli robot ilk olarak 2010 yılında Selber tarafından orofarengeal tümör rezeksiyonu ve rekonstrüksiyonunda kullanılmıştır (Selber, 2010; Çinpolat vd., 2015). Türkiye'de ise plastik cerrahi alanında robotik sistemin kullanıldığı ilk vaka Akdeniz Üniversitesi Hastanesi Plastik, Rekonstrüktif ve Estetik Cerrahi kliniğinde Çinpolat ve ark. tarafından yapılan omental flep ile bacaktaki doku defektinin rekonstrüksiyonudur. Yaklaşık iki buçuk sene önce trafik kazası sonucu sol tibiada açık fraktür gelişen vakada osteomyelit zemininde bacakta yumuşak doku defekti mevcut olup robotik sistem ile omentum dokusu serbest flep olarak kaldırılmış ve defekt alanına transfer edilmiştir. Bu uygulama Türkiye'de robotik sistem ile uygulanan ilk serbest flep cerrahisi olmuştur (Çinpolat vd., 2015).

Plastik Cerrahide Robotik Cerrahi Teknolojisinin Kullanımının Avantajları

Robotik cerrahinin avantajları; üç boyutlu görüntüleme, el becerisinde artış ve yedi derecede serbestlik sağlaması, cerrahın hassasiyetini ve el becerisini optimize etmeyi amaçlayan titreme azaltma ve hareket ölçekleme teknolojilerine sahip olması, mikro anastomozlara ve tele cerrahiye izin vermesi, organ, doku ve sinirlere erişimi kolaylaştırması, cerraha ergonomik pozisyon sağlamasıdır. Bunlara ek olarak daha küçük kesilerle cerrahi girişimin yapılması, minimal skar ve kan kaybının olması, cerrahi girişim sonrası dönemde enfeksiyon riskinin ve ağrının azalması, hastanede kalma süresinin azalması, kozmetik sonuçların daha iyi olması, anatomik olarak derin yapılar için daha küçük cerrahi kesilerin olması gibi avantajları bulunmaktadır (Grünherz vd., 2023; Henn vd., 2023; Walters vd., 2011; Alcan vd., 2019; Selber, 2010; Çinpolat vd., 2015).

Plastik Cerrahide Robotik Cerrahi Teknolojisinin Kullanımının Dezavantajları

Robotik cerrahinin dezavantajları ise; sistemin aletlerinin büyük olması, uzman bir ekip gerektirmesi, deneyim gerektiren kurulumunun olması, kurulumun uzun sürmesi, kamera ve portların yerlerinin değiştirilmesinin zorluğu, dokunma hissinin olmaması, ameliyat sırasında hastanın pozisyonunun değişiminin uzun zaman alması ve zaman zaman hastaya ulaşmanın güç olması, tam bir görüş alanının sağlanamaması ve maliyetli olmasıdır (Alcan vd., 2019; Abboudi vd., 2012; Kawashima vd., 2025; Selber, 2010; Çinpolat vd., 2015). Ek olarak görüş alanı sağlanması amacıyla cerrahi yapılan alanda karbondioksit gazı kullanılmaktadır. Bu uygulama retroperitoneal ya da subkutan alanda yapıldığında çeşitli komplikasyonlar gelişebilmektedir. Masif subkutan amfizem bu komplikasyonlardan biri olup pnömotoraks, pnömoperikardiyum veya gaz embolisi gibi hayatı tehdit eden durumlara sebep olabilmektedir (Çinpolat vd., 2015).

Robotik cerrahinin klinik ve klinik öncesi kullanımları, eğitim modelleri ve yaygın uygulama önündeki engelleri değerlendirme amacıyla yapılan sistematik incelemede, bu yöntemin cerrah ve hasta için yüksek kozmetik memnuniyet, daha az yara iziyle minimal invaziv erişim ve düşük komplikasyon oranları gibi çeşitli potansiyel faydalar sağladığı belirtilmektedir (Awad vd., 2024).Ghandourah ve ark.'nın, PubMed veri tabanı ve Cochrane kullanılarak "plastik ve rekonstrüktif cerrahide robotik mikrocerrahi" konusunu araştıran makalelerin literatür taramasını yaptıkları çalışmada, toplam 19 makale incelenmiş ve 5 makalenin robotik cerrahi ve manuel cerrahi yaklaşımlar arasında doğrudan bir karşılaştırma yaptığını, robotik cerrahi gruplarının daha yüksek öğrenme ve daha uzun çalışma sürelerine sahip olduğunu, robotik kullanımının bildirilen avantajları arasında daha yüksek doğruluğa, operasyonu yapan cerrahın daha hassasiyete ve esnekliğe sahip olduğunu, cerrahın el titremesini ortadan kaldırdığını ve ergonomik faktörlerin iyileştirilmesi gerektiğini bildirmişlerdir (Ghandourah vd., 2023).

Ruccia ve ark.'nın robotik destekli cerrahinin plastik ve rekonstrüktif cerrahide uygulanmasını kapsamlı değerlendirilme amacıyla yaptıkları sistematik incelemede, incelenen ilgili çalışmalardaki robotik cerrahinin mikrovasküler cerrahi, flep çıkarma cerrahisi, transoral

robotik cerrahi, sinir ve lenf cerrahisi ve osteotomi gibi çeşitli prosedürlerde kullanıldığı, robotik destekli cerrahinin mikrovasküler cerrahi girişimlerde yüksek derecede prosedürel başarı ve anastamoz açıklığı gösterdiğini, robotik ve manuel prosedürler arasında periprosedürel advers olaylar açısından anlamlı bir fark bulunmadığını, sonuç olarak da robotik destekli cerrahinin özellikle mikrocerrahi anastomoz ve transoral cerrahi için iyi bir etkinlik ve güvenliğe sahip olduğu, cerrahi girişimin süresini kısalttığı ve plastik ve rekonstrüktif cerrahide uygulanabilir bir cerrahi yöntem olduğunu vurgulamışlardır (Ruccia vd., 2024).

Robotik Cerrahinin Kullanımında Hemşirelik Yaklaşımları

Hastalarla en fazla zaman geçiren ve onlara bakım veren hemşireler, plastik cerrahi süreci boyunca aktif rol almaktadır. Robotik cerrahi hemşiresi cerrah, asistan ve hasta arasında hayati bir köprü görevi görmektedir. Bu yöntem sadece cerrahın bilgi ve deneyimini değil aynı zamanda hemşirenin de bilgi sahibi olmasını gerektirmektedir (Alcan vd., 2019; Yanık Demir vd., 2024). Yapılan bir çalışmada, hemşirelerin %90,6'sının robotik cerrahi terimini duyduklarını ancak sadece %34,6'sının bu konuda yeterli bilgiye sahip oldukları belirtilmiştir (Alcan vd., 2019). Cerrahi öncesi hemşirelerin, robotik ekipman kullanımı için hastayı uygun pozisyonlandırması gerekmektedir. Hemşireler, robot sisteminin sterilizasyonunu ve fonksiyon kontrolünü sağlamalıdır. Bu yöntem, yeni teknolojiler ve mesleki roller konusunda hemşirelerin deneyim sahibi olmalarına yardımcı olmaktadır. Hemşirelere robotik cerrahinin amaçları, avantajları, yöntemleri, kullanıldığı alanlar ve kaliteli bakım verebilmek için hemşirelik bakımını kapsayan eğitim programları düzenlenmeli, kanıta dayalı bilgi ve fırsat eşitliği sağlanmalıdır (Alcan vd., 2019; Yavuz Karamanoğlu vd., 2013).

Sonuç olarak, hemşirelerin gelişen teknolojiyle birlikte robotik tekniğin hasta üzerindeki olumlu ve olumsuz yönlerini bilmeleri ve hizmet içi eğitimlerle plastik, rekonstrüktif ve estetik cerrahideki son gelişmeleri takip ederek bu doğrultuda güncel hemşirelik uygulamalarını bakımlarına yansıtmaları gerekmektedir.

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STATE OF THE ART ON NANO-ENHANCED PHASE CHANGE MATERIALS FOR SOLAR THERMAL ENERGY STORAGE

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Abstract
Phase Change Materials (PCMs) have gained significant attention as promising candidates for thermal energy storage in solar applications, due to their high latent heat and ability to store and release heat at nearly constant temperatures. However, their low thermal conductivity and leakage during phase transition remain major limitations. Recent research has focused on developing nano-enhanced PCMs to overcome these drawbacks.
This poster presents a comparative review of two recent innovations in encapsulated PCMs. The first system involves paraffin wax microcapsules coated with titanium dioxide and doped with silicon carbide (PW@TiO_2-SiC), demonstrating a thermal conductivity improvement of 163% and photothermal efficiency up to 81.74%. The second approach introduces paraffin-based microcapsules using metal-polyphenol (MPN) shells modified with molybdenum disulfide (MoS_2), achieving 88.45% thermal conductivity enhancement and photothermal efficiency of 90.78%.
Both studies show that nano-additives not only improve thermal conductivity but also significantly boost solar absorption in the UV–Vis–NIR range. The use of TiO_2, SiC, and MoS_2 allows better heat transfer, improved structural stability, and enhanced durability over thermal cycling.
This state-of-the-art poster highlights the synthesis methods, structural characteristics, and key performance metrics of these nano-engineered PCMs, providing insights into future directions for efficient, compact, and durable solar thermal energy storage systems.
Keywords: Phase Change Materials, Thermal Energy Storage, Nano-additives, Photothermal Conversion, Paraffin, TiO_2, SiC, MoS_2.

PRACTICE OF FLOATING NET CAGE CULTIVATION IN LAMPUNG BAY, LAMPUNG PROVINCE, INDONESIA

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Abstract
The cultivation of floating net cages (FNC) in Lampung Bay, which began to be developed in the 1990s, is a strategic solution to support food security and economic improvement of coastal communities, but its development poses environmental challenges in the form of water pollution, degradation of the quality of marine habitats, and pressure on the carrying capacity of the ecosystem. This study aims to examine the cultivation practices of FNC in Lampung Bay, both from technical, socio-economic, and ecological aspects. The research method used in this study is a qualitative research method with a descriptive approach. The results of the study show that FNC activities can still develop according to the carrying capacity of the waters in several locations, and the lack of optimal supervision and implementation of regulations causes practices that are not environmentally friendly. This study recommends the implementation of the zoning system, strengthening local regulations, mentoring, and ecosystem approaches in the management of FNC cultivation to be sustainable.
Keywords: floating net cages, lampung bay, marine aquaculture, coastal environment, sustainable management

Introduction

Climate change, population increase, and pressures on the availability of capture fisheries resources have prompted many countries to develop aquaculture sectors, including marine aquaculture (Pham et al, 2023). In Indonesia, floating net cage cultivation (FNC) is one of the technologies widely adopted by coastal communities because it is relatively cheap, flexible, and adaptive to the geographical conditions of the waters (Suryana et al, 2023).

Lampung Bay is one of the strategic coastal areas in Lampung Province which since 1990 has been used for FNC cultivation activities, especially to meet market needs for grouper fish commodities (Kamil, 2021). The support of oceanographic conditions and market access has made this region experience a fairly rapid growth in the number of FNCs. However, this growth is not always accompanied by sustainable governance. Several previous studies have shown indications of declining water quality, organic sedimentation, and conflicts in the use of marine space between cultivators, capture fishermen, and the tourism sector.

Furthermore, data from the Lampung Provincial Marine and Fisheries Service (DKP Lampung Province, 2018) and the Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia (KKP RI, 2025) show that fish production from FNC in Lampung Bay has decreased sharply in the past decade, from 620.53 tons in 2013 to only 171.71 tons in 2023. This indicates that there is ecological and technical pressure on cultivation businesses.

In addition, the role of local governments in supporting the development of FNC is still considered to be less than optimal, especially in the aspects of environmental control, intervention of production facilities, access to capital, and marketing support. Many cultivators experience obstacles in running their businesses, such as high feed prices, limited access to markets, the risk of fish diseases, and the absence of an early warning system for water quality. The absence of affirmative policies and continuous technical assistance has also worsened the economic resilience of aquaculture actors.

Based on this background, this study aims to examine various scientific literature, government reports, and policy documents related to FNC cultivation practices in Lampung Bay. The main focus is on the identification of environmental impacts, socioeconomic factors, and governance in the context of sustainability.

Method

This study aims to develop a comprehensive understanding of the conditions, challenges, and opportunities for floating net cage cultivation (FNC) in Lampung Bay, Lampung Province. This approach is carried out by tracing various relevant theoretical and empirical information from reliable sources.

The primary data sources in this study were obtained through in-depth interviews with 30 key respondents consisting of cultivators, government officials, and experts. Secondary data sources are collected from:

- Articles in national and international scientific journals that discuss the technical, ecological, and socio-economic aspects of aquaculture
- Technical documents and fisheries statistics from government agencies such as the Lampung Provincial Marine and Fisheries Service and the Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia
- Government regulatory and policy documents.
- Publications from international organizations, related to trends in marine aquaculture and international trade.
- Numerical data related to FNC production, the number of cultivators, and the trend of marine fish export demand from 2013–2023 were processed from official documents of the Lampung DKP.

The analysis technique used is descriptive-qualitative analysis, to present the results of the study in the form of a systematic scientific narrative (Mardianto, 2022).

Results and Discussion

3.1 General Conditions of Research Sites

The place of research is Lampung Bay, Lampung Province, where there are 3 (three) districts/cities whose coastal areas are directly adjacent to the waters of Lampung Bay, namely; South Lampung Regency, Bandar Lampung City, and Pesawaran Regency (Figure 1).

Floating net cages (FNC) in these waters use a wooden frame and plastic drums as buoys to support a cube-shaped net containing fish. The types of fish cultivated in FNC in Lampung Bay are generally white snapper (*Lates calcarifer*), grouper (*Epinephelus spp.*), cobi *(Rachycentron canadum)* and star pom-pom. The practice of FNC cultivation began in 1990 and continued to increase until 2018, although eventually, its development declined until 2023. FNC cultivation business actors in Lampung Bay are generally coastal community groups that have limited capital, access to technology, and business management skills. High operational costs, fluctuations in selling prices, and dependence on natural feed are the main limiting factors in business development. Based on data from the One Data Portal of the Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia (2025), during the period 2019-2023, the number of Floating Net Cage (FNC) cultivators decreased by 33% (Figure 2).

In this area, there are regulations that regulate marine aquaculture activities, namely Regional Regulation Spatial Plan (RRSP) No. 14 of 2023 concerning the Lampung Provincial for 2023-2043, but its implementation is still weak due to limited supervisory capabilities. As a result, the overlap between fishing activities, shipping routes, and FNC cultivation locations causes repeated spatial conflicts. The absence of supervision and continuous guidance worsens the quality of governance of the mariculture sector (Yulianda et al., 2017).

Most cultivators still use the natural feed in the form of rucah fish because it is cheaper and available locally. However, the availability of rucah fish is highly dependent on the catch of cantrang ships. The ban on the use of cantrang through the Ministerial Regulation No. 71/2016 reduced the supply of rucah, causing a significant increase in feed costs. This condition is exacerbated by the lack of optimal use of high-quality artificial feed at the cultivation level due to cost issues. On the other hand, the excessive use of rucah feed contributes to*the eutrophication* of waters, worsening the conditions of the aquaculture environment (Isnansetyo et al., 2020).

FNC Cultivation in Lampung Bay

Data from the Lampung Provincial Marine and Fisheries Service (2023) shows a downward trend (on average 44.82 tons/year) of marine aquaculture production with the FNC system over the past decade. If in 2013 FNC production reached 620.53 tons, then in 2023 it was only recorded at 171.71 tons with a decrease of more than 70% (Figure 3). This indicates structural problems in technical, governance, and market aspects.

Some of the factors causing the decline in production include deteriorating water quality due to domestic and industrial waste pollution, the density of cages that cause a decrease in oxygen levels, and limited natural feed. The decrease in productivity also causes some cultivators to be inconsistent and even stop their activities.

Lampung Bay is experiencing significant environmental pressure due to anthropogenic activities, such as the growth of the city of Bandar Lampung and the development of surrounding industrial estates. A study by Prartono et al. (2019) showed the accumulation of organic matter and heavy metal pollutant compounds around the FNC site, caused by uneaten feed and fish excretion.

One of the environmental events that has a big impact on FNC cultivation in Lampung Bay is the*red tide phenomenon*. This phenomenon occurs due to the explosion of harmful phytoplankton populations (*Harmful Algal Bloom*), such as *Cochlodinium polykrikoides*, which causes a change in the color of the water to reddish-brown and a decrease in dissolved oxygen levels. As a result, there has been a mass death of farmed fish in floating net cages (ResearchGate, 2019).

The red *tide* wasfirst reported in Lampung Bay in 2012, causing mass deaths of farmed fish and significant economic losses for local cultivators. This phenomenon is triggered by an increase in nutrients in the waters due to domestic and industrial waste, as well as calm water conditions and high temperatures (Kompas, 2012).

Ideal water conditions for marine fish farming are beginning to be threatened, especially in the densely populated areas of FNC. Decreased dissolved oxygen levels, increased temperatures, and changes in flow patterns also contribute to increased disease attacks and mass deaths of fish.

From the market side, the products produced by FNC Lampung Bay face great challenges to compete in the export market. The main problems include non-compliance with export certification standards such as HACCP, GAP, and traceability. At the same time, neighboring countries such as Vietnam, Malaysia, and Singapore have developed more efficient, integrated, and export-oriented aquaculture ecosystems (FAO, 2022).

The limitation of live fish transport vessels, high logistics costs, and lack of support for trade and export promotion are also serious obstacles to increasing the competitiveness of local products. Cultivators in Lampung Bay tend to rely on the domestic market which is volatile and price volatile.

4. Conclusion and Recommendations

4.1 Conclusion

The Floating Net Cage (FNC) in Lampung Bay shows that this system has great potential in supporting food security and coastal economies, but faces various sustainability challenges. The decline in production over the past decade shows that there are pressures from environmental, socio-economic, and institutional aspects. Some of the main points that can be concluded are that the decline in FNC aquaculture production is caused by degradation of water quality, limited natural feed, and high operational costs. The environmental condition of Lampung Bay is getting worse due to waste pollution, eutrophication, and deadly red tide events. Aquaculture actors face various obstacles including dependence on rucah fish, lack of access to technology, and limited institutional support, which are exacerbated by regulations that have not been fully implemented with weak supervision, overlapping zoning, and lack of incentives for cultivators. This condition has an impact on the low competitiveness of FNC Teluk Lampung products in the export market due to the lack of compliance with certification standards and the limitations of the logistics system.

4.2 Recommendations

In order for FNC cultivation in Lampung Bay to develop sustainably and competitively, the following recommendations are recommended:

1. **Local and central governments need to develop zoning policies** based on environmental carrying capacity and enforce strict regulations against pollution and illegal activities.
2. **Expansion of technical support and financing** to small farmer groups to increase production capacity, technology adoption, and business efficiency.
3. **Diversification of feed sources**, including the development of high-quality artificial feed, must be prioritized to reduce dependence on fish and reduce the burden of pollution.
4. **Improving the certification and food safety system of** FNC products must be facilitated to open access to export markets, including HACCP, GAP, and traceability training.
5. **Further research** is needed to monitor the environmental dynamics of Lampung Bay, especially the risk of red tide, as well as the potential for ecosystem-based mitigation such as the use of biofilters or IMTA (Integrated Multi-Trophic Aquaculture).

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PRE-EMPTIVE SELF DEFENCE AND THE UN CHARTER: A LEGAL ANALYSIS

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Abstract:
The doctrine of preemptive self-defence has long been a contested concept within international law, situated at the intersection of state sovereignty, security imperatives, and the prohibition on the use of force under the United Nations Charter. This paper critically examines the legality, boundaries, and contentious aspects of preemptive self-defence in light of contemporary threats and evolving state practices. While Article 51 of the UN Charter recognizes the inherent right of self-defence in the event of an armed attack, the interpretation and application of this provision to preemptive scenarios remain highly controversial. Through a historical analysis beginning with the Caroline incident of 1837 and extending to modern justifications for anticipatory use of force, this study explores the shifting legal thresholds for imminence, necessity, and proportionality. It evaluates relevant state practices, including the United States' doctrine of preemption post-9/11, Israel's preventive strikes, and the emerging challenges posed by cyber warfare and non-state actors. The research engages with arguments for and against the recognition of preemptive self-defence as customary international law, and assesses the potential erosion of the collective security framework if the doctrine is broadly accepted. By analyzing legal instruments, judicial opinions, and scholarly debates, the paper offers a nuanced perspective on whether and how preemptive self-defence can be reconciled with the foundational norms of the international legal order.

Keywords:
Preemptive self-defence, international law, Article 51 UN Charter, use of force, imminence, necessity, proportionality, customary international law, anticipatory self-defence, collective security.

QSAR (QUANTITATIVE STRUCTURE-ACTIVITY RELATIONSHIP) IN DRUG DEVELOPMENT

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ABSTRACT:
Quantitative Structure-Activity Relationship (QSAR) is a computational modeling technique widely used in drug development to predict the biological activity, toxicity, and pharmacokinetic properties of chemical compounds based on their molecular structures. By correlating structural features with observed biological effects, QSAR models enable researchers to identify promising drug candidates, reduce the need for extensive laboratory testing, and accelerate the drug discovery process. The methodology involves the generation of molecular descriptors—such as hydrophobicity, electronic distribution, steric effects, and molecular topology—which are mathematically related to biological activity using statistical or machine learning approaches. QSAR has proven particularly valuable in the early stages of drug design, where it helps in virtual screening of chemical libraries, optimization of lead compounds, and identification of structure–activity trends. Advanced QSAR models, including 3D-QSAR and pharmacophore modeling, have enhanced the predictive power of the approach by incorporating spatial and conformational properties. The integration of QSAR with modern tools such as artificial intelligence, molecular docking, and high-throughput screening is further revolutionizing rational drug design. Despite its strengths, QSAR is limited by data quality, model applicability domains, and the need for rigorous validation. Nevertheless, it remains a cost-effective and powerful tool for guiding medicinal chemistry efforts, minimizing trial-and-error, and improving the efficiency of pharmaceutical R&D.
Keywords:QSAR, drug development, molecular descriptors, computational modeling, structure–activity relationship

FRAGRANCE PRODUCTION FROM WASTE MATERIALS BY *PSEUDOMONAS PUTIDA* THROUGH MICROBIAL PROCESSES

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Abstract:
Waste is typically characterized as any material, substance, or by-products that is discarded after its primary use because it is unwanted or deemed unusable, or that has no further utility. It can exist as a solid, liquid, or gas and is frequently linked to human activities; however, natural ecosystems also generate waste that is usually recycled. A fragrance is a pleasant aroma, usually created by essential oils or aroma compounds. Some bacteria and yeast generate fragrances as metabolic by-products. Two major environmental issues are waste management and the production of Fragrances. This research investigates the ability of *Pseudomonas putida* to transform waste products into valuable fragrances, providing a sustainable solution. Enrichment cultures and selective media are commonly employed to isolate *Pseudomonas putida* from environmental samples such as soil and water. Certain fragrances are indeed produced using fermentation. GC-MS (Gas Chromatography- Mass Spectrometry) serves as a robust analytical method for evaluating the quality And composition of fragrances through the identification and quantification of Volatile organic compounds. It aids in guaranteeing the quality of fragrances by Confirming the presence and levels of particular components, spotting possible Pollutants, and uncovering fraudulent items.

Keywords:
Pseudomonas putida, waste materials, fragrance production.

RATIONAL USE OF MEDICINES: ROLE OF THE PHARMACIST

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ABSTRACT:
The rational use of medicines (RUM) is a cornerstone of effective healthcare, aiming to ensure that patients receive medications appropriate to their clinical needs, in correct doses, for an adequate period, and at the lowest possible cost. However, irrational practices such as polypharmacy, self-medication, overprescribing antibiotics, and poor adherence to treatment regimens remain widespread, leading to increased adverse drug reactions, drug resistance, and healthcare costs. Pharmacists play a pivotal role in promoting RUM through their expertise in pharmacology, patient counseling, and medication management. As accessible healthcare professionals, pharmacists assess prescriptions for appropriateness, identify potential drug interactions, and ensure patient understanding of dosage, side effects, and storage conditions. In both community and hospital settings, pharmacists contribute to therapeutic decision-making, monitor treatment outcomes, and support adherence through patient education and follow-up. They also participate in antimicrobial stewardship programs, helping to curb antibiotic misuse and resistance. Furthermore, pharmacists engage in public health initiatives, advocate for formulary management, and support pharmacovigilance by reporting adverse drug events. Integration of clinical pharmacy services into multidisciplinary healthcare teams has been shown to improve treatment outcomes and optimize resource utilization. To maximize their impact on RUM, pharmacists require continuous professional development, policy support, and involvement in national medicine use strategies. Ultimately, empowering pharmacists enhances patient care, promotes safety, and strengthens health systems globally.
Keywords: Rational use of medicines, pharmacist, medication counseling, drug safety, antimicrobial stewardship

REVIEW ON ANTICOAGULANT THERAPY MANAGEMENT

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Abstract
Anticoagulant therapy plays a critical role in preventing and treating thromboembolic disorders, including deep vein thrombosis, pulmonary embolism, and stroke associated with atrial fibrillation. The article on Anticoagulant Therapy Management offers a comprehensive overview of the types of anticoagulants—vitamin K antagonists (VKAs), direct oral anticoagulants (DOACs), and heparins—highlighting their mechanisms of action, clinical indications, and monitoring requirements. A major strength of the article lies in its balanced discussion of individualized therapy, emphasizing patient-specific factors such as renal function, age, comorbidities, and bleeding risk. It also addresses challenges in clinical management, including drug-drug interactions, adherence issues, and perioperative anticoagulation. Notably, the article outlines best practices for INR monitoring with warfarin and the advantages of DOACs in reducing monitoring burden. The review effectively integrates current guidelines and evidence-based strategies, aiding clinicians in optimizing therapeutic outcomes while minimizing adverse effects. Furthermore, the article discusses reversal agents and protocols in managing bleeding complications. However, more emphasis on patient education and cost-effectiveness comparisons could enhance the practical utility. Overall, the abstract presents a well-structured, informative snapshot of anticoagulant therapy management, suitable for both primary care and specialist audiences, contributing meaningfully to clinical decision-making and patient safety.

Keywords
Anticoagulant, Thromboembolism, Warfarin, Direct Oral Anticoagulant, Heparin, Patient compliance, Clinical guidelines.

Introduction

Anticoagulant therapy is a cornerstone in the prevention and management of thromboembolic disorders, which are major contributors to morbidity and mortality worldwide. These disorders, including deep vein thrombosis (DVT), pulmonary embolism (PE), and ischemic stroke, often result from abnormal blood clot formation and can lead to life-threatening complications if not effectively managed. Anticoagulants, commonly referred to as “blood thinners,” do not dissolve existing clots but prevent the formation of new ones and the extension of existing clots.

There are several classes of anticoagulants used in clinical practice. Traditional agents such as vitamin K antagonists (VKAs), especially warfarin, have long been used but require frequent monitoring and dose adjustments. Heparins, including unfractionated heparin (UFH) and low molecular weight heparins (LMWHs), are widely used in acute settings due to their rapid onset of action. In recent years, direct oral anticoagulants (DOACs) like dabigatran, rivaroxaban, apixaban, and edoxaban have gained popularity for their predictable pharmacokinetics, fewer dietary restrictions, and reduced need for monitoring.

Despite their proven efficacy, anticoagulants carry a significant risk of bleeding, necessitating careful patient selection, dosing, and ongoing monitoring. Management challenges include balancing thrombotic and bleeding risks, addressing drug interactions, adjusting for renal or

hepatic impairment, and ensuring patient adherence. Furthermore, the use of anticoagulants in special populations—such as the elderly, pregnant women, and patients undergoing surgery—requires tailored approaches.

This article provides a comprehensive review of anticoagulant therapy management, including mechanisms of action, clinical indications, monitoring strategies, and management of complications. It also discusses emerging therapies and the role of guidelines in standardizing treatment protocols. Effective anticoagulant therapy management is essential not only for achieving optimal clinical outcomes but also for improving patient quality of life and safety in diverse clinical settings.

Classification of Anticoagulants

Anticoagulants are broadly classified into three main categories based on their mechanism of action and route of administration: Vitamin K antagonists (VKAs), heparins, and direct oral anticoagulants (DOACs).

Vitamin K Antagonists (VKAs):

Warfarin is the most commonly used VKA. It inhibits vitamin K–dependent clotting factors (II, VII, IX, and X), leading to reduced blood coagulation. Warfarin requires regular INR monitoring due to its narrow therapeutic index and interaction with foods and other medications.

Heparins:

These include unfractionated heparin (UFH) and low molecular weight heparins (LMWHs) such as enoxaparin and dalteparin. UFH works by enhancing antithrombin activity, inhibiting thrombin and factor Xa. It requires aPTT monitoring. LMWHs predominantly inhibit factor Xa and have more predictable effects, allowing for fixed dosing without routine monitoring.

Direct Oral Anticoagulants (DOACs):

DOACs include direct thrombin inhibitors (e.g., dabigatran) and factor Xa inhibitors (e.g., rivaroxaban, apixaban, edoxaban). These drugs act directly on specific clotting factors and have rapid onset, fewer food and drug interactions, and do not usually require routine coagulation monitoring.

Clinical Indications for Anticoagulant Use

Anticoagulants are essential in the prevention and treatment of various thromboembolic disorders. Their use is based on the underlying risk of abnormal clot formation, which can lead to life-threatening events such as stroke, pulmonary embolism, or myocardial infarction.

One of the most common indications for anticoagulation is atrial fibrillation (AF), an irregular heart rhythm that increases the risk of stroke due to clot formation in the left atrium. Anticoagulants reduce the risk of embolic stroke by preventing thrombus formation.

Another major indication is venous thromboembolism (VTE), which includes deep vein thrombosis (DVT) and pulmonary embolism (PE). These conditions are associated with immobility, surgery, trauma, cancer, or inherited clotting disorders. Anticoagulants are used both for acute treatment and long-term secondary prevention.

Prophylactic anticoagulation is commonly used in hospitalized patients, particularly those undergoing major orthopedic surgery (like hip or knee replacements), to prevent VTE.

In mechanical heart valve replacement, long-term anticoagulation, usually with warfarin, is required to prevent valve thrombosis and systemic embolism.

Anticoagulants are also indicated in acute coronary syndromes (ACS), including myocardial infarction and unstable angina, to prevent clot extension and recurrent events when used in combination with antiplatelet agents.

Additional uses include stroke prevention in patients with a history of thromboembolic events, hypercoagulable states (e.g., antiphospholipid syndrome), and peripheral arterial disease in selected cases.

The choice of anticoagulant and duration of therapy depend on the indication, risk of bleeding, patient comorbidities, and concurrent medications. Careful risk-benefit assessment is crucial in initiating and managing anticoagulant therapy to optimize outcomes and minimize complications such as hemorrhage. Proper patient selection and regular follow-up play a vital role in safe and effective anticoagulant use.

Monitoring and Dosing Strategies

Effective anticoagulant therapy requires careful monitoring and individualized dosing to achieve optimal therapeutic outcomes while minimizing the risk of bleeding or thrombotic complications. The monitoring approach varies depending on the class of anticoagulant used.

Vitamin K Antagonists (VKAs):

Warfarin dosing is highly variable among patients due to differences in diet, age, genetics, and drug interactions. Therefore, regular monitoring of the International Normalized Ratio (INR) is essential to maintain the INR within a therapeutic range (typically 2.0–3.0 for most indications). Dosing is adjusted based on INR results, and frequent monitoring is necessary, especially when initiating therapy, adjusting doses, or changing medications or diet.

Heparins:

Unfractionated heparin (UFH) requires monitoring through the activated partial thromboplastin time (aPTT) to ensure it remains within the therapeutic range (usually 1.5–2.5 times control). It has a short half-life and is administered intravenously, often in hospitalized patients.

Low molecular weight heparins (LMWHs), such as enoxaparin, have more predictable pharmacokinetics and generally do not require routine monitoring. However, anti-factor Xa level testing may be used in certain populations, such as pregnant women, renal impairment patients, or those with obesity.

Direct Oral Anticoagulants (DOACs):

DOACs, including dabigatran, rivaroxaban, apixaban, and edoxaban, have fixed dosing regimens based on the indication, renal function, and body weight. Routine coagulation monitoring is not required due to predictable pharmacokinetics. However, renal and hepatic function should be monitored periodically to ensure safe drug clearance, and adherence should be assessed regularly.

Management of Bleeding Complications

Bleeding is the most significant adverse effect of anticoagulant therapy and can range from minor to life-threatening. Effective management involves prompt assessment, identification of the bleeding source, and reversal or adjustment of anticoagulation, depending on severity and clinical context.

Initial Assessment:

Management begins with evaluating the type and severity of bleeding (minor vs. major), the patient's hemodynamic stability, and the anticoagulant used. Minor bleeding often requires local control and supportive care, while major bleeding demands urgent intervention.

Temporary Discontinuation:

The first step in managing moderate to severe bleeding is to withhold the anticoagulant. The duration depends on the half-life of the drug, renal function, and bleeding resolution.

Reversal Agents:

For warfarin (a VKA): Administer vitamin K (oral or IV) along with fresh frozen plasma (FFP) or prothrombin complex concentrate (PCC) for rapid reversal in major bleeding.

For heparin: Use protamine sulfate to neutralize UFH and partially reverse LMWH.

For DOACs: Specific reversal agents are available—idarucizumab for dabigatran, and andexanet alfa for factor Xa inhibitors (rivaroxaban, apixaban). In the absence of specific agents, activated charcoal (if ingestion was recent), PCCs, and supportive care may be used.

Supportive Measures:

These include fluid resuscitation, blood transfusion, mechanical pressure, surgical intervention, or endoscopic procedures based on the bleeding site.

5. Re-initiation of Therapy:

Once bleeding is controlled, a careful risk-benefit analysis is needed before restarting anticoagulation, considering the patient's thromboembolic risk. Close monitoring, individualized care plans, and emergency protocols improve outcomes. Educating patients about bleeding signs and when to seek help is vital for early intervention and safety during anticoagulant therapy.

Anticoagulant Use in Special Populations

Anticoagulant therapy requires special consideration in certain populations due to altered pharmacokinetics, increased bleeding risk, and unique clinical needs. Individualized treatment plans and close monitoring are essential for safe and effective therapy in these groups.

Elderly Patients:

Older adults often have multiple comorbidities, polypharmacy, and age-related decline in renal and hepatic function, increasing the risk of bleeding. Lower starting doses and more frequent monitoring are usually recommended. DOACs are often preferred due to their predictable effects, but careful dose adjustment is crucial.

Patients with Renal or Hepatic Impairment:

Renal dysfunction affects the clearance of many anticoagulants, particularly DOACs and LMWHs. Dose reduction or alternative agents may be required based on renal function. In hepatic impairment, VKAs may be used cautiously, as liver dysfunction affects clotting factor production and drug metabolism.

Pregnant Women:

Warfarin is teratogenic and contraindicated in pregnancy. LMWHs are the preferred anticoagulants during pregnancy due to their safety profile, minimal placental transfer, and ease of dosing. Anticoagulation may be required in conditions like thrombophilia or mechanical heart valves.

Cancer Patients:

These individuals have a higher risk of both thrombosis and bleeding. LMWHs were traditionally the mainstay, but DOACs (e.g., apixaban, rivaroxaban) are now increasingly used, with caution in those with gastrointestinal or genitourinary malignancies.

Obese Patients:

Weight can alter drug distribution and efficacy. LMWH and DOAC dosing should be based on actual body weight, and monitoring may be necessary to ensure therapeutic levels. In all special populations, a tailored approach based on individual risk factors and evidence-based guidelines is essential for optimal anticoagulant use.

Drug Interactions and Contraindications (250 words)

Anticoagulants are prone to significant drug interactions and have specific contraindications that must be carefully managed to ensure patient safety and therapeutic effectiveness.

Drug Interactions:

Vitamin K Antagonists (e.g., warfarin) interact with numerous medications, including antibiotics (e.g., metronidazole, ciprofloxacin), antifungals, antiepileptics, and nonsteroidal anti-inflammatory drugs (NSAIDs). These interactions can either increase the risk of bleeding

(by enhancing warfarin's effect) or thrombosis (by reducing its efficacy). Dietary intake of vitamin K (e.g., green leafy vegetables) can also alter warfarin's anticoagulant effect.

Direct Oral Anticoagulants (DOACs) such as rivaroxaban, apixaban, and dabigatran are affected by drugs that inhibit or induce P-glycoprotein and cytochrome P450 enzymes (CYP3A4). Strong inhibitors (e.g., ketoconazole, amiodarone) can increase bleeding risk, while inducers (e.g., rifampin, phenytoin) can reduce effectiveness.

Contraindications:

- Absolute contraindications include:
- Active major bleeding
- Recent or ongoing hemorrhagic stroke
- Severe uncontrolled hypertension
- Known hypersensitivity to the anticoagulant
- Pregnancy (for warfarin specifically)
- Severe hepatic impairment with coagulopathy

Relative contraindications include:

- Recent major surgery or trauma
- Peptic ulcer disease
- Severe thrombocytopenia
- High risk of falls (in elderly or neurologically impaired patients)

Careful assessment of drug history, medical conditions, and laboratory parameters is essential before initiating anticoagulant therapy. Monitoring for signs of bleeding, checking for potential interactions, and educating patients about drug and dietary influences significantly reduce complications and improve outcomes.

Guideline-Based Management Approaches

The management of anticoagulant therapy is guided by evidence-based recommendations from international clinical organizations such as the American College of Cardiology (ACC), American Heart Association (AHA), American College of Chest Physicians (ACCP), and European Society of Cardiology (ESC). These guidelines provide structured approaches for the use, monitoring, and adjustment of anticoagulants in various clinical settings.

For atrial fibrillation (AF), the ACC/AHA/ESC guidelines recommend assessing stroke risk using tools like CHA_2DS_2-VASc score. Patients with higher scores are advised to receive long-term anticoagulation, with DOACs preferred over warfarin for non-valvular AF due to lower bleeding risks and ease of use.

In venous thromboembolism (VTE), including deep vein thrombosis and pulmonary embolism, the ACCP guidelines suggest DOACs as first-line agents for most patients, unless contraindicated. Warfarin is recommended in specific situations, such as in patients with mechanical heart valves or severe renal impairment.

For mechanical heart valves, lifelong anticoagulation with warfarin is recommended due to the high thrombogenicity of prosthetic valves. INR targets are valve-specific and must be maintained with regular monitoring.

In cancer-associated thrombosis, updated guidelines now endorse DOACs (apixaban, rivaroxaban) for select patients, though LMWHs are still recommended for high-bleeding-risk tumors (e.g., gastrointestinal cancers).

The perioperative management of anticoagulation is another critical area addressed in guidelines. Bridging strategies using LMWH or UFH may be needed when warfarin is interrupted for surgery, while DOACs typically require temporary discontinuation without bridging.

Additionally, guidelines emphasize individualized care, especially in special populations like the elderly, pregnant women, or those with renal/hepatic dysfunction. They also advocate for patient education, regular follow-ups, and integration of clinical decision tools. Following these standardized, guideline-based strategies helps ensure effective anticoagulant therapy while minimizing complications and improving patient outcomes.

Recent advances and Emerging Trends

Direct Factor XI/XIa Inhibitors

New agents targeting the contact activation pathway—such as milvexian (factor XIa inhibitor)—show promise for preventing thrombosis with reduced bleeding risk. Milvexian is currently in Phase II trials for post-surgical venous thromboembolism prevention .

Novel DOACs and Refined Indications

The introduction of factor XIa inhibitors and next-gen DOACs continues evolving. Ongoing research is expanding DOAC use in extended thromboprophylaxis for medically ill and cancer patients at high VTE risk—betrixaban is approved in the US, and rivaroxaban/apixaban are gaining traction in guidelines .

Clinical Trials with Novel Agents

Recent phase 3 trials (e.g., PACIFIC-AF) found asundexian reduced bleeding events by 34% versus apixaban in atrial fibrillation. Other trials like RIVER (bioprosthetic valves) and ENAVLE (edoxaban in VTE) showed comparable efficacy with potentially improved safety .

Personalized Risk Stratification via AI

Machine-learning models are outperforming traditional risk scores (CHA_2DS_2-VASc, HAS-BLED) for predicting stroke and bleeding risks in non-valvular AF .

Optimized Dosing Strategies

Enhanced DOAC dosing algorithms focus on renal function, age, body weight, and drug interactions to avoid under- or over-dosing . Tools like SAMe-TT_2R_2 and HERDOO2 assist in personalizing duration and bridging decisions.

Patient-Centered Care and Cost Considerations

Greater emphasis is now placed on balancing efficacy, safety, adherence, and cost—acknowledging that despite therapeutic advances, cost-effectiveness and individualized patient preferences remain critical.

Challenges in Clinical Practice

Despite advancements in anticoagulant therapy, several challenges persist in clinical practice, complicating the safe and effective use of these agents.

Balancing Bleeding and Thrombotic Risks:

A major clinical dilemma is achieving a balance between preventing thrombosis and minimizing bleeding. High-risk patients, such as those with atrial fibrillation, mechanical heart valves, or cancer-associated thrombosis, require long-term anticoagulation, but are also more vulnerable to bleeding. Clinicians often struggle to tailor the intensity and duration of therapy to individual risk profiles.

Monitoring and Dose Adjustments:

Although direct oral anticoagulants (DOACs) offer fixed dosing and fewer monitoring requirements compared to warfarin, they still pose challenges in patients with renal or hepatic impairment, extreme body weight, or drug interactions. Lack of routine monitoring tools for DOACs also makes it difficult to assess adherence and drug levels in emergency situations.

Drug Interactions and Polypharmacy:

Many anticoagulants, particularly warfarin, interact with commonly used medications such as antibiotics, antifungals, NSAIDs, and antiplatelets. These interactions can lead to significant

fluctuations in anticoagulant effect, increasing the risk of either bleeding or clotting, especially in elderly patients or those with multiple comorbidities.

Management of Bleeding Complications:

Timely recognition and management of bleeding events remain a clinical challenge, particularly in settings without access to specific reversal agents or advanced care. Identifying when and how to restart anticoagulation after a bleeding episode is another grey area lacking strong evidence.

Perioperative Management:

Interrupting anticoagulants for surgical or diagnostic procedures without increasing the risk of thrombosis is a complex issue. Bridging with heparin or LMWH requires careful timing and monitoring, yet guidelines are often inconsistently applied.

Patient Education and Adherence:

Ensuring patient understanding of the importance of adherence, dietary restrictions (with warfarin), and early reporting of side effects is critical. However, limited health literacy, financial constraints, and poor follow-up can lead to therapy failure or adverse outcomes.

Limited Access to Newer Agents:

In many regions, DOACs and reversal agents are expensive or unavailable, limiting optimal care. Addressing these challenges requires multidisciplinary efforts, standardized protocols, and patient-centered care to improve safety and efficacy in anticoagulant therapy.

Conclusion

Anticoagulant therapy has revolutionized the prevention and treatment of thromboembolic disorders, significantly reducing the burden of conditions such as atrial fibrillation, deep vein thrombosis, pulmonary embolism, and stroke. The evolution from traditional agents like warfarin to newer direct oral anticoagulants (DOACs) has simplified management in many ways, offering predictable pharmacokinetics, fixed dosing, and fewer monitoring requirements. However, the use of anticoagulants in clinical practice remains complex and demands a patient-centered, evidence-based approach. Key challenges include balancing thrombotic and bleeding risks, managing drug interactions, ensuring appropriate monitoring, and navigating anticoagulant use in special populations such as the elderly, pregnant women, and patients with organ dysfunction or cancer. The emergence of novel agents, improved reversal strategies, and the integration of artificial intelligence for risk prediction are promising developments that may further optimize outcomes and safety.

Guideline-directed therapy, individualized dosing strategies, patient education, and access to reversal agents are crucial to achieving therapeutic success. Equally important is the role of interdisciplinary collaboration among healthcare providers to ensure coordinated care, especially during transitions such as surgery, hospitalization, or changes in health status. In conclusion, while anticoagulants remain a cornerstone of modern medical management for thromboembolic conditions, their safe and effective use requires ongoing vigilance, clinical expertise, and adaptability to new research findings. As advancements continue, personalized care models and innovative technologies will likely play a greater role in enhancing therapeutic precision and reducing complications, ultimately improving patient outcomes in anticoagulant therapy.

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REVOLUTIONIZING PHARMACY WITH ARTIFICIAL INTELLIGENCE: APPLICATIONS AND CHALLENGES

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ABSTRACT:
Pharmacy is being actively transformed by artificial intelligence (AI), which is improving drug development, automating processes, improving clinical decision-making, and promoting customized medicine. Deep learning, generative models, and QSAR are just a few of the AI and ML techniques used in drug discovery that significantly cut down on time and expense by speeding up target identification, optimizing chemical design, and predicting pharmacokinetics and toxicity. More effectively than conventional techniques, AI-powered decision support systems (CDSS) in pharmacy practice examine electronic health records to identify drug–drug interactions, highlight unusual medication orders, and track adverse drug reactions (ADRs). Smart inventory management technologies and robotic automation are increasing operating efficiency and dispensing accuracy; UCSF and other institutions are reporting near-perfect dosage accuracy. Ingestable sensors, video confirmations, and smart pillboxes are examples of AI-driven patient adherence systems that provide real-time monitoring and assistance. However, major barriers stand in the way of widespread implementation. Data quality and bias, privacy regulations (e.g., HIPAA, GDPR), black-box algorithm transparency, regulatory uncertainty around AI as software or medical devices, ethical accountability, and worker resistance are among the fundamental obstacles. Although user-centric explanations are still not fully integrated, explainable AI (XAI) is particularly important for fostering clinician trust. Clinical deployment is further complicated by the fact that the majority of research are retrospective and lack real-world validation. The literature highlights the following priorities in order to fully realize AI's potential: transparent and interpretable model design; adherence to emerging regulatory frameworks; rigorous real-world trials; interdisciplinary collaboration; pharmacist education; and robust, standardized, and representative data. By improving patient safety, treatment optimization, and operational efficiency, these initiatives aim to make pharmacy a more intelligent, data-driven field.

ROLE OF ASYMMETRICAL DIMETHYL ARGININE IN CARDIOVASCULAR DIABETOLOGY

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ABSTRACT

Objective: To determine the serum ADMA level and association of different biochemical parameters with ADMA in diabetes mellitus patients with and without coronary artery disease and normal healthy individuals.

Material and Methods: A total of 210 patients ,out of which 70 type 2 diabetics without coronary artery disease in group B and 70 type 2 diabetics with CAD in group C are included. 70 normal control individuals in group A were also enrolled in the study. Blood was obtained from each participant for biochemical analysis of fasting blood sugar (FBS), glycated hemoglobin (HbA1c), total cholesterol (TC), high density lipoprotein (HDL), low density lipoprotein (LDL), triglyceride (TG) and asymmetrical dimethyl arginine (ADMA).

Results: An elevated ADMA was noted in diabetic subjects with and without coronary artery disease than the healthy control group (03.9±1.5µmol/L and 02.0±0.6 Vs. 0.6±0.2 µmol/L). Similarly different parameters like FBS, HbA1c, HDL, LDL-C Triglyceride were found to be elevated in groupB and group C as compared to group A.

Conclusion: All biochemical parameters are found to be increased in both the diseased groups i.e type 2 diabetes mellitus without CAD and type 2 diabetes mellitus with CAD as compared to the normal healthy individuals.

Key Words: Asymmetric dimethylarginine (ADMA),Type 2 diabetes mellitus,Coronary artery disease, Glycosylated hemoglobin, Lipid profile.

ROLE OF PHARMACOVIGILANCE IN ENSURE DRUG SAFETY

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ABSTRACT:
Pharmacovigilance plays a vital role in safeguarding public health by monitoring, detecting, assessing, and preventing adverse drug reactions (ADRs) and other drug-related problems. As medications undergo rigorous clinical trials before approval, many rare or long-term adverse effects may remain unidentified until widespread use in the general population. Pharmacovigilance bridges this gap by continuously evaluating drug safety post-marketing, thus forming an essential component of drug lifecycle management. The core functions include spontaneous reporting systems, signal detection, risk assessment, and regulatory action. National and international pharmacovigilance programs, such as those led by the World Health Organization (WHO) and regulatory bodies like the FDA and EMA, contribute to a global network for monitoring drug safety. Through data collection from healthcare professionals, patients, and pharmaceutical companies, pharmacovigilance systems help in early detection of potential risks and enable timely interventions such as labeling changes, restricted use, or withdrawal of harmful drugs. Moreover, the integration of digital health tools, real-world data, and artificial intelligence is enhancing the efficiency of pharmacovigilance activities. Ultimately, pharmacovigilance ensures the safe and effective use of medicines, protects patient welfare, and promotes trust in the healthcare system. Strengthening pharmacovigilance infrastructure is critical for achieving comprehensive drug safety worldwide.

SAĞLIK TAHMİNLERİNDE MAKİNE ÖĞRENİMİ: VERİDEN DEĞERE DÖNÜŞÜM

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ÖZET
Bu çalışmanın temel amacı, makine öğrenimi algoritmalarını kullanarak bireylerin sağlık verilerini analiz etmek ve bu verilerden yola çıkarak sağlık sonuçlarını tahmin etmektir. Çalışmada kullanılan veri seti, 349 hastaya ait ateş, öksürük, yorgunluk, nefes alma zorluğu, yaş, cinsiyet, kan basıncı, kolesterol ve genel sağlık durumu gibi çeşitli semptomlar ve demografik faktörleri içermektedir. Bu veriler, bireylerin sağlık durumlarını değerlendirmek ve olası sonuçları tahmin etmek amacıyla makine öğrenmesi sınıflandırma metotları için kullanılmıştır. Bu modellerin oluşturulması, hasta profili, klinik değerlendirmeler, epidemiyolojik analizler ve araştırma çalışmaları gerçekleştiren tıp uygulayıcıları, klinisyenler ve araştırmacılar için büyük önem taşımaktadır. Çünkü hasta verilerinin analiz edilmesi, semptom yaygınlığı ve tıbbi hastalıklardaki eğilimler hakkında değerli içgörüler sunarak tanı, tedavi ve halk sağlığının iyileştirilmesine katkı sağlamaktadır. Bu doğrultuda karar ağacı, rastgele orman, destek vektör makineleri, lojistik regresyon, k-en yakın komşu ve gradyan artırma gibi çeşitli makine öğrenmesi algoritmaları kullanılmıştır. Her bir modelin performansı doğruluk oranları üzerinden değerlendirilmiş ve karşılaştırılmıştır. Sonuç olarak, rastgele orman modelinin %80 doğruluk oranı ile en başarılı tahmin performansına sahip olduğunu ortaya koymuştur. Bunu %77 doğruluk oranı ile gradyan artırma modeli izlemiştir. Diğer modeller ise bu iki algoritmaya kıyasla daha düşük performans sergilemişlerdir. Bulgular, uygun şekilde toplanmış ve ön işleme tutulmuş sağlık verilerinin makine öğrenmesi modelleri aracılığıyla yüksek doğrulukla işlenebileceğini ve sağlık tahminlerinde etkili şekilde kullanılabileceğini göstermektedir. Bu tür modellerin özellikle erken teşhis ve önleyici sağlık hizmetlerine büyük katkılar sağlayabileceği düşünülmektedir. Bu çalışma hem makine öğrenmesi tekniklerinin sağlık alanındaki potansiyelini vurgulamakta hem de bu tekniklerin iyileştirme sürecinde nasıl kullanılabileceğine dair değerli bir örnek sunmaktadır.
Anahtar Kelimeler: Makine öğrenmesi, sınıflandırma, sağlık verileri, semptom analizi, rastgele orman.

MACHINE LEARNING IN HEALTH PREDICTIONS: TRANSFORMING DATA TO VALUE

ABSTRACT

The main purpose of this study is to analyze the health data of individuals using machine learning algorithms and to predict health outcomes (positive or negative) based on these data. The dataset used in the study includes various symptoms and demographic factors such as fever, cough, fatigue, difficulty breathing, age, gender, blood pressure, cholesterol and general health status of 349 patients. These data were used to evaluate the health status of individuals and predict possible outcomes. The creation of these models is of great importance for medical practitioners, clinicians and researchers who conduct patient profiles, clinical assessments, epidemiological analyses and research studies. Because analyzing patient data provides valuable insights into symptom prevalence and trends in medical diseases, contributing to the improvement of diagnosis, treatment and public health. In this regard, various machine learning algorithms such as decision tree, random forest, support vector machines, logistic regression, k-nearest neighbor and gradient boosting have been used. The performance of each model was evaluated and compared in terms of accuracy rates. The results revealed that the random forest model had the most successful prediction performance with an accuracy rate of 80%. This was followed by the gradient boosting model with an accuracy rate of 77%. The other models showed lower performance compared to these two algorithms. The findings show that health data collected and preprocessed appropriately can be processed with high accuracy by machine learning models and can be used effectively in health predictions. It is thought that such models can make great contributions especially to early diagnosis and preventive health services. In conclusion, this study both emphasizes the potential of machine learning techniques in the field of health and provides a valuable example of how these techniques can be used in the process of improving health outcomes.

Keywords: Machine learning, classification, health data, symptom analysis, random forest

GİRİŞ

Hastalık belirtileri bireyler arasında farklılık gösterebilir ve erken evrelerde fark edilmeden kalabilir. Bu belirtilerin erken aşamada tespit edilmesi, vakaların şiddetine bakılmaksızın etkili bir şekilde yönetilmesi ve tedavi edilmesi açısından büyük önem taşımaktadır. MÖ, son yıllarda önemli ilerlemeler kaydetmiş ve çeşitli sağlık uygulamalarında etkinliğini kanıtlamıştır (Furizal, Ma'arif, & Rifaldi, 2023). MÖ tekniklerini kullanarak hastalıkların teşhisini kolaylaştıran bir model ya da sistem geliştirilmesi, yapay zekâ (YZ) alanında hem umut verici hem de zorlu bir konudur (Caballé-Cervigón, Castillo-Sequera, Gómez-Pulido, Gómez-Pulido, & Polo-Luque, 2020). Bu amaç doğrultusunda, söz konusu semptomların ilk teşhisine yönelik YZ tabanlı bir metodoloji geliştirmek üzere bir çalışma gerçekleştirilmiştir. MÖ algoritmalarının sağlık alanındaki uygulamaları, son dönem çalışmalarda açıkça görülmektedir. Yürütülen bazı araştırmalar, MÖ tabanlı hastalık teşhisi üzerine kapsamlı incelemeler sunmakta ve bu alandaki en güncel eğilimleri ve yaklaşımları ele almaktadır (Pal, Ghosh, Majumdar, Pan, & Ghosh, 2023). Bu incelemelerde öne çıkan bulgular arasında; Naïve Bayes (NB), Destek Vektör Makineleri (DVM), En Yakın Komşu (KEYK) ve Rastgele Orman (RO) gibi algoritmaların hastalık teşhisinde yaygın olarak kullanıldığı vurgulanmıştır (Bajwa, Munir, Nori, & Williams, 2021). Ayrıca, bazı araştırmacılar, YZ uygulamalarını genişletmek amacıyla en yaygın kullanılan MÖ yöntemlerine odaklanmışlardır. Bunlar arasında yapay sinir ağları (YSA), DVM, karar ağaçları (KA), lojistik regresyon (LR) ve sinir ağı destekli yöntemler yer almaktadır. Woodman ve Mangoni, MÖ tekniklerinin hem yaygın hem de nadir hastalıkların teşhisinde artan şekilde kullanılmasına dikkat çekmiştir (Woodman & Mangoni, 2023). Öte yandan, Poudel; MÖ algoritmalarının hastalık teşhisinde en sık kullanılanlarını özetlemiş ve bu

algoritmalara güvenmenin beraberinde getirdiği klinik zorluklara odaklanmıştır (Poudel, 2022). Başka bir araştırma ise sağlık sektöründe MÖ algoritmalarının kullanımıyla ilgili yararları, yöntemleri ve işlevsellikleri ele almıştır. Ferdous ve arkadaşları, sağlık alanında MÖ algoritmalarının hastalık teşhisindeki doğruluk oranlarına ilişkin bir literatür taraması sunmuştur (Ferdous, Debnath, & Chakraborty, 2020). Fatima ve Pasha ise bu yöntemlerin avantaj ve dezavantajlarını vurgulamış ve farklı MÖ tekniklerinin hastalık teşhisi açısından karşılaştırmalı analizini yapmıştır (Fatima & Pasha, 2017). Genel olarak, bu literatür incelemeleri, MÖ algoritmalarının hastalık teşhisindeki kullanımı hakkında değerli bilgiler sunmaktadır.

Bu çalışmada, MÖ yöntemleri kullanılarak hastalar arasındaki semptom desenlerini ve genel kuralları belirlemeyi amaçlamaktadır. Kurallara dayalı MÖ teknikleri ile sınıflandırma yöntemlerinin entegrasyonu, genişletilmiş bir tahmin modeli oluşturmak için kullanılmıştır. Çalışmada, Kaggle veri üzerinden çevrimiçi olarak elde edilen hasta verileri analiz edilmiştir. Verilerin ön işlenmesi ve tanımlayıcı istatistiklerinin incelenmesinin ardından, hastalıkları tahmin etmek amacıyla çeşitli makine öğrenme modelleri uygulanmıştır. Bu modeller arasında LR, DVM, Gradyan Artırma Makineleri (GAM), KA, KEYK ve RO yer almaktadır. Bu modeller, hastalıkların doğru bir şekilde tahmin edilmesi amacıyla kullanılmıştır. Bu modellerin performansı da doğruluk gibi kesin göstergeler kullanılarak değerlendirilmiş, verilerin dağılımını göstermek ve modelleri değerlendirmek için bir takım grafikler çizilmiştir.

MATERYAL VE YÖNTEM

Analiz aşamısında kullanılan veri seti ("Disease Symptoms and Patient Profile Dataset," n.d.), Tablo 1'de belirtilen 10 özelliği içermektedir. Kullandığımız bu halka açık Kaggle veri seti, kişisel tanımlayıcı bilgiler içermemektedir. Dolayısıyla Sağlık Sigortası Taşınabilirlik ve Sorumluluk Yasası (HIPAA) ile Genel Veri Koruma Yönetmeliği (GDPR) gibi veri gizliliği düzenlemelerine uygunluk gözetilmiştir. Veri seti, hastalar ve hastalıklar arasındaki karmaşık ilişkilerin ayrıntılı bir incelemesini sunmakta olup, 100'den fazla farklı tıbbi durumu ve toplam 349 kaydı içermektedir. Veri seti; ateş, öksürük, yorgunluk ve nefes darlığı gibi semptomları; yaş, cinsiyet, tansiyon ve kolesterol düzeyleri gibi demografik ve sağlık göstergeleriyle ilişkilendirerek, bu unsurlar arasındaki dikkat çekici bağlantıları gözler önüne sermektedir. Veri setindeki bağımsız değişkenler; hastalık türü, ateş, öksürük, yorgunluk, nefes darlığı, yaş (yıl olarak), cinsiyet, kan basıncı ve kolesterol seviyesidir. Bu değişkenlerin tamamı kategorik olup yalnızca yaş sayısal bir değişkendir. Bağımlı değişken ise hastalık sonucunu ifade eden "Sonuç Değişkeni"dir (Pozitif/Negatif).

Tablo 1. Veri Kümesinin Açıklaması

Özellik adı	Tanım	Veri türü
Disease	Hastalığın veya tıbbi durumun adı	Nominal
Fever	Hastanın ateşi olup olmadığını belirtir (Evet=1/Hayır=0)	İkili
Cough	Hastanın öksürüğü olup olmadığını belirtir (Evet=1/Hayır=0)	İkili
Fatigue	Hastanın yorgunluk yaşayıp yaşamadığını belirtir (Evet=1/Hayır=0)	İkili
Difficulty Breathing	Hastanın nefes almada zorluk yaşayıp yaşamadığını belirtir (Evet=1/Hayır=0)	İkili
Age	Hastanın yıl cinsinden yaşı	Sayısal
Gender	Hastanın cinsiyeti (Erkek=1/Kadın=0	İkili
Blood pressure	Hastanın kan basıncı düzeyi (Yüksek/Normal/Düşük)	Nominal

Cholesterol level	Hastanın kolesterol düzeyi (Yüksek/Normal/Düşük)	Nominal
Outcome variable	Spesifik hastalığa ilişkin tanı veya değerlendirme sonucunu gösteren sonuç değişkeni (Pozitif=1/Negatif=0)	İkili

Modelleme aşamasında, çeşitli sınıflandırma algoritmaları tanımlanmıştır. Bu modeller arasında, LR, KA, RO, GAM, KEYK ve DVM yer almaktadır.

"LR, Maksimum Entropi sınıflandırması (MaxEnt), logit regresyonu veya log-lineer sınıflandırıcı gibi çeşitli isimlerle bilinen istatistiksel bir modeldir. Bu model, belirli bir deneyin veya olayın en olası sonuçlarını değerlendirmek için lojistik bir fonksiyon kullanarak olasılığı hesaplar. Temel olarak LR, bağımlı değişken ile bir veya birden fazla bağımsız değişken arasındaki ilişkiyi modelleyerek, belirli bir girdinin belirli bir kategoriye veya sınıfa ait olma olasılığını tahmin eder. Bu özelliği sayesinde, sonuçların "başarı" veya "başarısızlık" gibi ikili olduğu sınıflandırma problemlerinde sıkça tercih edilir. Ancak, çok sınıflı sınıflandırma problemlerini çözmek için de uyarlanabilir. Lojistik fonksiyon, giriş değerlerini 0 ile 1 arasında olasılıklara dönüştürür; bu da onu ikili sonuçları modellemek için oldukça uygun hale getirir" (Peng, Lee, & Ingersoll, 2002).

"KA, veriyi, özelliklere göre dallara ayırarak sınıflandıran ağaç yapılı bir algoritmadır . Her düğümde bir özellik üzerinde soru sorulur ve cevaba göre veri alt dallara bölünür; bu şekilde yaprak düğümlerde sınıf etiketleri elde edilir. KA parametrik olmayan, hızlı anlaşılan modellerdir. Hataları azaltmak amacıyla veri içinde en iyi bölünme kurallarını gini indeks veya entropi kullanarak ağaç inşa eder" (Quinlan, 1986).

"RO, hem regresyon hem de sınıflandırma uygulamaları için kullanılan topluluk tabanlı bir MÖ yöntemidir. Bu yöntem, birden fazla KA oluşturarak, bu ağaçların tahminlerini birleştirir ve daha güvenilir, daha doğru sonuçlar elde edilmesini sağlar. Tek tek karar ağaçlarının tahminlerini birleştirme süreci sayesinde, RO algoritması aşırı öğrenme (overfitting) problemini azaltabilir; bu da tek başına kullanılan karar ağaçlarında sıkça karşılaşılan bir sorundur. Bu nedenle, RO karmaşık veri yapılarında etkili tahminler sağlayan güçlü bir model olarak kabul edilir" (Hastie, 2009).

"GAM, genellikle RO modellerinden daha yüksek doğruluk ve performans sunar. GAM modelleri, diğer artırma (boosting) yöntemleri gibi adım adım inşa edilir; ancak GAM yöntemi, türevlenebilir bir kayıp fonksiyonunun optimize edilmesine olanak tanıyarak bu yöntemleri genelleştirir. Bu algoritma, zayıf öğrenicilerden (genellikle küçük karar ağaçları) oluşan bir dizi model oluşturur ve her yeni model, önceki modellerin yaptığı hataları düzeltmeye odaklanır. Bu yaklaşım, özellikle karmaşık veri kümelerinde güçlü ve esnek sınıflandırma performansı sağlar. Ayrıca, problemi özelleştirmek için farklı kayıp fonksiyonları seçilebilir" (Lee et al., 2022).

"DVM, hem sınıflandırma hem de regresyon görevlerinde kullanılabilen denetimli bir MÖ yöntemidir. DVM algoritması, verileri en iyi şekilde ayıran bir hiper düzlem (hyperplane) bularak çalışır; bu hiper düzlem, sınıflar arasındaki en geniş marjini sağlayacak şekilde karar sınırını belirler. Bu bağlamda, DVM algoritmaları, giriş değişkenleri ile hedef değişkenler arasındaki bilinen ilişkilere dayanarak tahmin yapabilen modeller oluşturmak için kullanılır. Bu özelliği sayesinde, özellikle doğruluğun kritik olduğu sınıflandırma problemlerinde tercih edilmektedir" (Cortes & Vapnik, 1995).

KEYK, mesafeye göre sınıflandırma yapar, ancak büyük veri setlerinde yavaş çalışabilir ve aykırı değerlere duyarlıdır (Cover & Hart, 1967).

Her bir modelin uygulanma nedeni, farklı yöntemlerin sınıflandırma yeteneklerini kıyaslamak ve en iyi sonucu veren yaklaşıma ulaşmaktır. Bazı modeller, örneğin LR ve KA, açıklanabilirliği yüksek ve hızlı çalışırken, topluluk yöntemleri (RO, GAM) genellikle daha yüksek doğruluk elde edebilme potansiyeline sahiptir.

Model performanslarını ilk değerlendirmek amacıyla doğruluk metriği hesaplanmıştır (Eşitlik-1). "Bu metrik, modelin test verisi üzerinde yaptığı doğru sınıflandırma oranını gösterir ve genel başarım hakkında hızlı bir fikir sunar. Hesaplaması doğru sınıflandırılan örnek sayısının toplam örnek sayısına bölünmesiyle yapılır. Doğru Pozitifler (True Positives - TP), modelin pozitif sınıfı doğru bir şekilde tahmin ettiği durumlardır. Gerçek değer pozitiftir ve modelin tahmini de pozitiftir. Doğru Negatifler (True Negatives - TN), modelin negatif sınıfı doğru bir şekilde tahmin ettiği durumlardır. Gerçek değer negatiftir ve tahmin de negatiftir. Yanlış Pozitifler (False Positives - FP), modelin pozitif sınıfı yanlış tahmin ettiği durumlardır. Tahmin pozitiftir ancak gerçek değer negatiftir. Bu tür hatalar Tip 1 Hatası (Type I Error) olarak da bilinir. Yanlış Negatifler **(**False Negatives - FN), modelin negatif sınıfı yanlış tahmin ettiği durumlardır. Tahmin negatiftir ancak gerçek değer pozitiftir. Bu tür hatalar Tip 2 Hatası (Type II Error) olarak da bilinir." (Cover & Hart, 1967). Bu durumlar Tablo-2'de yer almaktadır.

Tablo 2: Karışıklık Matrisi

		Gerçek Değerler	
		Olumlu	Negatif
Tahmin Edilen Değerler	Olumlu	Gerçek Pozitif	Yanlış Pozitif
	Negatif	Yanlış Negatif	Gerçek Negatif

Model doğruluk değerinin hesaplanması için kullanılan eşitlik aşağıda yer almaktadır.

$$Doğruluk = \frac{TP+TN}{TP+FP+TN+FN} \quad (1)$$

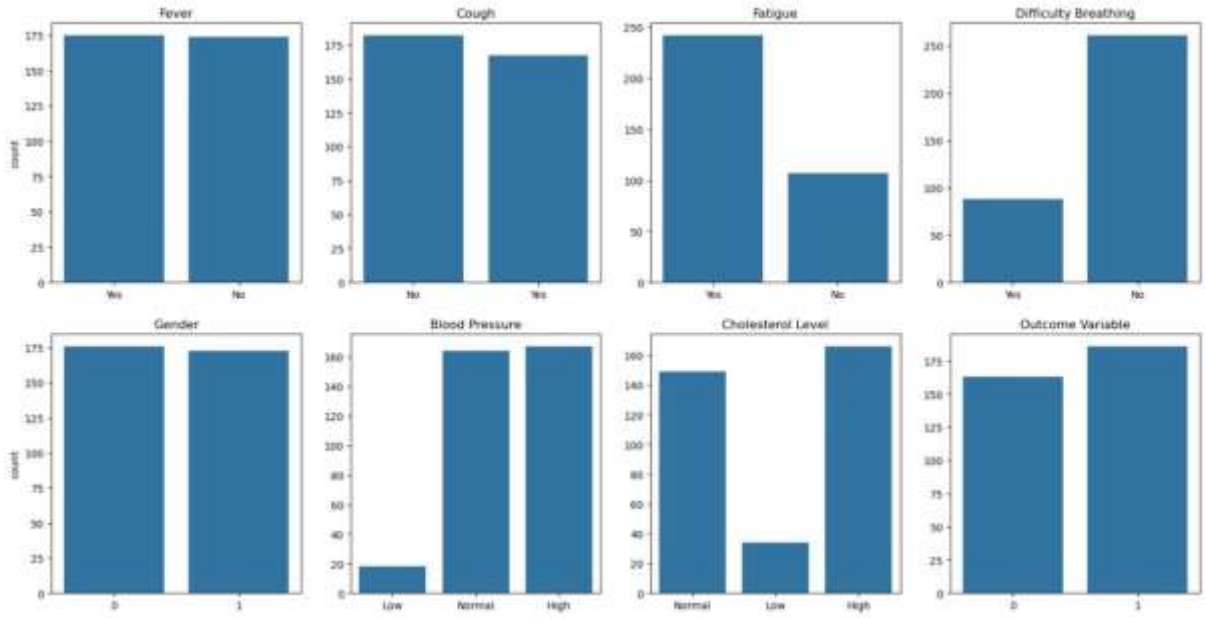
SONUÇLAR VE TARTIŞMA

Veri setinde %7 astım hastası, %5 inme hastası ve %89 oranında genel hastalık vakalarını içermektedir. Ateş belirtisi açısından pozitif ve negatif test oranları %50 ile eşittir. Öksürük pozitif vakalar %48, yorgunluk vakaları %69 ve nefes darlığı yaşayan hastalar %25 oranındadır. Yaş dağılımı 19 ile 90 yaş arasında olup, en yoğun veri 30-40 yaş aralığında gözlemlenmiştir. Cinsiyete göre veri dağılımı kadın ve erkekler arasında eşit şekilde paylaşılmıştır. Yüksek tansiyon ve kolesterol seviyesine sahip hastaların oranı %48'dir. Bu veriler, hastaların mevcut özelliklerine göre hastalık semptomlarına sahip olup olmadığını belirlemek amacıyla kullanılmıştır ve 100'den fazla vakada hastalar ile hastalıklar arasındaki güçlü ilişkiyi göstermektedir.

Bir sınıflandırıcı, bazı durumlarda ham veriyi işlerken eksiklik ve tutarsızlık gibi nedenlerden dolayı etkisiz olabilir. Bu nedenle, veri önişleme süreci, veri madenciliği ve MÖ modellerinde tahmin doğruluğunu artırmak için kritik bir adımdır. Bu çalışmada, veri analizine başlamadan önce veri önişleme gerçekleştirilmiştir. Bu süreçte etiket kodlama, veri dönüşümü ve aykırı değerlerle başa çıkma adımları uygulanmıştır. İlk olarak, veri kümesinde eksik değer bulunmadığı tespit edilmiş, bu nedenle eksik veri temizliği yapılmamıştır. Kategorik değişkenler arasında yer alan semptomlar (ateş, öksürük, yorgunluk), cinsiyet, tansiyon ve kolesterol düzeyi gibi metin verileri sayısal değerlere (0 ve 1) dönüştürülmüştür. Bu işlem, modellerin veriyi daha etkili işlemesini ve öğrenmesini sağlamaktadır. Veri kümesindeki tek sayısal değişken "Yaş" olup diğer tüm değişkenler kodlama işlemine tabi tutulmuştur. Etiketleme işlemi tamamlandıktan sonra, veri seti eğitim ve test olarak ikiye ayrılmış ve özellikle sayısal değişkenler arasındaki dağılım farkını azaltmak amacıyla StandardScaler kullanılarak veriler normalize edilmiştir. Bu normalizasyon adımı, özellikle KEYK ve DVM gibi modellerde daha tutarlı ve doğru sonuçlar elde edilmesini sağlamaktadır.

Ön analiz aşamasında veri içindeki dağılımları ve ilişkileri incelemek için cinsiyet ile sonuç değişkeni arasındaki ilişki incelenmiş ve sonuçların %57'si kadınlarda, %43'ü ise erkeklerde

pozitif sağlık durumu gözlemlenmiştir. Diğer faktörlerin görsel incelenmesi, her bir özelliğin değerine göre hastalık tahmininde önemli değişiklikler olduğunu ortaya koymuştur. Örneğin, kolesterol seviyeleri (yüksek, normal veya düşük) hastalık tahmini üzerinde dikkate değer bir etki yaratabilmekte ve bu durum gerçek dünyadaki hastalıkların çeşitliliğini yansıtmaktadır. Bu analizde iki önemli bulgu dikkat çekmiştir. Düşük tansiyonun inme riskinin azalmasıyla ilişkili olduğu ve bunun inme tahmini için kritik bir bileşen olduğu tespit edilmiştir. Ayrıca, yorgunluk, kolesterol seviyesi ve kan basıncı değerleri arasında anlamlı farklılıklar gözlemlenmiş, bu da söz konusu değişkenlerin modelde güçlü öngörücüler olarak kullanılabileceğini ortaya koymuştur. Bu gözlemler, söz konusu değişkenlerin hastalık tahmininde taşıdığı önemi açıkça ortaya koymaktadır. Şekil 1'de alt grafikten oluşmaktadır. Her bir alt grafik, sırasıyla Fever, Cough, Fatigue, Difficulty Breathing, Gender, Blood Pressure, Cholesterol Level, Outcome Variable değişkenlerinin countplot (kategori frekansı) dağılımını gösterir**. Değişkenlerin frekanslarına göre dağılımını göstererek sınıflandırma açısından anlamlı olabilecek özelliklerin belirlenmesini sağlar.**



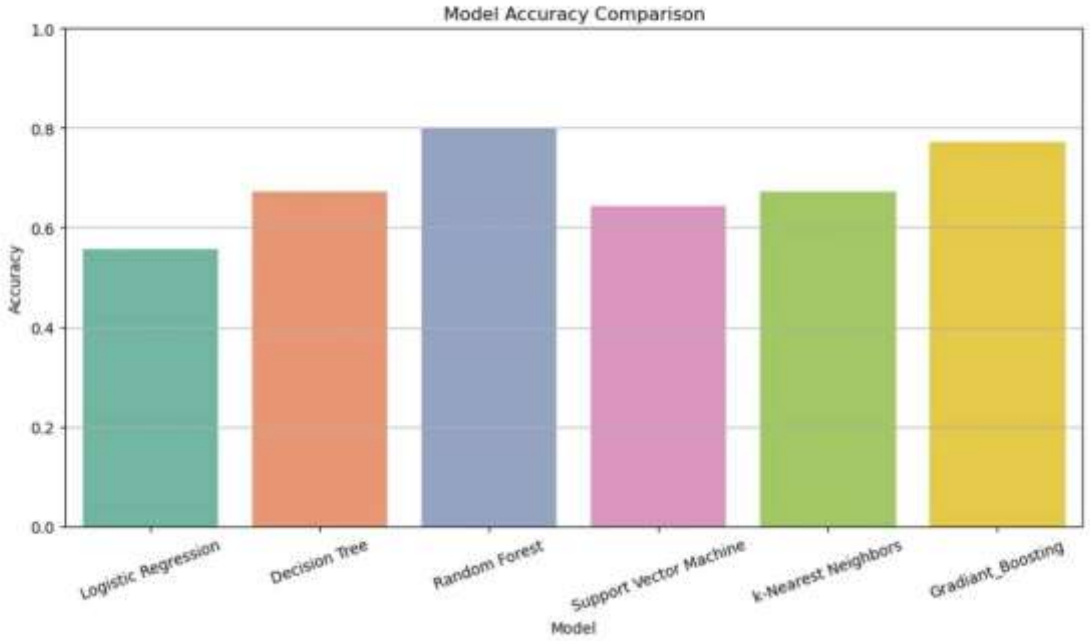
Şekil 1: Özellikler ve Hedef Değişkenin Sınıf Dağılımı

Tablo 3'de çeşitli modellerin performans ölçümleri gösterilmektedir. Elde edilen sonuçlara göre, **RO** modeli %80 doğruluk oranı ile en başarılı sonuçları vermiştir. Bu, modelin karmaşık örüntüleri yakalayabilme kapasitesinin yüksek olduğunu ve ağaç tabanlı yapısının güçlü genelleme yeteneğine sahip olduğunu göstermektedir. Onu %77 doğrulukla **GAM** modeli takip etmektedir; bu da modelin güçlü hata düzeltme mekanizması sayesinde iyi performans sergilediğini ortaya koymaktadır. **KA** ve **KEYK** modelleri %67 doğruluk ile benzer düzeyde sonuçlar vermiştir. KA modelinin kolay yorumlanabilir yapısı ve KEYK'nun basit hesaplamaya dayanan yaklaşımı göz önüne alındığında, bu doğruluk oranları tatmin edici bulunabilir. Ancak bu modeller, veri setinin karmaşıklığı karşısında sınırlı performans gösterebilir. **DVM,** %64 doğruluk oranıyla orta düzeyde bir başarı sağlamış olup, bu oran modelin doğrusal olmayan sınırlarda sınıflandırma yapmada sınırlı kaldığını düşündürebilir. En düşük doğruluk ise %56 ile **LR** modeline aittir. Bu durum, veri setinde doğrusal olmayan ilişkilerin ağırlıkta olduğunu ve bu nedenle doğrusal sınırlayıcı modellerin yetersiz kaldığını göstermektedir.

Tablo 3: Modellerin Doğruluk Oranları

Model	Doğruluk (Accuracy)
Logistic Regression	0.56
Decision Tree	0.67
Support Vector Machine	0.64
k-NN	0.67
Gradient Boosting	0.77
Random Forest	0.80

Şekil 2'de görüldüğü üzere RO en yüksek doğruluk oranına sahip olmuştur. GAM de yüksek performans sergilerken, LR nispeten düşük doğruluk göstermiştir.



Şekil 2:Modellerin Doğruluk Oranlarının Karşılaştırması

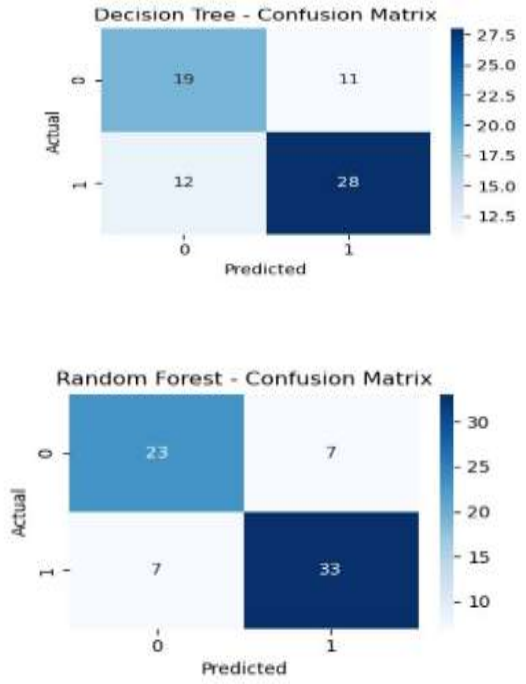
Karışıklık Matrisi (Confusion Matrix) Analizi, bir sınıflandırma modelinin, gerçek değerleri bilinen bir veri kümesi üzerindeki performansını tanımlamak için kullanılan bir tablodur. Bu matris, MÖ modelinin doğruluğunu değerlendirmeye ve modelin yaptığı hata türlerini ve sayısını anlamaya yardımcı olur. Böylece, modelin güçlü ve zayıf yönleri hakkında önemli iç görüler sağlar. TP, TN, FP ve FN gibi değerlerin analiz edilmesiyle, modelin sınıflandırma başarımı kapsamlı bir şekilde değerlendirilebilir ve gerekli durumlarda iyileştirmeler yapılabilir. Satırlar, hedef değişkenin gerçek değerlerini temsil eder. Sütunlar ise hedef değişkenin tahmin edilen değerlerini temsil eder.

Çalışmada kullanılan her bir MÖ algoritmasının test verisi üzerindeki sınıflandırma performansı detaylı şekilde görselleştirilmiştir. Karışıklık matrisleri, sadece doğruluk oranından ziyade modelin hangi tür hataları yaptığını (FP, FN) ve doğru sınıflandırmaları (TP, TN) nasıl gerçekleştirdiğini açıkça ortaya koymaktadır. Özellikle sağlık alanındaki sınıflandırma problemlerinde, yanlış negatif oranı (yani hastayı sağlıklı göstermek) hayati riskler taşıyabileceğinden, yalnızca doğruluk değil, duyarlılık (recall) ve özgüllük (specificity) gibi metriklerin de dikkate alınması elzemdir. Bu nedenle, modellerin doğruluk oranlarına ek olarak karışıklık matrisleri üzerinden yapılan bu karşılaştırmalar, model seçimi sürecinde çok önemli bir rol oynamaktadır.

RO modeli, doğruluk ve denge açısından güçlü bir performans sergilemiştir. Şekil 3'de yer alan karışıklık matrisi incelendiğinde, toplam 40 pozitif vakanın 33'ünü doğru şekilde sınıflandırarak yaklaşık %82,5 pozitif doğruluk oranına ulaşılmış, ayrıca 30 negatif vakanın 23'ünü doğru tanımlayarak %76,7 negatif doğruluk sağlamış olduğu görülmektedir. Hem pozitif hem de negatif vakalarda 7'şer yanlış sınıflandırma gerçekleşmiştir. Bu sonuçlar, modelin dengeli bir hassasiyete sahip olduğunu ve sağlık sonuçlarının tahmininde etkili bir araç olabileceğini göstermektedir; çünkü yanlış negatif ve yanlış pozitif oranlarının benzer seviyede olması modelin önyargısız çalıştığını işaret eder.

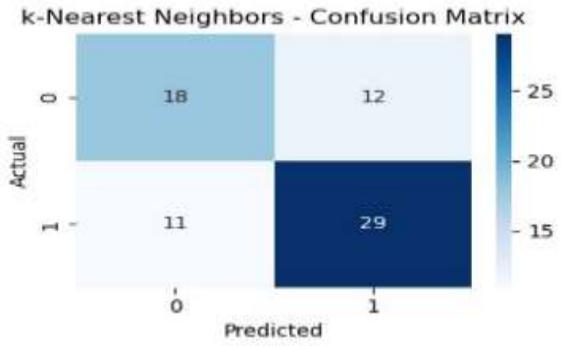
Şekil 3: RO Karışıklık Matrisi

KA modeli, doğruluk ve denge açısından orta seviyede bir performans sergilemiştir. Şekil 4'de yer alan karışıklık matrisi incelendiğinde, toplam 40 pozitif vakanın 28'ini doğru şekilde sınıflandırarak %70 pozitif doğruluk oranına ulaşılmış, ayrıca 30 negatif vakanın 19'unu doğru tanımlayarak yaklaşık %63,3 negatif doğruluk sağlandığı görülmektedir. Pozitif vakalarda 12, negatif vakalarda ise 11 yanlış sınıflandırma meydana gelmiştir. Bu sonuçlar, modele ait hataların hem yanlış negatif hem de yanlış pozitif sınıflarda dengeli dağıldığını ancak genel doğruluk oranının %67,1 civarında olduğunu göstermektedir; bu nedenle modelin geliştirilmesi gerektiği söylenebilir.



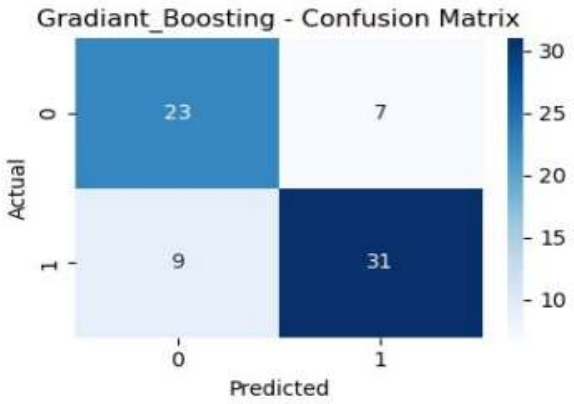
Şekil 4: KA Modeli Karışıklık Matrisi

KEYK, doğruluk ve denge açısından orta seviyede bir performans göstermiştir. Şekil 5'de yer alan karışıklık matrisi incelendiğinde, toplam 40 pozitif vakanın 29'unu doğru şekilde sınıflandırarak yaklaşık %72,5 pozitif doğruluk oranına ulaşılmış, ayrıca 30 negatif vakanın 18'ini doğru tanımlayarak %60 negatif doğruluk sağlanmıştır. Pozitif vakalarda 11, negatif vakalarda ise 12 yanlış sınıflandırma gerçekleşmiştir. Bu sonuçlar, modelin genel doğruluk oranının %67,1 civarında olduğunu ve sağlık sonuçlarının tahmininde sınırlı bir başarı sağladığını göstermektedir; bu da modelin performansını artırmak için iyileştirmeler yapılması gerektiğine işaret etmektedir.



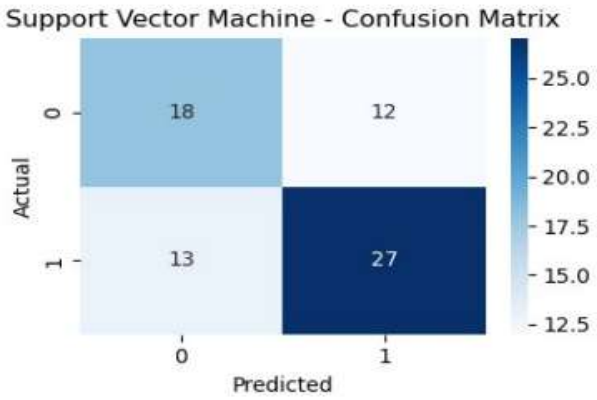
Şekil 5: KEYK Modeli Karışıklık Matrisi

GAM modeli oldukça dengeli bir performans sergilemiştir. Şekil 6'da yer alan karışıklık matrisi incelendiğinde, toplam 40 pozitif vakanın 31'ini (%77.5) ve 30 negatif vakanın 23'ünü (%77) doğru şekilde sınıflandırmıştır. Her iki sınıfta da benzer başarı oranı gözlemlenmiştir. Bu durum, modelin dengeli bir tahmin yeteneğine sahip olduğunu ve özellikle kritik karar destek sistemlerinde güvenle kullanılabileceğini göstermektedir .



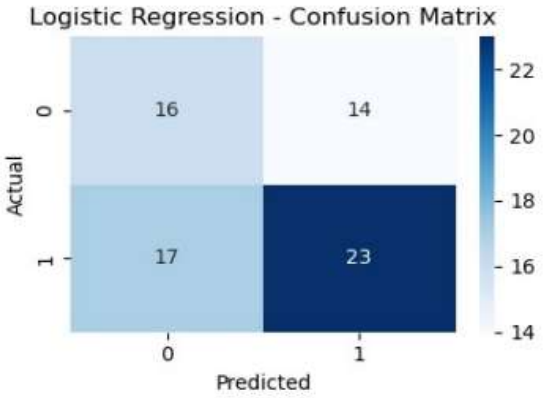
Şekil 6: **GAM Modeli** Karışıklık Matrisi

DVM modeli, dengesiz bir performans göstermiştir. Şekil 7'de yer alan karışıklık matrisi incelendiğinde, **pozitif vakaların %67.5'ini ve negatif vakaların %60'ını doğru sınıflandırmıştır. Bu sonuçlar, modelin sınıflar arasında ayırt etme başarısının sınırlı olduğunu göstermektedir.**



Şekil 7: **DVM Modeli** Karışıklık Matrisi

LR modeli en zayıf performansı göstermiştir. Şekil 8'de yer alan karışıklık matrisi incelendiğinde, 40 pozitif vakanın sadece 23'ünü (%57,5) ve 30 negatif vakanın yalnızca 16'sını (%53,3) doğru tanımlayabilmiştir.Yüksek hata oranı (17 FN ve 14 FP), modelin verinin karmaşıklığına uyum sağlayamadığını ve tıbbi uygulamalarda güvenilirliğinin sınırlı olduğunu ortaya koymaktadır.



Şekil 18: **LR Modeli** Karışıklık Matrisi

Toplu öğrenme tekniklerine dayalı modeller olan **RO** ve **GAM**, doğruluk ve sınıflar arası denge açısından en başarılı sonuçları vermiştir. Bu modeller, verideki karmaşık desenleri fazla hata üretmeden öğrenme yeteneği sayesinde öne çıkmaktadır. Buna karşılık, **LR** gibi geleneksel yöntemler çok boyutlu ve karmaşık veri setlerinde yetersiz kalmış, sağlık sonuçlarının öngörülmesinde sınırlı etki göstermiştir.

Hastalıkların erken tahmini, sağlık hizmetlerinin kalitesini önemli ölçüde artırmakta ve ciddi sağlık komplikasyonlarının önüne geçilmesini sağlamaktadır. Bu proaktif yaklaşım, özellikle yeni hastalık varyantlarının ortaya çıkması ve sağlık verilerinin giderek daha erişilebilir hâle gelmesiyle birlikte, büyük önem taşımaktadır. Bu bağlamda, sağlık durumlarını sınıflandırmak için çeşitli MÖ modelleri kullanılmış ve modellerin doğruluk oranları arasında farklılıklar gözlemlenmiştir. Elde edilen sonuçlar, modele özellik sağlayan semptom ve hasta bilgileri arasında anlamlı ilişkiler olduğunu; doğru model seçimi ile yüksek başarı sağlanabileceğini göstermiştir. İleride, model parametre ayarları (örneğin DVM kernel seçimi, KEYK için optimum k değeri belirlenmesi) veya denenmemiş diğer MÖ metotları ve derin öğrenme tabanlı daha gelişmiş yöntemlerle performansın artırılması denenebilir. Ancak mevcut çalışma, sağlık verisi sınıflandırmasında RO tipi topluluk yöntemlerinin özellikle etkili olduğunu ortaya koymuştur.

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Chenopodium foliosum'UN BİYOLOJİK DEĞERLENDİRMESİ: ANTİOKSİDAN VE ANTİKANSER AKTİVİTELERİNE ODAKLANMA

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ÖZET

Tıbbi bitkiler, uzun süredir geleneksel tıp sistemlerinin temel bileşenleri arasında yer almakta olup, günümüzde de doğal ve düşük toksisiteli terapötik ajanların geliştirilmesinde umut verici kaynaklar olarak bilimsel ilgi görmeye devam etmektedir. Bu bitkilerde tanımlanan terpenoidler, fenolik asitler, flavonoidler, kumarinler ve alkaloidler gibi ikincil metabolitlerin antioksidan ve antikanser özelliklere sahip olduğu yaygın biçimde rapor edilmiş; bu özellikler farmakolojik araştırmalarda artan bir ilgiyle karşılanmıştır. Ayrıca, bu biyoaktif bileşiklerin farmakolojik aktivite gösterdiği ve özellikle kanser tedavisinde tedaviye bağlı toksisiteyi azaltma potansiyeli taşıdığı bildirilmiştir.

Bu çalışmada, Türkiye florasında doğal olarak bulunan ve geleneksel tıpta kullanılan *Chenopodium foliosum* (Moench) Asch. türünün toprak üstü kısımlarından elde edilen metanolik ekstraktın fenolik ve flavonoid içerikleri ile antioksidan ve antikanser potansiyeli değerlendirilmiştir. Toplam fenolik ve flavonoid içerikleri sırasıyla 50.33±0.28 mg GAE/g ve 14.52±0.55 mg QE/g olarak saptanmıştır. Antioksidan aktivite, FRAP yöntemiyle 45.21±0.20 µg TE/g olarak belirlenmiş; DPPH serbest radikal süpürme analizinde ise IC_{50} değeri 147.96±1.57 µg/mL olarak bulunmuştur.

Antikanser etkinlik; A549, Calu1 ve H1650 insan akciğer kanseri hücre hatları ile Beas2B normal bronşiyal epitel hücre hattında değerlendirilmiştir. GI_{50} değerlerinin <10 µg/mL olması, ekstraktın belirgin antiproliferatif aktivite gösterdiğini ortaya koymuştur. TGI değerleri sırasıyla A549'da 122.07 µg/mL, Calu1'de 40.71 µg/mL ve H1650'de 19.37 µg/mL olarak belirlenmiştir. Calu1 ve H1650 hücreleri, 5-fluorourasil uygulanan hücrelere kıyasla ekstrakta karşı daha yüksek duyarlılık göstermiştir. LC_{50} değerlerinin >500 µg/mL olması, ekstraktın genel sitotoksik etkisinin düşük olduğunu göstermektedir. Beas2B hücrelerinde ekstraktın TGI değeri 292.60 µg/mL iken, bu değer 5-FU için 112.19 µg/mL olarak saptanmıştır. Tümör Seçicilik İndeksi (TSI) >2 olan değerler, tümör hücrelerine karşı seçici sitotoksisiteyi desteklemektedir. A549 hücre hattı dışında, ekstrakt 5-FU'ya kıyasla daha yüksek membran toksisitesi (%10.9–29.6) indüklemiştir.

Elde edilen bulgular, *Chenopodium* cinsine ait diğer türlerde bildirilen farmakolojik aktivitelerle uyumlu olup, *C. foliosum*'un seçici antikanser aktivite ve düşük hedef dışı toksisiteye sahip fenolik ve flavonoid bileşikler bakımından potansiyel bir kaynak olduğunu göstermektedir. Bu çalışma, söz konusu türün doğal kaynaklı yeni antikanser ajanların geliştirilmesine yönelik umut verici bir endemik fitokimyasal rezervuar niteliği taşıdığını ortaya koymaktadır.

Anahtar Kelimeler: Antikanser aktivite, Antioksidan aktivite, *Chenopodium foliosum*, Tümör seçicilik indeksi (TSI).

BIOLOGICAL EVALUATION OF *Chenopodium foliosum*: FOCUSING ON ANTIOXIDANT AND ANTICANCER ACTIVITIES

ABSTRACT

Medicinal plants have long been recognized as essential components of traditional medical systems and continue to receive scientific attention as promising sources of natural, low-toxicity therapeutic agents. Secondary metabolites identified in these plants such as terpenoids, phenolic acids, flavonoids, coumarins, and alkaloids are widely reported to possess antioxidant and anticancer properties, attracting growing interest in pharmacological research. These bioactive constituents have been reported to exhibit pharmacological activity and reduced treatment-associated toxicity, particularly in cancer therapy.

In this study, the phenolic and flavonoid contents, along with the antioxidant and anticancer potential, of the methanolic extract obtained from the aerial parts of *Chenopodium foliosum* (Moench) Asch. a species naturally found in Turkish flora and used in traditional medicine were investigated. The total phenolic and flavonoid contents were 50.33 ± 0.28 mg GAE/g and 14.52 ± 0.55 mg QE/g, respectively. Antioxidant activity was determined via the FRAP assay (45.21 ± 0.20 µg TE/g), while the DPPH assay yielded an IC_{50} of 147.96 ± 1.57 µg/mL. Anticancer activity was determined in A549, Calu1, and H1650 human lung cancer cell lines and the Beas2B normal bronchial epithelial line. GI_{50} values <10 µg/mL indicated strong antiproliferative activity. TGI values were 122.07 µg/mL for A549, 40.71 µg/mL for Calu1, and 19.37 µg/mL for H1650. Calu1 and H1650 showed greater sensitivity than cells treated with 5-fluorouracil. LC_{50} values >500 µg/mL suggested low cytotoxicity. In Beas2B cells, the extract's TGI was 292.60 µg/mL versus 112.19 µg/mL for 5-FU. A TSI >2 confirmed selective cytotoxicity. Except in A549, the extract induced higher membrane toxicity than 5-FU.

These findings are consistent with previously reported pharmacological activities of other species within the Chenopodium genus, supporting that *C. foliosum* represents a potential source of phenolic and flavonoid compounds with selective anticancer activity and low off-target cytotoxicity. This study highlights its potential as a promising endemic phytochemical reservoir for the development of novel natural anticancer agents.

Keywords: Anticancer potential, Antioxidant activity, *Chenopodium foliosum*, Tumor selectivity index (TS

ÇUKURALAN BÖLGESİ ALTIN CEVHERİNİN LİÇ YÖNTEMİYLE ZENGİNLEŞTİRME ŞARTLARININ ARAŞTIRILMASI

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ÖZET
Altın cevherlerinin siyanür liçi ile zenginleştirilmesi dünyada altın kazanımı için en yaygın yöntem olarak kabul edilmektedir. Çukuralan altın cevherinin siyanür liçinde etkin koşulların değerlendirilmesine dayanan bu çalışmada, farklı liç parametrelerinin incelenmesinin ardından optimum zenginleştirme koşulları belirlenmiştir. Bu çalışmada çok sayıda kırılmış Çukuralan cevher numunesi farklı tane boyutlarına öğütülmüş ve sonuç olarak testler, cevherin en optimum öğütme boyutu olan %80'inin -88 µm'ye öğütülmesi gerektiğini ortaya koymuştur. Tüm liç parametreleri, belirlenen bu öğütme boyutuna göre sırayla uygulanmış, tüm liç verimleri değerlendirilmiş ve doğru liç parametreleri belirlenmiştir.
Anahtar Kelimeler: Altın, liç, tane boyutu, siyanür

INVESTIGATION OF ENRICHMENT CONDITIONS OF ÇUKURALAN REGION GOLD ORE BY LEACHING METHOD

ABSTRACT
Cyanide leaching of gold ores have been accepted as the most common method for the recovery of gold in the world. In this study, which based on the evaluation of effective conditions on cyanide leach of Çukuralan gold ore, the optimal enrichment conditions were identified after investigation of the different leach parameters. In this study multiple crushed Çukuralan ore samples are grinded to different particle size and as a conclusion, the tests revealed that the ore should be grinded to p80=-88 µm which was most optimum grinding size. All leach parameters applied in an order to this determined grinding size, all leach efficiencies are evaluated and correct leach parameters have been identified.
Keywords: gold, leach, particle size, cyanide.

Giriş:
Altın metalurjinin gelişiminde çok önemli bir yere sahiptir [1]. Altın, diğer metaller arasında en yüksek sünekliliğe ve şekillendirilebilirliğe sahiptir [3]. Korozyona karşı yüksek direnç ve stabilite gösterir [4]. Selenik asit (H_2SeO_4) istisna olmak üzere basit mineral asitlerinde çözünme göstermezler. Oksijen varlığında alkali metal siyanür çözeltilerinde veya *Diehl prosesini* oluşturan siyanojen bromür, nitrobenzen sülfonik asit çözeltilerinde altın çözünebilmektedir [7]. Altın kaynakları, birincil ve ikincil kaynaklar olmak üzere iki temel başlıkta toplanabilmketedir. Birincil kaynaklar, serbest altın içeren cevherler, plaser tip cevherler, oksitli cevherler, sülfürlü cevherler, altın tellür cevherleri, karbon kökenli cevherler şeklinde sınıflandırılırken, ikincil kaynaklar, gravite konsantreleri, flotasyon konsantreleri, atıklar, rafineri malzemeleri ve geri dönüşüm şeklinde sınıflandırılabilmektedir [24]. Altının üretiminde başlıca faktörler mineralojik, metalürjik, çevresel, coğrafi, ekonomik ve siyasi olarak sıralanabilir. Bu üretim ve zenginleştirme teknikeri amalgamasyon, flotasyon, gravite,

liç işlemleridir. Altın cevheri kazanımında liç yöntemi kimyasal bir kazanım prosesi olup hidrometalurjik yöntemler başlığı altında değerlendirilir. Kimyasal zenginleştirme yöntemlerinde genellikle kimyasal çözünürlük farkından yararlanılmaktadır. Kıymetli metalce zengin içerikli cevherlerin hızla tükenmesi dolayısıyla taleplerin karşılanması bakımından düşük tenörlü ve ince dağılıma sahip cevherlerin değerlendirilerek kullanıma sunulması büyük önem kazanmıştır. Pirometalürjik ve fiziksel yöntemlerin dezavantajları ve ekonomik olumsuzlukları kimyasal zenginleştirme yöntemlerine karşı olan ilginin gün geçtikçe artmasına yol açmıştır. Önemli bir kimyasal kazanım yöntemi olan liç metodunda; alüminyum, uranyum, titanyum, sodyum, potasyum, altın, nikel, gümüş ve kobalt gibi metallerin seçici bir şekilde elde edilmesi mümkündür [3]. Kompozisyon olarak çok fakir olan cevherlerde yığın, fakir ve zengin cevherlerde ise karıştırmalı tank liçi yöntemi izlenir. Altının zenginleştirilmesinde en sık kullanılan çözdürücüler ise; siyanür liçi, thiourea liçi, thiosülfat liçi, bromin liçi, klorin liçi, iodin liçidir [28].

Siyanür kullanımının bu seviyede gelenekselleşmesi, siyanür liçi yönteminin sağladığı temel avantajlara dayanmaktadır. Bu avantajlardan başlıcaları aşağıdaki gibidir [10];

- Siyanür liçi prosesinin kimyasal mekanizmasının iyi bilinmesi
- Çok ince taneli ve fakir cevherlerin yüksek verimlerde işlenebilmesi
- Yöntemin pratik ve ekonomik oluşu
- Geniş çapta endüstriyel ölçekte kullanım kapasitesi
- Aktif karbon üzerinde etkili adsorpsiyon performansı

Siyanür liçi yöntemi üzerinde çözünmeye etkili olan pH değeri, sıcaklık, tane boyutu, siyanür ve oksijen konsantrasyonu, yüzey alanı, karıştırma hızı ve diğer metaller gibi birçok faktör incelenmiştir.

Deneysel Çalışmalar:

Malzeme ve Metot:

Bu çalışmada, Koza Altın İşletmelerine ait İzmir İli'nin kuzeyinde Ayvalık ve Dikili ilçeleri arasında kalan Çukuralan İşletmesine ait cevher kullanılmıştır. Çukuralan Altın Madeni'nde cevherleşme iki ana damardan oluşmakta olup, düşük sülfidasyon epitermal bir yapıya sahiptir. Cevherin besleme analizlerinde Altın ve Gümüş analizleri Perkin Elmer AAS, diğer metal analizleri The Agilent MS-ICP ile gerçekleştirilmiştir. Elementel anlamda besleme içeriği incelendiğinde, 3.70 g/t Au, 1.65 g/t Ag içeriğine sahip olduğu görülürken diğer metaller açısından %2.2 oranında demir içeriği dışında yüksek bir içerik görülmemiştir. Çukuralan cevherine ait besleme analiz sonuçları Tablo 1'de verilmektedir.

Tablo 1. Testlerde kullanılan cevherlerin elementel içeriği.

	Katıda										
	Au*	Ag*	Cu	Ni	Zn	Pb	As	Sb	Fe	S	C
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	%
	AAS	AAS	ICP-OES	ICP-OES	ICP-OES	ICP-OES	ICP-OES	ICP-OES	AAS	LECO	LECO
	0,1	0,2	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,01	0,01
BESLEME 1	3,59	1,67	38,89	23,59	87,47	78,35	29,85	8,62	23244	0,54	1,32
BESLEME 2	5,32	1,95	32,24	21,20	80,41	80,36	31,84	8,49	21852	0,55	1,32
BESLEME 3	3,80	1,71	29,58	21,01	78,50	77,53	29,03	9,27	21656	0,50	1,33
BESLEME 4	3,12	1,56	28,53	22,01	78,01	71,00	25,16	9,91	21451	0,54	1,29
BESLEME 5	3,19	1,50	31,32	22,82	78,63	78,27	30,94	5,31	22371	0,49	1,31
BESLEME 6	3,85	1,74	30,35	22,02	81,46	74,15	32,82	10,42	22116	0,53	1,32
BESLEME 7	3,59	1,57	30,63	21,7	80,09	73,76	35,11	6,07	22235	0,52	1,32
BESLEME 8	3,14	1,52	30,47	22,16	80,69	78,66	31,77	8,95	22822	0,52	1,31
Ortalama	3,70	1,65	31,50	22,06	80,66	76,51	30,82	8,38	22218,38	0,52	1,32

Kullanılan cevherin ayrıca XRF analizi de yapılmış ve Tablo 2'de verilmiştir. XRF analizine göre kütlece cevherin %62,79'unu SiO_2 kaplamaktadır. Alumina (Al_2O_3) ve hematit (Fe_2O_3) quarttdan sonra gelen baskın yapılardır.

Tablo 2. Testlerde kullanılan cevherlerin XRF ile mineral içerik analizi.

XRF WR-01	XRF WR-01	XRF WR-01	XRF WR-01	XRF WR-01	XRF WR-01	XRF WR-01	XRF WR-01	XRF WR-01	XRF WR-01	XRF WR-01	XRF WR-01	XRF WR-01	XRF WR-01
*Al2O3	*BaO	*CaO	*Cr2O3	*Fe2O3	*K2O	*MgO	*MnO	*Na2O	*P2O5	*SO3	*SiO2	SrO	*TiO2
%	%	%	%	%	%	%	%	%	%	%	%	%	%
0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
12.80	0.05	8.22	<0.01	4.99	2.26	1.41	0.10	0.68	0.25	1.37	62.79	0.04	0.45

Kullanılan malzemeler Memmert UFE-800 marka etüve yüklenerek 50 °C'de kurutulmuştur. Metalürjik testlerin gerçekleştirileceği tane boyutlarını elde etmek amacıyla ilk aşamada TM Engineering marka çeneli kırıcıdan 2-3 mm boyutuna kırılmış ve ardından malzemenin öğütülmesi için, 305 mm çaplı 360 mm uzunluğunda Essa marka çubuklu değirmen kuru öğütme şartlarında kullanılmıştır. Boyutlandırma çalışmaları ardından numuneler testlerin gerçekleştirileceği 300 g'lık posiyonlara bölünerek paketlenmiştir. Kullanılan ekipmanlara ait görseller Şekil 1'de verilmiştir;



Kırılmış (2-3mm) Numune Örnekleri Öğütülen Örnekler

Şekil 1. Testlerde kullanılan kırılmış ve öğütülmüş cevherler.

Liç testlerinin gerçekleştirildiği ekipmana ait görsel Şekil 2'de verilmiştir.

Şekil 2. Karıştırmalı liç test ekipmanı.

Sonuçlar

Karıştırmalı Siyanür Liç Testleri

- *Tane Boyutunun Optimizasayonu ve Optimum Koşul Eldesi*
  Liç testleri için P80 53µm, 75µm, 90µm ve 125µm olan üç farklı tane boyu belirlenmiştir. Liç süresi 48 saat ve 400ppm siyanür konsantrasyonunda 4 farklı karıştırmalı liç yapılmıştır. Tablo 3'te farklı tane boyutlarındaki test sonuçları verilmiştir.

Tablo 3. Farklı tane boyutlarında Au liç verimleri.

	2-53	2-75	2-90	2-125
Au Verim % 2saat	62,62"	61,44	62,65	64,66
Au Verim % 4saat	66,13	66,13	66,20	71,91
Au Verim % 8saat	72,21	72,21	71,94	76,75
Au Verim % 24saat	84,40	84,40	79,74	85,31
Au Verim % 32saat	86,55	86,55	84,08	88,22
Au Verim % Toplam	97,04	96,30	95,99	95,08
Hesaplanan Tenör, gAu/mt	3,78	3,78	3,74	3,25
Analiz edilen Tenör, gAu/mt	3,70	3,70	3,70	3,70
Ag Verim % Toplam	71,46	71,78	70,99	66,30
Hesaplanan Tenör, gAg/mt	2,21	2,20	2,21	1,90
Analiz edilen Tenör, gAg/mt	1,65	1,65	1,65	1,65
Beslemedeki Toplam %S	0,52	0,52	0,52	0,52
NaCN Tüketimi, kg/mt	0,22	0,31	0,30	0,28

Farklı P_{80} tane boyutlarında yapılan test sonuçları incelendiğinde en yüksek kazanım Au verimliliği 48. Saatte elde edilmiş olup %97,04 ile %95,08 arasında değişmektedir. Ag kazanım verimliliği ise %71,78 ile %66,30 arasında değişmek olduğu görülmüştür. Test sonuçlarına bakıldığında tane boyunun küçülmesi ile altın verimliliğinin orantılı olarak arttığı görülmüştür. Optimal bir tane boyut seçimi için öğütme maliyetleri, altın ve gümüş kazanımları ve reaktif tüketimleri açısından incelendiğinde P_{80} = 88 µm tane boyutunun optimal tane boyutu olarak kabul edilmiştir.

- *Siyanür Derişim Optimizasayonu ve Optimum Koşul Eldesi*
  Farklı siyanür konsantrasyonlarında cevherlerin karıştırmalı liç testlerindeki verimliliğini incelemek amacıyla bi takım test planı yapılmıştır. Bu test planına göre ilk aşamada optimum koşul olarak tayin edilen P80 = 88 µm tane boyutunu sabit tutarak 50, 100, 200, 300, 400, 500, 600, 700ppm NaCN konsantrasyonlarında ayrı ayrı testler gerçekleştirilmiştir. Farklı siyanür konsantrasyonlarında elde edilen test sonuçları Tablo 4'te verilmiştir.

Tablo 4. Farklı siyanür derişimlerinde Au liç verimleri.

	50 ppm NaCN	100 ppm NaCN	200 ppm NaCN	300 ppm NaCN
Au Verim % 2saat	60,62	58,38	60,84	61,19
Au Verim % 4saat	63,00	61,87	62,97	63,26
Au Verim % 8saat	69,65	66,42	69,04	69,18
Au Verim % 24saat	77,76	78,64	78,01	78,25
Au Verim % 32saat	82,20	81,88	82,87	82,99
Au Verim % Toplam	91,46	93,24	95,19	95,30
Hesaplanan Tenör, gAu/mt	3,51	4,14	3,33	3,40
Analiz edilen Tenör, gAu/mt	3,25	3,25	3,25	3,25

Ag Verim % Toplam	52,41	60,20	70,70	70,76
Hesaplanan Tenör, gAg/mt	1,70	1,78	1,78	1,85
Analiz edilen Tenör, gAg/mt	1,61	1,61	1,67	1,67
Beslemedeki Toplam %S	0,51	0,51	0,54	0,54
NaCN Tüketimi, kg/mt	0,12	0,31	0,35	0,54
	400 ppm NaCN	500 ppm NaCN	600 ppm NaCN	700 ppm NaCN
Au Verim % 2saat	61,40	61,63	62,44	62,81
Au Verim % 4saat	63,84	64,24	65,02	65,34
Au Verim % 8saat	69,49	69,91	69,92	70,16
Au Verim % 24saat	78,32	78,67	79,25	79,63
Au Verim % 32saat	83,11	83,46	83,66	83,97
Au Verim % Toplam	95,53	94,91	94,98	95,08
Hesaplanan Tenör, gAu/mt	3,36	3,14	3,19	3,25
Analiz edilen Tenör, gAu/mt	3,25	3,25	3,25	3,25
Ag Verim % Toplam	70,81	67,07	67,19	67,30
Hesaplanan Tenör, gAg/mt	1,68	1,64	1,58	1,74
Analiz edilen Tenör, gAg/mt	1,67	1,67	1,67	1,67
Beslemedeki Toplam %S	0,54	0,54	0,54	0,54
NaCN Tüketimi, kg/mt	0,62	0,85	0,83	0,89

Farklı sodyum siyanür derişimlerinde yapılan test sonuçları incelendiğinde en yüksek kazanım Au verimliliği 200 ppm ve üstü derişimlerde elde edilmiş olup %95 üzerinde bir kazanım hesaplanmıştır. Ag kazanım verimliliği ise 200ppm ve üzeri konsantrasyonlarda %70 üzerinde bir kazanım olduğu hesaplanmıştır. Test sonuçlarına bakıldığında siyanür konsantrasyonunun artması ile altın verimliliğinin orantılı olarak arttığı görülmüştür. Optimal bir NaCN konsantrasyon seçimi için incelendiğinde 200 – 300 ppm arası optimal derişim olarak kabul edilmiştir.

- *Farklı Katı Oranlarının Liç Verimliliğine Etkisinin İncelenmesi ve Optimum Koşul Eldesi*

Farklı katı oranlarıyla cevherlerin karıştırmalı liç testlerindeki verimlilik üzerindeki etkisini incelemek amacıyla bi takım test planı yapılmıştır. Bu test planına göre ilk aşamada optimum koşul olarak tayin edilen P_{80} = 88 µm tane boyutunu, 300ppm NaCN reaktif derişimi sabit tutarak %35, %40, %45 katı oranlarında ayrı ayrı testler gerçekleştirilmiştir. Tablo 5'te farklı katı oranlarındaki test sonuçları verilmiştir.

Tablo 5. Farklı katı oranlarında Au liç verimleri.

	%35 Katı	%40 Katı	%45 Katı
Au Verim % 2saat	61,59	61,61	61,19
Au Verim % 4saat	63,72	63,53	63,26
Au Verim % 8saat	69,86	69,40	69,18
Au Verim % 24saat	78,48	78,15	78,25
Au Verim % 32saat	83,35	83,15	82,99
Au Verim % Toplam	95,52	95,50	95,30
Hesaplanan Tenör, gAu/mt	4,24	3,78	3,40
Analiz edilen Tenör, gAu/mt	3,25	3,25	3,25

Ag Verim % Toplam	70,91	70,88	70,76
Hesaplanan Tenör, gAg/mt	1,96	1,92	1,85
Analiz edilen Tenör, gAg/mt	1,67	1,67	1,67
Beslemedeki Toplam %S	0,54	0,54	0,54
NaCN Tüketimi, kg/mt	1,09	0,70	0,54

Yapılan testler incelendiğinde farklı katı oranlarının liç verimliliği üzerinde bariz bir etkisi olmadığı görülürken, altın kazanım verimliliği ortalama %95.44 oranlarında, gümüş kazanım verimliliği ise ortalama %70.85 oranlarında olduğu hesaplanmıştır. Altın-gümüş kazanım prosesinde aktif karbon ile adsorpsiyon yapılan işletmelerde, tank içerisinde aktif karbonun yüzme yada batma eğilimi olmadan nispeten homojen dağılması amacıyla proses katı oranı %43-45 arasında tutulmaktadır. Bu nedenle optimal katı oranı olarak testlerde %45 katı oranı kabul edilmiştir.

- *Farklı Ph Değerlerinin Liç Verimliliğine Etkisinin İncelenmesi ve Optimum Koşul Eldesi*

  Farklı pH seviyelerinde cevherlerin karıştırmalı liç testlerindeki verimlilik üzerindeki etkisini incelemek amacıyla bi takım test planı yapılmıştır. Bu test planına göre ilk aşamada optimum koşul olarak tayin edilen P_{80} = 88 µm tane boyutunu, 300ppm NaCN reaktif derişimi ve %45 katı oranı sabit tutarak 9.5, 10, 10.5, 11 pH seviyelerinde ayrı ayrı testler gerçekleştirilmiştir. Farklı pH değerlerindeki test sonuçları Tablo 6'da verilmiştir.

	Ph = 9,5	Ph = 10	Ph = 10,5	Ph = 11
Au Verim % 2saat	61,08	61,13	60,58	61,19
Au Verim % 4saat	62,91	63,21	63,25	63,26
Au Verim % 8saat	69,15	70,01	69,16	68,88
Au Verim % 24saat	78,12	79,21	78,19	77,86
Au Verim % 32saat	82,95	83,01	82,94	83,20
Au Verim % Toplam	95,01	95,84	94,96	95,30
Hesaplanan Tenör, gAu/mt	3,46	3,37	3,43	3,40
Analiz edilen Tenör, gAu/mt	3,25	3,25	3,25	3,25
Ag Verim % Toplam	70,71	70,75	71,25	71,04
Hesaplanan Tenör, gAg/mt	1,80	1,83	1,86	1,85
Analiz edilen Tenör, gAg/mt	1,67	1,67	1,67	1,67
Beslemedeki Toplam %S	0,54	0,54	0,54	0,54
NaCN Tüketimi, kg/mt	0,48	0,51	0,52	0,54

Tablo 6. Farklı pH değerlerinde elde edilen Au liç verimleri.

Farklı pH seviyelerine göre yapılan test sonuçları incelendiğinde pH seviyelerinin altın ve gümüş kazanım verimliliği üzerinde bir etkisi olmadığı görülürken, altın kazanım verimliliği ortalama %95.28 oranlarında, gümüş kazanım verimliliği ise ortalama %70.94 oranlarında olduğu hesaplanmıştır. Sistemde NaCN kullanımı olduğundan dolayı HCN gaz cıkışı olmaması amacıyla prosesin 10.5 - 11 seviyelerinde olması gerekmektedir.

TARTIŞMA

Koza Altın İşletmeleri, Çukuralan İşletmesine ait cevher ile yapılan testler sonucunda elde edilen sonuçlar aşağıdaki gibidir;

Farklı P80 tane boyutlarında yapılan test sonuçları incelendiğinde Au kazanım verimliliği 48 saatlik liç süresinde %97.04 ile %95.08 arasında değişmekte olduğu örülmüştür. Tesiste üretim yapılan normal tane boyutu olarak P80 = 88 mikrondan daha fazla öğütme yaparak P80=56

mikrona ait test altın kazanım oranında % 1.05'lük bir artış olduğu tespit edilmiştir. Ag kazanım verimliliği ise yapılan testlerde %71.78 ile %66.30 arasında değişmek olduğu görülmüştür. Test sonuçlarına bakıldığında tane boyunun küçülmesi ile altın verimliliğinin orantılı olarak arttığı görülmüştür. Optimal bir tane boyut seçimi için öğütme maliyetleri, altın ve gümüş kazanımları ve reaktif tüketimleri açısından incelendiğinde P80 = 88 µm tane boyutunun optimal tane boyutu olarak kabul edilmiştir.

Farklı sodyum siyanür derişimlerinde yapılan test sonuçları incelendiğinde 50 ve 100ppm siyanür konsantrelerinin yetersiz olduğu, en yüksek kazanım Au verimliliği 200 ppm ve üstü derişimlerde elde edilmiş olup %95 üzerinde bir kazanım hesaplanmıştır. Test sonuçlarına bakıldığında siyanür konsantrasyonunun artması ile altın verimliliğinin orantılı olarak arttığı görülmüştür. 200ppm siyanür konsantrasyonu ile yapılan testlerde ton başına siyanür tüketim değeri 0.35 gr/t iken bu değer konsantrasyon artışıyla diğer metal çözünme oranlarınıda arttıracağı için optimal bir NaCN konsantrasyon seçimi için incelendiğinde 200 – 300 ppm arası optimal derişim olarak kabul edilmiştir.

Yapılan testler incelendiğinde farklı pülp katı oranlarının liç verimliliği üzerinde bariz bir etkisi olmadığı görülürken, altın kazanım verimliliği ortalama %95.44 oranlarında olduğu hesaplanmıştır. Altın-gümüş kazanım prosesinde aktif karbon ile adsorpsiyon yapılan işletmelerde, tank içerisinde aktif karbonun yüzme yada batma eğilimi olmadan nispeten homojen dağılması amacıyla proses katı oranı % 43-45 arasında tutulmaktadır. Bu nedenle optimal katı oranı olarak testlerde %45 katı oranı kabul edilmiştir.

Farklı pH seviyelerine göre yapılan test sonuçları incelendiğinde pH seviyelerinin altın ve gümüş kazanım verimliliği üzerinde bir etkisi olmadığı görülürken, altın kazanım verimliliği ortalama %95.28 oranlarında olduğu hesaplanmıştır. Sistemde NaCN kullanımı olduğundan dolayı HCN gaz cıkışı olmaması amacıyla prosesin 10.5 - 11 seviyelerinde olması gerekmektedir.

İş indeksi değeri olan 16.23 kWs/t ve 90 ton/saat besleme kuru tonajı verileri ile yapılan hesaplama sonucunda, çalışmaların yapıldığı dönemdeki çalışma koşullarında, nihai öğütme inceliğini 88 µm'dan 56 µm'a düşürmek için fazladan 394.83 kWsaat enerji gerekliliği, buda güncel enerji maliyetleriyle saatte fazladan 1575 tl/saat, ayrıca kullanılacak fazladan öğütücü media giderleri olarak 3009 tl/saat, NaCN giderlerinide göz önünde bulundurunca 660tl/saat, diğer artan kimyasal maliyetleri ile toplam giderler 7836 tl/saat olarak hesaplanmıştır.

Test sonuçlarına göre P80 = 56 µm boyutunda sağlanacak %1.05'lük artış fazladan 1.8 gr/saat altın kazanımı ortaya koymaktadır. Bu da güncel fiyatlar ile hesaplandığında saatte 7509 tl fazladan kazanç sağlayacakken, artacak giderler ile değerlendirildiğinde ekonomik gözükmemektedir.

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SİLİSYUM OKSİT KATKILI ULTRA EVER DRY® KAPLAMALARIN PASLANMAZ ÇELİK YÜZEYLERDE ISLANABİLİRLİK PERFORMANSINA ETKİSİNİN DENEYSEL İNCELENMESİ

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ÖZET

Hidrofobik ve süperhidrofobik yüzey kaplamaları, su itici, kir tutmaz ve kendini temizleyebilir özellikleri sayesinde enerji, otomotiv, inşaat, biyomedikal ve tekstil gibi birçok sektörde yaygın şekilde kullanılmaktadır. Bu çalışma, Ultra Ever Dry® adlı iki bileşenli ticari bir kaplama solüsyonuna silisyum oksit (SiO_2) nanopartikül katkısı eklenerek, paslanmaz çelik yüzeylerin ıslanabilirlik performansı üzerindeki etkisini deneysel olarak araştırmaktadır. Kaplama sisteminde modifikasyon yalnızca alt katman (bottom coat) bileşenine uygulanmış; üst katman (top coat) katkısız orijinal haliyle bırakılmıştır. Katkı oranları ağırlıkça %0.25 (UEDSO25), %0.50 (UEDSO50) ve %0.75 (UEDSO75) olarak belirlenmiş, katkı çözeltileri paslanmaz çelik levhalara hava destekli sprey yöntemiyle tatbik edilmiştir.

Kaplama sonrası yüzeylerin temas açıları, Hacettepe Üniversitesi HÜNİTEK laboratuvarlarında bulunan yüksek çözünürlüklü gonyometre cihazı ile, standart sessile drop yöntemi kullanılarak ölçülmüştür. Her numune için üç tekrar alınarak ortalama değerler üzerinden değerlendirme yapılmıştır.

Elde edilen bulgulara göre, katkı maddesi uygulanmamış baz malzeme olan paslanmaz çelik yüzey, 123.7° temas açısıyla hidrofobik karakter göstermiştir. Buna karşılık, katkısız Ultra Ever Dry® kaplamasının uygulandığı UED00 numunesinde temas açısı 171.4° olarak ölçülmüş ve bu değer yüzeyin süperhidrofobik özellik kazandığını ortaya koymuştur. %0.25 ve %0.75 oranlarında silisyum oksit katkısı içeren UEDSO25 ve UEDSO75 numuneleri ise sırasıyla 167.4° ve 163.6° temas açılarıyla süperhidrofobik sınıfta yer almalarına rağmen, katkısız kaplamaya kıyasla performanslarında belirgin düşüşler gözlemlenmiştir. Bu durum, katkı oranının yüzey morfolojisi ve kaplama bütünlüğü üzerinde etkili olduğunu; özellikle çok düşük veya çok yüksek katkı oranlarının, yüzeyde ideal pürüzlülük düzeyini bozarak hidrofobik performansı sınırlayabileceğini göstermektedir. En yüksek performans UEDSO50 numunesinden elde edilerek 171.1° temas açısı ile süperhidrofobik sınırın korunduğu tespit edilmiştir.

Sonuç olarak, silisyum oksit katkısının belirli bir eşik değerde uygulandığında kaplama performansını maksimuma çıkardığı görülmüştür. UEDSO50 süperhidrofobik numunesinde hem yüzey homojenliği hem de temas açısı açısından ideal değer olarak öne çıkmaktadır. Elde edilen veriler, SiO_2 katkılı kaplamaların süperhidrofobik yüzey tasarımında yüksek potansiyele sahip olduğunu ve özellikle endüstriyel yüzey uygulamalarında etkin şekilde kullanılabileceğini göstermektedir.

Anahtar Kelimeler: Süperhidrofobik, Temas açısı, Ultra Ever Dry®, SiO_2

EXPERIMENTAL INVESTIGATION OF THE EFFECT OF SILICIUM OXIDE ADDED ULTRA EVER DRY® COATINGS ON THE WETTABILITY PERFORMANCE OF STAINLESS-STEEL SURFACES

ABSTRACT

Hydrophobic and superhydrophobic surface coatings are widely used in many industries such as energy, automotive, construction, biomedical and textile due to their water repellent, dirt repellent and self-cleaning properties. This study experimentally investigates the effect of silicon oxide (SiO_2) nanoparticle doping to a two-component commercial coating solution called Ultra Ever Dry® on the wettability performance of stainless-steel surfaces. In the coating system, the modification was applied only to the bottom coat component, while the topcoat was left in its original state without additives. The additive rates were 0.25 wt% (UEDSO25), 0.50 wt% (UEDSO50) and 0.75 wt% (UEDSO75) and the additive solutions were applied to the stainless-steel sheets by air-assisted spray method.

The contact angles of the surfaces after coating were measured using the standard sessile drop method with a high-resolution goniometer in Hacettepe University HÜNİTEK laboratories. Three repetitions were taken for each sample and evaluated on average values.

According to the findings, the stainless-steel surface, which is the base material without additives, showed a hydrophobic character with a contact angle of 123.7°. On the other hand, the contact angle of the UED00 sample, to which Ultra Ever Dry® coating without additives was applied, was 171.4°, indicating that the surface became superhydrophobic. UEDSO25 and UEDSO75 samples with 0.25% and 0.75% silicon oxide additives were classified as superhydrophobic with contact angles of 167.4° and 163.6°, respectively, but their performance decreased significantly compared to the coating without additives. This indicates that the additive ratio has an impact on the surface morphology and coating integrity; especially very low or very high additive ratios can limit the hydrophobic performance by disrupting the ideal roughness level on the surface. The highest performance was obtained from the UEDSO50 sample, maintaining the superhydrophobic limit with a contact angle of 171.1°.

As a result, it was observed that silicon oxide doping maximizes the coating performance when applied at a certain threshold value. UEDSO50 stands out as the ideal value in terms of both surface homogeneity and contact angle in the superhydrophobic sample. The data obtained show that SiO_2 doped coatings have high potential in superhydrophobic surface design and can be used effectively especially in industrial surface applications.

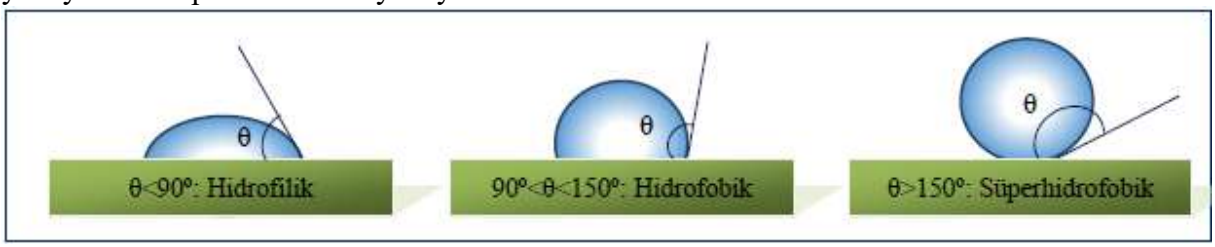
Keywords: Superhydrophobic, Contact angle, Ultra Ever Dry®, SiO2

GİRİŞ

Enerji verimliliği, günümüz mühendislik sistemlerinde yalnızca ekonomik fayda sağlamakla kalmayıp, aynı zamanda çevresel sürdürülebilirlik açısından da stratejik bir gereklilik hâline gelmiştir. Artan enerji talebi, sınırlı doğal kaynaklar ve küresel ölçekteki karbon salınımı baskısı, enerji tüketiminin daha verimli ve daha az kayıpla gerçekleştirilmesini zorunlu kılmaktadır. Bu kapsamda, sistemlerin genel performansını artırmak amacıyla yüzey mühendisliğine dayalı çözümler son yıllarda ön plana çıkmaktadır.

Özellikle sıvıların taşındığı, aktarıldığı ya da yüzeylerle temas hâlinde olduğu sistemlerde, yüzeyin akışkanla etkileşimi enerji kayıplarının önemli bir kaynağını oluşturmaktadır (Gouin ve Box, 1998). Bu bağlamda, hidrofobik ve süperhidrofobik yüzey kaplamaları, yüzey ile sıvı arasındaki sürtünmeyi azaltarak akışkan taşınmasında enerji tüketimini azaltabilmektedir (Mollicone vd., 2022). Ayrıca bu yüzeyler, kendini temizleme, buzlanmayı geciktirme, korozyon direncini artırma ve ısı transferini optimize etme gibi ek avantajlar sunarak çok yönlü verimlilik katkısı sağlamaktadır (Shen vd., 2023).

Hidrofobik ve süperhidrofobik yüzeylerin geliştirilmesine yönelik araştırmalar, doğada gözlemlenen benzersiz ıslanmazlık özelliklerinden ilham alarak başlamıştır (Barthwal vd., 2024). Özellikle nilüfer yaprağının yüzey yapısından esinlenerek geliştirilen bu tür kaplamalar; su itici, kendi kendini temizleyen ve kir tutmayan yüzeyler oluşturarak hem endüstriyel hem de günlük kullanıma yönelik geniş bir uygulama alanına sahiptir (Latthe vd., 2014). Yüzeyin ıslanabilirliği yani hidrofobikliği temas açısı ile belirlenir. Bu bağlamda, Şekil 1'de de gösterildiği gibi, yüzeylerin hidrofobiklikliği yani ıslanabilirliği temas açısı (θ) ölçümleriyle değerlendirilmekte ve temas açısı 90°'nin üzerindeki yüzeyler hidrofobik, 150°'nin üzerindeki yüzeyler ise süperhidrofobik yüzey olarak tanımlanmaktadır.



Şekil 8. Yüzeyin ıslanabilirliği

Son yıllarda, bu tür kaplamaların üretiminde katkı maddelerinin kullanımı yaygınlaşmış, özellikle silika (SiO_2) ve grafen gibi nanomalzemelerin yüzey morfolojisine ve yüzey enerjisine olan etkileri üzerine yoğunlaşılmıştır (Liu vd., 2017).

Bu çalışmada, başlangıçta ticari bir hidrofobik kaplama malzemesi olan Ultra Ever Dry® ürününe farklı oranlarda SiO_2 katkısı eklenerek temas açısındaki değişimler incelenmiştir. Kaplama malzemesinin çift bileşenli yapısı dikkate alınarak katkı maddesi yalnızca astar katmana uygulanmış; elde edilen kompozit kaplamalar paslanmaz çelik yüzeylere sprey yöntemiyle uygulanmıştır. Gonyometrik ölçümler yoluyla yüzeylerin temas açıları belirlenmiş ve katkı oranlarına bağlı olarak hidrofobiklik seviyeleri değerlendirilmiştir. Bu yaklaşım, hem yüzey modifikasyonlarının etkisini ortaya koymak hem de kaplama sistemlerinde katkı optimizasyonunun önemini vurgulamak açısından önem taşımaktadır. Ayrıca çalışma, uygulamalı yüzey mühendisliği alanında deneysel araştırma yürütme becerilerinin geliştirilmesine de katkı sağlamaktadır.

MATERYAL VE METOT

Bu çalışma üç ana başlık altında yapılandırılmıştır.

Kaplama Solüsyonlarının Hazırlanması

Bu çalışmada hidrofobik yüzey elde etmek amacıyla kullanılan kaplama malzemesi, ticari olarak temin edilen Ultra Ever Dry® adlı iki bileşenli bir süperhidrofobik kaplama sistemidir. Ürün, düşük yüzey enerjisine sahip mikro/nano yapılı bir film oluşturarak yüzeydeki sıvı ile katı faz arasındaki etkileşimi minimize etmektedir. Kaplama sistemi, bottom coat (astar katman) ve top coat (üst katman) olmak üzere iki ayrı bileşenden oluşmakta ve yüksek temas açısı (>160°) ve düşük kayma açısı sunan süperhidrofobik karakterde bir yüzey oluşmaktadır.

Ultra Ever Dry®, su, çamur, buz, yağ, boya gibi pek çok sıvı ve yarı akışkan materyale karşı dayanıklı olup, bu tür maddelerin yüzeye tutunmasını engelleyerek kendini temizleme etkisi yaratır. Ürün, geniş bir sıcaklık aralığında (yaklaşık -34°C ila +149°C) etkinliğini koruyabilmekte ve dış ortam koşullarına karşı yüksek dayanım sergilemektedir. Uygulama yöntemi olarak hava destekli sprey püskürtme tekniği önerilmekte olup, yüzey ile malzeme arasında güçlü bir yapışma sağlanması için ön işlem (temizleme, zımparalama) gerekmektedir (Ultra dry ever, 2013).

Bu çalışmada kullanılan Ultra Ever Dry® kaplama, üretici tavsiyesi doğrultusunda uygulanmış; katkı maddesi olarak yalnızca bottom coat bileşenine belirli oranlarda SiO_2 ilave edilmiştir. Top coat bileşeni ise katkı içermeyen orijinal formunda kullanılmıştır.

SiO_2; 7-40 nm arasında değişen boyutlardaki partikül yapısı, kimyasal kararlılığı ve düşük yüzey enerjisi nedeniyle hidrofobik kaplamalarda yaygın olarak tercih edilen etkili bir katkı

malzemesidir (Wu vd., 2022). Ayrıca yüzey pürüzlülüğünü artırarak sıvı temasını azaltmakta ve böylece yüzeyin su tutmama özelliğini geliştirmektedir.

Ultra Ever Dry® solüsyonuna ağırlıkça %0.25, %0.5 ve %0.75 oranlarında SiO_2 nanopartikülleri ilave edilmiştir. Homojen bir dağılım elde edebilmek amacıyla karışımlar, 20 dakika boyunca ultrasonik karıştırıcıda işlem görmüş, ardından 10 dakika boyunca manyetik karıştırıcıda oda sıcaklığında çevrilerek katkının dispersiyonu tamamlanmıştır. Bu kapsamda oluşturulan numuneler Tablo 1'de verilmiştir.

Tablo 7. Numune bilgileri

Numune	Açıklama
Baz Malzeme	Kaplanmamış paslanmaz çelik levha
UED00	Ultra Ever Dry® kaplama uygulanmış yüzey
UEDSO25	Ağırlıkça %0.25 SiO_2 katkılı Ultra Ever Dry®
UEDSO50	Ağırlıkça %0.50 SiO_2 katkılı Ultra Ever Dry®
UEDSO75	Ağırlıkça %0.75 SiO_2 katkılı Ultra Ever Dry®

Kaplama Solüsyonlarının Uygulanması

İlk olarak, 50x50x1 mm boyutlarındaki paslanmaz çelik levhalara yüzey temizliği amacıyla zımpara ile pürüzlendirme işlemi yapılmış, ardından levhalar izopropil alkol ile silinerek yağ, oksit ve kir tabakaları uzaklaştırılmıştır. Bu işlem, kaplama malzemesinin yüzeye daha etkin yapışabilmesini sağlamak adına önemli bir hazırlık adımıdır.

Öncelikle paslanmaz çelik levha yüzeyine UED00 malzemesi yani katkısız Ultra Ever Dry® solüsyonu uygulanmıştır. Sonra katkılı astar çözeltileri, hazırlanan paslanmaz çelik yüzeylere hava destekli sprey kaplama yöntemi ile uygulanmıştır. Püskürtme işlemi sırasında uygulama basıncı, mesafe ve açılar sabit tutularak her numune için kontrollü bir kaplama sağlanmıştır. Astar katmanın kuruması için oda sıcaklığında uygun süre beklenmiş ve yüzeyde fiziksel bütünlük sağlandıktan sonra Ultra Ever Dry® üst katman (top coat), aynı püskürtme yöntemiyle astarın üzerine uygulanmıştır. Bu sayede, alt katmanda yüzey pürüzlülüğü ve partikül etkisi, üst katmanda ise homojen sıvı itici tabaka birlikte oluşturularak iki katmanlı UEDSO25, UEDSO50 ve UEDSO75 kaplamaları elde edilmiştir. Her kaplama işlemi, üç farklı numune üzerinde tekrarlanarak deneysel güvenilirlik sağlanmıştır.

Temas Açısı Ölçümleri

Bu aşamada, yüzeyleri farklı kaplama solüsyonlarıyla modifiye edilen paslanmaz çelik levhaların temas açıları ölçülerek, hidrofobik karakterleri nicel olarak değerlendirilmiştir. Temas açısı, bir sıvı damlasının yüzeyle oluşturduğu denge açısını ifade eder ve yüzeyin ıslanabilirliğini belirlemede temel parametrelerden biridir.

Tüm temas açısı ölçümleri, HÜNİTEK – Hacettepe Üniversitesi İleri Teknolojiler Uygulama ve Araştırma Merkezi laboratuvarlarında, yüksek hassasiyetli bir gonyometre cihazı olan Biolin Scientific – Attension Theta marka model cihaz ile gerçekleştirilmiştir. Bu cihaz, damlacığın yüzey üzerinde oluşturduğu temas profili görüntüsünü yüksek çözünürlükte analiz ederek, yazılım destekli olarak temas açısını otomatik biçimde hesaplamaktadır. Kullanılan ölçüm yöntemi, standart sessile drop tekniğine dayanmaktadır. Bu yöntemde belirli hacimde saf su damlası, test yüzeyi üzerine kontrollü biçimde bırakılmış ve damla-sıvı temas çizgisi ile katı yüzey arasındaki açı, cihazın 1984 × 1264 piksel çözünürlüğündeki kamera sistemi yardımıyla tespit edilmiştir. Yüzey ile sıvı arasındaki etkileşimden doğan temas açısı, sıvının yüzey gerilimi ve yüzeyin serbest enerjisiyle ilişkilendirilerek analiz edilmiştir.

Cihazın teknik özellikleri şunlardır:

- Kamera hızı: 3000 FPS
- Çözünürlüğü: 1984 × 1264 piksel
- Ölçüm parametreleri: Temas açısı, serbest yüzey enerjisi, yüzey gerilimi

Deneysel düzenekte uygulanan adımlar:

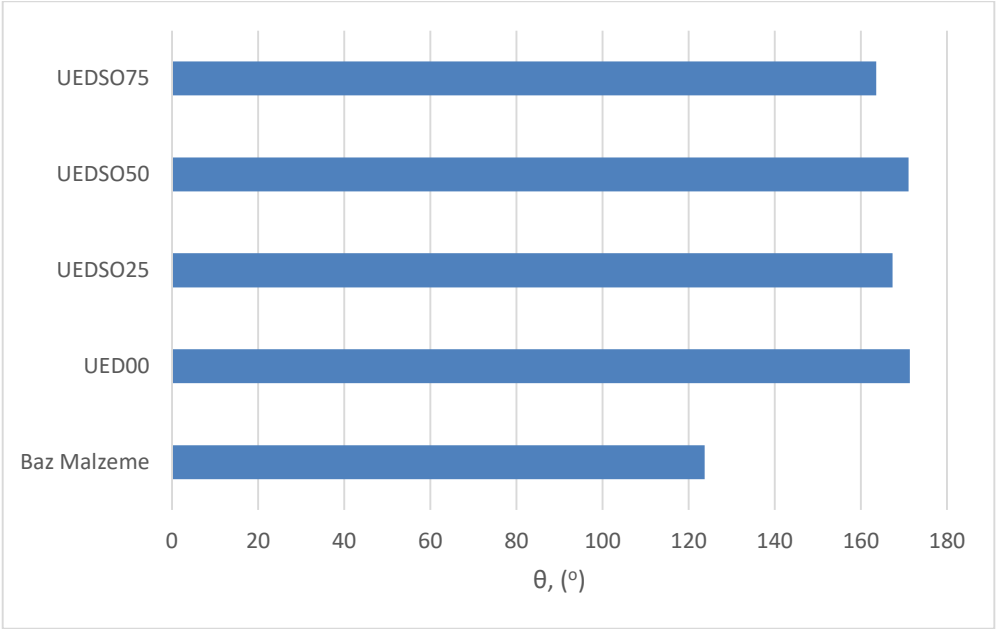
- Her kaplama türü için (UED00, UEDSO25, UEDSO50, UEDSO75 ve kaplanmamış baz malzeme) üç ayrı numune hazırlanmıştır.
- Her numune için üç tekrar ölçüm yapılmış ve toplamda her grup için 9 veri noktası elde edilmiştir.
- Tüm ölçümler yaklaşık 22 °C sabit oda sıcaklığı ve kontrollü bağıl nem koşullarında gerçekleştirilmiştir.
- Cihaz, damlacığın hem sol hem sağ kenarından temas açısı ölçümü alarak ortalama bir değer üretmiş; böylece ölçüm simetrisi ve tekrarlanabilirlik güvence altına alınmıştır.

Bu cihaz ve yöntem sayesinde yüzeylerin hidrofobik karakteristikleri nicel olarak belirlenmiş, katkı oranlarının temas açısı üzerindeki etkisi karşılaştırmalı olarak değerlendirilmiştir.

BULGULAR VE TARTIŞMA

Bu çalışma kapsamında, paslanmaz çelik yüzeylerin su itici özelliklerini geliştirmek amacıyla ticari olarak temin edilen iki bileşenli Ultra Ever Dry® kaplama malzemesi kullanılmış; astar katmana (bottom coat) farklı oranlarda silisyum oksit (SiO_2) katkısı eklenerek oluşturulan kaplamaların temas açısı üzerindeki etkileri sistematik olarak incelenmiştir. Kaplama işlemleri çift katmanlı olarak yürütülmüş, katkılar yalnızca alt katmanda uygulanmış; üst katman (top coat) ise saf Ultra Ever Dry® malzemesi olarak kalmıştır.

Kaplanan numunelerin temas açısı ölçümleri, yüksek çözünürlüklü gonyometre cihazı ile, HÜNİTEK – Hacettepe Üniversitesi İleri Teknolojiler Uygulama ve Araştırma Merkezi laboratuvarlarında gerçekleştirilmiştir. Bu kapsamda elde edilen temas açısı verileri Şekil 2'de verilmiştir.

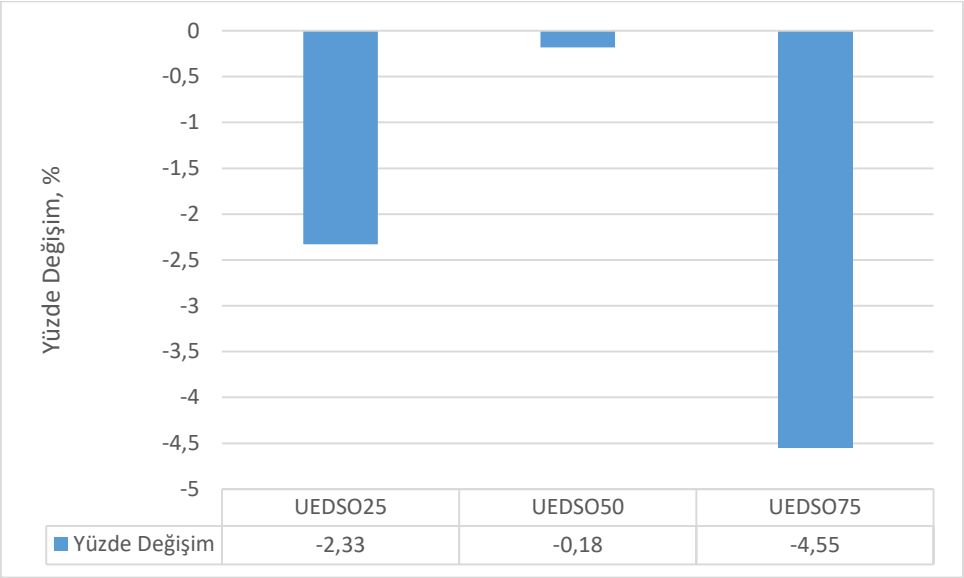


Şekil 9. Temas açısı ölçümleri

Yapılan temas açısı ölçümleri sonucunda, katkı maddesi uygulanmış ve Ultra Ever Dry® kaplaması içeren numunelerin tümü, baz malzeme olan kaplanmamış paslanmaz çeliğe göre belirgin oranda artış göstermiştir. Kaplanmamış baz malzemenin temas açısı 123.7° olarak ölçülmüştür. Bu değere göre, yüzeylere uygulanan kaplamaların temas açısı ve baz malzemeye göre yüzde artış oranları şu şekildedir: UED00 %38.56, UEDSO25 %35.33, UEDSO50 %38.32 ve UEDSO75 %32.26 oranında artış göstermiştir.

Elde edilen bu veriler, yüzeylerin ıslanabilirliğinde belirgin değişiklikler olduğunu ortaya koymuştur. Kaplanmamış paslanmaz çelik levhanın 123.7°'lik temas açısı, yüzeyin hidrofobik karakterde olduğunu göstermektedir.

UED00 numunesi, yalnızca Ultra Ever Dry® kaplaması içeren referans yüzey olarak değerlendirilmiş ve temas açısı 171.4° olarak ölçülmüştür. Diğer katkılı kaplamalar bu değere göre karşılaştırıldığında Şekil.3'te yüzdelik değişimler verilmiştir.



Şekil 10. UED00'a göre diğer kaplanmış malzemelerin yüzde değişim grafikleri

Bu bulgular, katkı malzemesi içeriğinin optimize edilmesinin, kaplama performansı üzerinde doğrudan etkili olduğunu göstermektedir. Özellikle silisyum oksit katkısının belirli bir eşik değerin üzerinde uygulanması durumunda süperhidrofobik etkinin zayıfladığı anlaşılmaktadır. Öte yandan, düşük ve dengeli katkı oranları ile yüzeyde pürüzlülük artışı sağlanarak Cassie-Baxter rejimi içinde daha yüksek temas açılarına ulaşmak mümkündür.

Sonuç olarak, bu çalışmada geliştirilen kaplama sistemi ile paslanmaz çelik yüzeylerin süperhidrofobik hale getirilmesi başarıyla gerçekleştirilmiştir. En verimli sonuçlar, %0.50 oranında SiO_2 katkısı içeren kaplama ile elde edilmiş olup, bu oran kaplama performansı açısından optimum değer olarak önerilmektedir. Bu sonuçlar hem literatürle uyumlu hem de ileride yapılacak yeni yüzey tasarımı çalışmalarına referans teşkil edecek niteliktedir.

SONUÇLAR

Bu çalışmada, paslanmaz çelik yüzeylerin süperhidrofobik özellik kazanmasını sağlamak amacıyla ticari bir kaplama malzemesi olan Ultra Ever Dry®'a farklı oranlarda silisyum oksit (SiO_2) nanopartikülleri eklenmiş ve elde edilen kompozit kaplamaların temas açısı üzerindeki etkisi deneysel olarak incelenmiştir. Uygulamalar çift katmanlı olacak şekilde planlanmış; katkı maddesi yalnızca alt katman (bottom coat) bileşenine entegre edilmiş, üst katman (top coat) ise orijinal haliyle uygulanmıştır. Kaplama işlemleri hava destekli sprey yöntemiyle gerçekleştirilmiş ve temas açıları, Hacettepe Üniversitesi HÜNİTEK laboratuvarlarında bulunan yüksek hassasiyetli gonyometre cihazı (Biolin Scientific – Attension Theta) ile ölçülmüştür.

Elde edilen bulgular, katkı maddesi içeren tüm kaplamaların kaplanmamış baz malzeme olan paslanmaz çeliğe kıyasla belirgin biçimde daha yüksek temas açısı sunduğunu ortaya koymuştur. Katkısız Ultra Ever Dry® (UED00) ile 171.4° temas açısı elde edilerek süperhidrofobik karakter sağlanmıştır. %0.25 (UEDSO25) ve %0.75 (UEDSO75) katkılı numuneler sırasıyla %2.33 ve %4.55 oranlarında düşüş gösterirken, %0.50 oranında katkı içeren UEDSO50 numunesi yalnızca %0.18'lik farkla UED00'a oldukça yakın bir performans sergilemiştir.

Bu sonuçlar, katkı oranının optimize edilmesinin süperhidrofobik kaplama performansı üzerinde kritik rol oynadığını göstermektedir. Düşük katkı oranları istenilen yüzey pürüzlülüğünü tam olarak sağlayamazken, yüksek oranlar ise partikül birikimi nedeniyle kaplama bütünlüğünü bozmakta ve hidrofobik etkinliği azaltmaktadır. En uygun performans,

%0.50 oranında silisyum oksit katkısı ile elde edilmiş olup, bu oran gelecekteki uygulamalar için önerilen ideal katkı düzeyi olarak değerlendirilmektedir.

TEŞEKKÜR

Bu çalışma, Türkiye Bilimsel ve Teknolojik Araştırma Kurumu (TÜBİTAK) tarafından 2209-A Üniversite Öğrencileri Araştırma Projeleri Destekleme Programı kapsamında desteklenen, 1919B012333278 başvuru numaralı proje doğrultusunda yürütülmüş ve elde edilen verilerden üretilmiştir. Yazarlar, sağladığı mali destek ve araştırma altyapısı imkanları için TÜBİTAK'a teşekkür eder.

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STRES FAKTÖRLERİNİN ÇALIŞANLAR ÜZERİNDEKİ ETKİLERİ VE BAŞ ETME YÖNTEMLERİ

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ÖZET
Stres en genel tanımıyla bireyin karşılaştığı bir olay ya da durumu üstesinden gelemeyecek düzeyde zorlayıcı, tehditkar ya da kontrol edilemez olarak değerlendirdiğinde ortaya çıkan tepkiler bütünüdür. Çalışma hayatında ortaya çıkan değişiklikler de stresi doğrudan etkilemektedir. Temel anlamda modern iş hayatında bireyler, çok yönlü stres kaynaklarıyla karşı karşıya kalmaktadır. Teknolojik yenilikler, global rekabet, esnek ancak yoğun çalışma düzenleri ve çalışma hayatı ile özel yaşam arasındaki sınırların birbiri içine girmesi, çalışanlar üzerinde fiziksel ve psikolojik baskılar yaratmaktadır. Özellikle uzaktan çalışma gibi dijital sistemlerin yaygınlaşması, zaman yönetimi ve tükenmişlik gibi sorunları beraberinde getirmiştir. Bu bağlamda, çalışanların karşılaştığı stres unsurlarını tanımlamak ve bu durumlarla başa çıkma yollarını değerlendirmek gün geçtikçe daha fazla önem kazanmaktadır. Bu çalışma, iş yaşamındaki stres faktörlerinin bireyler üzerindeki çeşitli etkilerini incelemekte ve birtakım stresle baş etme stratejilerini ele almaktadır. Farklı ülkelerde ve kültürlerde yapılan uygulamalardan elde edilen bulgular, toplumsal ve yapısal farklılıkların stres algısını ve baş etme biçimlerini doğrudan etkilediğini göstermektedir. Sadece bireysel yöntemlerin yeterli olmadığı; örgütsel düzeyde geliştirilen teşvik edici politikaların da çalışanların biyolojik ve psikolojik sağlığı ile verimliliği açısından hayati bir öneme sahip olduğu görülmektedir. Sonuç olarak, işletmelerin değişen iş koşullarına uyum sağlayabilmesi için stres yönetimini stratejik bir öncelik haline getirmesi gerekmektedir. Çalışanların psikolojik dayanıklılığını artırmaya yönelik uygulamalar, hem bireylerin iyilik halini hem de kurumların sürdürülebilir başarısını desteklemektedir.
Anahtar Kelimeler: Stres, stresle baş etme, çalışan

EFFECTS OF STRESS FACTORS ON EMPLOYEES AND COPING METHODS

ABSTRACT
Stress is, in its most general definition, the set of reactions that occur when an individual evaluates an event or situation as challenging, threatening or uncontrollable to a degree that they cannot overcome. Changes in work life also directly affect stress. In a basic sense, individuals in modern work life are faced with multifaceted sources of stress. Technological innovations, global competition, flexible but intense working arrangements and the intertwining of boundaries between work life and private life create physical and psychological pressures on employees. The spread of digital systems, especially remote working, has brought about problems such as time management and burnout. In this context, defining the stress factors that employees encounter and evaluating ways to cope with these situations are becoming increasingly important. This study examines the various effects of stress factors in work life on individuals and addresses a number of stress coping strategies. Findings obtained from applications conducted in different

countries and cultures show that social and structural differences directly affect the perception of stress and coping styles. It is seen that individual methods alone are not sufficient; encouraging policies developed at the organizational level are also of vital importance in terms of the biological and psychological health and productivity of employees. As a result, businesses need to make stress management a strategic priority in order to adapt to changing business conditions. Practices aimed at increasing the psychological resilience of employees support both the well-being of individuals and the sustainable success of organizations.

Keywords: Stress, coping, employee

GİRİŞ

Stres kavramı araştırmacılar tarafından uzun zamandır tartışılagelen bir kavramdır. Stres, genellikle üzüntü, kaygı ve endişe gibi duygularla ilişkilendirilse de tanımını yapmak oldukça karmaşıktır. Hans Selye'nin belirttiği gibi, stres hem çok tanınan hem de yeterince anlaşılmayan bir olgudur; insan bedeninde çeşitli gerilimlere neden olan bilimsel bir süreçtir (Olpin & Hesson, 2012). Günümüz iş yaşamında da önemli bir yer tutan stres, birey üzerinde baskı oluşturarak işten uzaklaşmasına ve verimliliğinin azalmasına yol açabilir. Modern literatürde stres, bireyin çevresinden gelen uyaranlara verdiği tepkiler ya da bu uyaranlarla kurduğu etkileşim olarak da ele alınmaktadır (Dewe, O'Dristrol & Cooper, 2010). Günümüz iş dünyasındaki çalışanların birçoğu, iş yükünün fazlalığı**,** zaman baskısı**,** tekno-stres**,** finansal belirsizlik ve toksik iş ortamı gibi çeşitli stres kaynaklarıyla karşı karşıya kalmaktadır (Bakker & Demerouti, 2007; Kivimäki vd., 2012). Özellikle teknolojik taleplerin giderek arttığı dijital ortamlarda; çalışanların iş ve özel yaşam arasındaki sınırları gittikçe bulanıklaşmakta, bu durum da performans kaybı ve psikolojik yıpranma riskini artırmaktadır (Rohwer ve vd, 2022; Saleem & Malik, 2023). Dünya Sağlık Örgütü' de (DSÖ) işyeri stresini, çalışanların profesyonel ortamda karşılaştıkları talepler, baskılar ve zorluklar nedeniyle yaşadıkları duygusal, fiziksel ve psikolojik gerilim olarak tanımlamaktadır. Bu stres, artan rekabet, hızlı teknolojik gelişmeler ve daha yüksek beklentilerle karakterize edilen, genellikle iş yükü, kişilerarası çatışmalar ve iş güvencesizliği gibi faktörlerden kaynaklanan, günümüz toplumunda yaygın bir sorundur. Bu bağlamda, çalışmanın; stres faktörlerini tanımlayarak çalışanlar üzerindeki etkileri ele almayı ve hem bireysel hem kurumsal düzeyde etkin baş etme yöntemlerini sistemli şekilde ortaya koyması amaçlanmaktadır.

Kuramsal Çerçeve: İş Stresi ve Başa Çıkma

İş yeri kaynaklı stres, çalışanların iş ortamındaki talepleri ile bu talepleri karşılamaya yönelik yetenekleri arasında dengesizlik yaşandığı durumlarda ortaya çıkmaktadır (Holmlund-Rytkönen & Strandvik, 2005). Bu durumda, hem çalışanların psikolojik iyi oluşu hem de iş verimliliği açısından risk oluşturmaktadır. Kuramsal düzeyde, iş stresini açıklayan 2 model bulunmaktadır. Bunlar Talep-Kontrol Modeli (Karasek, 1979) ve İş Talepleri-Kaynakları Modeli' dir (Bakker & Demerouti, 2007).

Talep-Kontrol Modeli' nde, yüksek iş talepleri ile düşük kontrol düzeyinin birleştiği durumların yüksek stres riski doğurduğu öne sürülürken; İş Talepleri-Kaynaklar Modeli' nde ise her işin kendine özgü talepleri (örneğin zaman baskısı, bilişsel yük) ve kaynakları (örneğin sosyal destek, karar özerkliği) olduğu, stresin ise bu iki faktörün dengesizliği sonucu geliştiğini ortaya koymaktadır.

İşyerinde yaşanan stres eğer işlevsel bir şekilde yönetilmezse hem fiziksel hem de duygusal ve psikolojik anlamda istenmeyen sonuçlar doğurabilir. Fiziksel sonuçlar arasında baş ağrıları, kas gerginliği, uyku sorunları, sindirim sorunları, kalp hastalığı, yüksek tansiyon, diyabet ve bağışıklık sistemi problemleri bulunur. Duygusal sonuçlar arasında ise anksiyete, depresyon, öfke, sinirlilik, yorgunluk, hayal kırıklığı, düşük özsaygı ve tükenmişlik bulunur. Psikolojik sonuçlar arasında bozulmuş bilişsel işlev, azalmış verimlilik, artan hata oranı ve azalmış iş tatmini ve bağlılığı bulunmaktadır. Hem fiziksel hem de duygusal sonuçlar, bir çalışanın zihinsel sağlığı ve refahı üzerinde önemli bir etkiye sahip olabilir.

Lazarus ve Folkman (1984)' a göre başa çıkma, stresi yönetmek için kullanılan bilişsel ve davranışsal çabaların tümüdür. Çalışanların iş ortamındaki stresle başa çıkma stratejileri genel olarak üç ana gruba ayrılır:

1. Problem odaklı başa çıkma: Bireyin stresin kaynağını değiştirmeye yönelik aktif çabalarını kapsar. Örneğin iş yükünü yeniden düzenleme, zaman yönetimi becerilerinin kullanımı gibi.
2. Duygu odaklı başa çıkma: Kişinin stresin yarattığı duygusal tepkilerle başa çıkmaya çalıştığı stratejilerdir. Örneğin gevşeme teknikleri, duygusal boşalım, sosyal destek arayışı gibi.
3. Kaçınma/çekilme stratejileri: Bu tür stratejiler genellikle işlevsiz olup; stres kaynağından uzaklaşma, görmezden gelme gibi pasif tepkileri içerir.

Modern yaklaşımlar, özellikle dijitalleşmeyle gelen tekno-stres gibi yeni stres kaynaklarına karşı, bireysel düzeyde dijital düşünme becerisi, farkındalık (mindfulness) ve psikolojik sağlamlık (resilience) gibi baş etme becerilerinin öne çıktığını göstermektedir. Kurumsal düzeyde ise esnek çalışma modelleri, katılımcı yönetim, psikososyal güvenlik iklimi ve liderlik desteği önemli koruyucu faktörler arasında yer alır.

Bu kuramsal altyapı, stres faktörlerinin karmaşık ve çok katmanlı bir yapıda ele alınması gerektiğini; başa çıkma stratejilerinin ise bireysel farklılıklar, kültürel bağlam ve sektör dinamiklerine göre şekillenebileceğini göstermektedir.

ARAŞTIRMA VE BULGULAR

Yöntem

Bu çalışmada yöntem olarak literatür taramasına dayalı bir çalışma yapılmıştır. Literatür incelemesi, belirli bir konu çerçevesinde daha önce yapılmış araştırmaların düzenli biçimde ele alınarak açıklanması ve ortak noktalarının bir araya getirilmesi sürecidir (Günbayı, 2020). Bu amaçla PubMed, ScienceDirect, Emerald, Sage, DergiPark ve Google Scholar üzerinden 2005–2025 döneminde yayımlanmış nicel ve nitel çalışmalardan örneklem büyüklüğü, yöntem çeşitliliği ve konuya katkı düzeyine göre çalışmalar seçilerek analiz edilmiştir.

Yurtdışı Çalışmaları

Podsakoff ve diğerleri (2007), farklı türdeki stresörlerin iş tutumları ve işle ilgili davranışlar üzerindeki etkisini araştıran bir meta-analiz gerçekleştirmiştir. Çalışma, stresörlerin, özellikle de zorluk stresörlerinin, bireysel iş performansı üzerinde önemli bir olumsuz etkisi olduğu sonucunu bulmuştur. Bu stres faktörleri, bilişsel yetenekleri, karar verme süreçlerini ve motivasyonu olumsuz etkileyerek iş yerinde verimliliğin düşmesine ve hataların artmasına neden olduğu sonucuna ulaşılmıştır. Çinli çalışanlarla yapılan bir başka çalışmada ise bireylerin işine yönelik güçlü özyeterliliğinin duygusal tükenmişlik düzeyini azalttığı tespit edilmiştir (Ma vd., 2021). Avrupa' da yapılan bir çalışmada Yunanistan, İtalya ve İngiltere' deki 894 üniversite öğrencisi ile COVID-19 pandemi sürecinde, tekno-stresin öğrencilerin kaygı ve depresyon düzeylerini doğrudan etkilediği ve artırdığı buna karşın sosyal destek ve işlevsel baş etme stratejilerinin ise bu stres durumuna karşı koruyucu bir rol üstlendiği belirtilmiştir (Galvin vd., 2022). Güney Kore' de teknoloji baskısının çalışanlar üzerindeki etkisini inceleyen bir çalışmada, yüksek tekno-stres düzeyi ile örgütsel bağlılık arasında negatif yönde anlamlı bir ilişki bulunmuştur (Choi, 2023). Madhavi ve Rao (2023) stresin iş yerindeki memnuniyet ve çalışan performansına etkisini inceledikleri çalışmada stresin işyerindeki hataların artmasına, üretkenliğin azalmasına ve sosyal ilişkilerin bozulmasına sebep olurken işyerlerinde etkili stresle baş etme yöntemlerinin ve çalışan yardım programlarının uygulanmasının stresi azaltmada önemli bir rol oynadığını sonucuna ulaşmıştır. Almanya' da yürütülen bir başka çalışmada da dijital yeterlilik düzeyi yüksek bireylerde tekno-stres kaynaklı iş tatmininde olumsuz etkinin anlamlı bir şekilde azaldığı bulunmuştur (Valta vd., 2024). Diğer bir çalışmada Mohd (2024), mesleki stresin, çalışanların verimliliğini ve genel organizasyon sağlığını olumsuz etkileyerek performansın düşmesine neden olacağını belirtmektedir. Ancak, stres aynı zamanda çalışanların görevlerini zamanında

tamamlamaları için heyecan ve motivasyonlarını artırabileceğini de belirtmektedir. Zorlukla ilgili stres, çalışanları zorlu görevleri üstlenmeye motive ederken, engelleyici stres çalışanların performanslarını engellemektedir. Düzenli ve periyodik motivasyon, stres seviyelerini dengeleyebilir ve tükenmişliğin bu modelde aracı olarak işlev göreceğini belirtmektedir. Mesleki stresi yönetmek, uygun stres başa çıkma stratejilerini benimsemeyi ve tükenmişliği ele almayı gerektirir, böylece çalışanların refahını artırır.

Türkiye' de Yapılan Çalışmalar

Tekin ve diğerleri (2019), 8 farklı meslek grubundan toplam 287 çalışan ile yaptıkları çalışmada mesleklere göre stres düzeylerinin değiştiği sonucuna ulaşmıştır. Buna göre stres düzeyi en yüksek meslek madencilik olurken, sağlık çalışanları, öğretmenlik, bankacılık gibi meslek elemanlarının da stres düzeyinin yüksek olduğu belirtilmiştir. Hiçyılmaz (2020); Türkiye' den 5, Rusya' dan 5 toplam 10 beyaz yakalı çalışanla yaptığı nitel çalışmada Türk ve Rus çalışanların stres hissi arasında bir fark olmadığını belirtmiş, çalışanların çoğunun stresin alarm aşamasında olduğunu, fiziksel belirtilerin (baş ağrısı, yorgunluk) öne çıktığını vurgulamıştır. Yaman ve Sarıkaya (2020), Ankara Sosyal Güvenlik Kurumu' nda çalışan 200 kişi ile yaptıkları çalışmada, çalışanların stres kaynaklarında dedikodunun yaygın olması ve iş yükünün fazla olması yer alırken çalışanların stresli durumlar karşısında olaylardan ders alma, kendini geliştirme gibi baş etme yöntemlerini kullandıkları sonucuna ulaşmıştır. Bir başka çalışmada ise Özmete ve Tahtacı (2021), sosyal çalışmacıların iş yaşamındaki stres düzeyi ile ilgili yaptıkları çalışmada 30 katılımcı ile yaptıkları nitel görüşmeler sonucunda çalışanların stres kaynaklarının daha çok çoklu iş yükü, haksızlıklar karşısında sessiz kalamama, ekip çalışmasındaki yetersizlik gibi faktörler olarak sıralanmış, baş etme yöntemi olarak da bireysel çabalar ve meslektaş desteği ön plana çıkmıştır. Sürmeneli Yiğci ve Babaoğlu (2021) bir inşaat firmasında çalışan işçilerle yaptığı çalışmada özellikle iş kazalarında iş yerindeki stres etmenlerinin de etkili olduğu belirtilmiş, iş-işçi uyumunun en iyi şekilde sağlanarak psikolojik faktörlerden kaynaklı kazaların en aza indirilebileceği sonucuna ulaşılmıştır. İstanbul örneklemindeki çalışanların stres, mutluluk ve performans düzeyleri analiz edilmiş; stresin mutluluğu negatif yönde etkilediği ve performansla stres arasında negatif yönde anlamlı bir ilişki olduğu tespit edilmiştir (Çakar vd., 2023). Bir başka çalışmada İstanbul'daki özel bir hastanede çalışan 205 hemşire ile yapılan kesitsel çalışmada, hemşirelerin yaklaşık %45'inin yüksek stres düzeyine sahip olduğu tespit edilirken, stresin serviste çalışmaya istekli olup olmama ve ekipten memnuniyet düzeyine göre farklılık gösterdiği bulunmuştur (Yıldız ve Babaoğlu, 2024). Üniversite personeli arasında yapılan çalışma, pozitif yeniden değerlendirme ve soruna yönelik çözüm stratejilerinin psikolojik dayanıklılığı artırdığını; rehberlik aramanın ise ters etki gösterdiğini ortaya koymuştur. Selçuk Üniversitesi'nde yürütülen bir çalışmada (Tefek, 2025), akademik personelin kullandığı pozitif yeniden değerlendirme ve çözüm odaklı başa çıkma stratejilerinin psikolojik dayanıklılığı anlamlı ölçüde artırdığı rapor tespit edilmiştir.

Tablo 1. Yurtdışı ve Türkiye Çalışmalarının Karşılaştırma Tablosu

Kriter	Yurtdışı Çalışmalar	Türkiye Çalışmaları
Stres Kaynakları	- Zorluk stresörleri (Podsakoff vd., 2007) - Tekno-stres (Galvin vd., 2022; Choi, 2023; Valta vd., 2024) - Mesleki baskı (Madhavi ve Rao, 2023; Mohd, 2024)	- Yoğun iş yükü, dedikodu, ekip sorunları (Yaman ve Sarıkaya, 2020; Özmete ve Tahtacı, 2021) - Adaletsizlik, çoklu iş (Tekin vd., 2019; Hiçyılmaz, 2020)
Fiziksel Belirtiler	- Baş ağrısı, tükenmişlik, yorgunluk (Ma vd., 2021; Choi, 2023)	- Alarm düzeyi belirtileri: baş ağrısı, yorgunluk (Hiçyılmaz, 2020; Yıldız ve Babaoğlu, 2024)

Psikolojik Etkiler	- Kaygı, depresyon, motivasyon kaybı (Galvin vd., 2022; Mohd, 2024)	- Psikolojik dayanıklılığın azalması, sosyal ilişkilerde bozulma (Tefek, 2025; Özmete ve Tahtacı, 2021)
Baş Etme Yöntemleri	- Sosyal destek, pozitif yeniden değerlendirme, çözüm odaklılık (Galvin vd., 2022; Mohd, 2024)	- Ders çıkarma, bireysel gelişim, ekip desteği, çözüm odaklılık (Yaman ve Sarıkaya, 2020; Tefek, 2025)
Pozitif Etki / Fırsat Yönü	- Zorluk stresörünün motive edici etkisi (Mohd, 2024)	- Pozitif yeniden değerlendirme psikolojik dayanıklılığı artırır (Tefek, 2025)
Teknoloji Kaynaklı Stres	- Pandemi sürecinde tekno-stresin yaygınlaşması, dijital yetkinliğin koruyucu etkisi (Valta vd., 2024; Galvin vd., 2022; Choi, 2023)	- Türkiye'de tekno-strese az vurgu yapılmakta; daha çok sosyal ve örgütsel stres faktörleri üzerinde durulmaktadır.
Kurum Desteği / Müdahale	- Çalışan destek programları, düzenli motivasyon önlemleri (Madhavi ve Rao, 2023)	- İş-işçi uyumu, kurum içi sosyal destek, ekip uyumunun artırılması (Sürmeneli Yiğci ve Babaoğlu, 2021; Özmete ve Tahtacı, 2021)
Metodolojik Yaklaşımlar	- Meta-analiz, çok uluslu nitel-nicel araştırmalar (Podsakoff vd., 2007; Galvin vd., 2022)	- Kesitsel anket çalışmaları, meslek temelli saha araştırmaları (Tekin vd., 2019; Yıldız ve Babaoğlu, 2024)

Öne çıkan ortak yönler; Hem Türkiye hem de yurtdışı çalışmalarında yoğun iş yükü, rol belirsizliği ve örgütsel baskılar ortak stres kaynakları olarak tespit edilmiştir. Çalışanların stresle baş etme sürecinde en sık kullandıkları stratejiler arasında pozitif yeniden değerlendirme, sosyal destek arayışı ve çözüm odaklılık bulunmaktadır. Fiziksel belirtiler (baş ağrısı, yorgunluk, enerji kaybı) ve psikolojik etkiler (kaygı, tükenmişlik) her iki literatürde de vurgulanmaktadır. Ulusal ve uluslararası çalışmalar, iş stresi ve başa çıkma yöntemlerinin bireysel, örgütsel ve kültürel faktörlerden etkilendiğini göstermektedir. Tekno-stres, duygusal tükenmişlik ve iş-özel yaşam çatışması gibi ortak temalar öne çıkmakta; bireysel farkındalık, sosyal destek ve örgütsel esneklik gibi faktörlerin stres üzerinde koruyucu etki yarattığı görülmektedir.

Farklılıklar ise yurtdışı çalışmalarında teknolojik gelişmeler ve tekno-stres vurgusu dikkat çekerken, Türkiye'deki çalışmalar daha çok sosyal ortam, iş güvenliği ve kurum içi ilişkilerle ilgilidir. Yurtdışında, özellikle meta-analiz ve çokuluslu karşılaştırmalı çalışmalar yapılmışken, Türkiye'de daha çok meslek-temelli saha araştırmaları ve yerel örneklemli nitel-nicel çalışmalar tercih edilmiştir. Türkiye'deki çalışmalarda dedikodu, adaletsizlik, ekip uyumsuzluğu gibi daha kültürel ve sosyal yönlü stres kaynakları belirginleşirken, yurtdışında stresin bilişsel, dijital ve organizasyonel boyutlarına daha fazla odaklanılmıştır.

SONUÇ

Son yıllarda yapılan çalışmalar, iş stresinin çok boyutlu bir olgu olduğunu ortaya koymaktadır. Tekno-stres, duygusal tükenmişlik ve iş-özel yaşam çatışması gibi ortak temalar, hem bireysel hem kurumsal dinamiklerle şekillenen temel stres kaynaklarındandır. Uluslararası ve ulusal bulgular; dijital yeterlilik, öz-yeterlilik, sosyal destek ve öz farkındalık gibi bireysel stratejilerin iş yerindeki stresi anlamlı şekilde azaltabileceğini göstermektedir. Ayrıca iş-serbest zaman çatışması, pozitif bilişsel yeniden yapılandırma, sosyal ortam desteği ve dayanıklılık eğitimlerinin stresle başa çıkmada etkin olduğu tespit edilmiştir. Bununla birlikte başarılı bir stres yönetimi, kişisel özellikler, yaş, mali varlıklar, eğitim, geçmiş deneyimler, fiziksel ve zihinsel sağlık gibi çeşitli faktörlere dayanır. Bu faktörlerin her biri stresi etkili bir şekilde yönetmek için hayati öneme sahiptir. Öneriler, bireysel, kurum düzeyinde ve yöneticiler için sıralanabilir;

- Bireysel düzeyde; Dijital ve bilişsel yeterlilik düzeyinin artırımı, psikolojik dayanıklılık ve sosyal destek sistemlerinin güçlendirilmesi,
- Kurumsal düzeyde; Esnek çalışma modelleri, çalışanların karar süreçlerine katılımın teşvik edilmesi, psikososyal güvenlik iklimi ve lider destekleyiciliğinin artırılması teşvik edilmelidir.
- Yöneticiler için; Black ve diğerleri (2019) yöneticilerin iş yerlerindeki stresi azaltmak için bir takım yöntemler kullanabileceklerini belirtmiştir. Yöneticiler; kişisel seçim ve yerleştirme, beceri eğitimi, işin yeniden tasarımı, iş rotasyonu ve artan katılım ile kişisel kontrol gibi stratejileri uygulayarak iş ile ilgili stresi azaltabilirler. Yöneticiler, çalışanların belirsizliğe toleransını ve rol çatışmasını yönetme yeteneğini dikkate almalıdır. Beceri eğitimi, kısayollar kullanarak veya becerileri genişleterek stresi azaltabilirken, iş yeniden tasarımı ise görev önemi, özerklik, sorumluluk ve geri bildirimi iyileştirebilir. İş rotasyonu, stresli işlerden geçici bir rahatlama sağlayabilirken, artan katılım ve kişisel kontrol belirsizlik ve çatışmayı hafifletebilir. Yöneticiler, takım oluşturma çabaları ve iletişimi geliştirerek uyumlu çalışma grupları oluşturarak iş yerindeki stresi azaltabilirler. Bu, rol belirsizliğini ve çatışmayı azaltabilirken, aynı zamanda çalışanların endişelerini dile getirmelerine de olanak tanır. Tanı, eğitim ve davranış değişikliği faaliyetlerini içeren sağlık teşvik programları, fiziksel uygunluk, kilo kontrolü ve madde bağımlılığı gibi sağlıkla ilgili endişeleri ele almaya yardımcı olabilir. Bu programlar, daha yüksek verimlilik, azalan devamsızlık ve azalan stresle ilgili hastalıklara yol açabilir. Şirketler genellikle bu hizmetleri sunmanın sıkı bir iş piyasasında işe alım için cazip bir teşvik olduğunu düşünürler.

Bütüncül yaklaşımla hareket edildiğinde, çalışanların refahı desteklenirken, örgütsel performansının da olumlu yönde etkileneceği düşünülmektedir.

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APPLICATION OF MACHINE LEARNING FOR CRACKDETECTION ON CONCRETE STRUCTURES USING CNN ARCHITECTURE

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Abstract
Concrete structures and the associated cracking represent a persistent challenge within the fields of construction and civil engineering, a dilemma that has persisted for decades. Generally, cracks arise from the expansion and contraction of materials, which can lead to various forms of damage within buildings. Engineers typically address these damages and irregularities through manual inspections or by employing predictive models developed using machine learning techniques, thereby facilitating a comprehensive assessment of the structural health of the edifices. This research aims to implement tools such as the VGG 16 network model alongside other machine learning methodologies to identify cracks in concrete structures. We propose a model that integrates Convolutional Neural Networks (CNN) with a VGG-based architecture. For image processing and segmentation, we have employed the gradient boosting algorithm. The datasets utilized in this study were sourced from the Kaggle platform, and the Hugging Face Transformers library was leveraged for implementation. To assess the performance of the developed models, metrics including precision, accuracy, recall, and F1 score were employed. The accuracy achieved by our model can be benchmarked against the accuracy rates of Vision Transformers (ViT). The proposed method demonstrates significant validation accuracy rates, positioning it as a highly innovative and novel machine learning model capable of effectively predicting cracks in concrete structures.
Keywords: *VGG16-Net; concrete cracks; concrete non-cracks; convolutional neural network; Structural health; concrete structures; ViT; vision transformers*

EFFECT OF CBR RESULTS FOR FLY ASH PURIFIED CLAYEY SOIL MATERIALS

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Abstract

Clayey soil having low shear strength and high compressibility cannot be used for sub grade as its CBR value will not be in permissible standard. So it's needed to bemodified when required to use for sub grade under pavements. To modify, stabilizationor ground modification technique is required. In this regard we are making an attempt to modify the properties feasible to be used as sub grade material. Here we are using Fly ash as admixture to stabilize and improve the properties. Many attempts were madeusing fly ash; here we are attempting an study of fly ash stabilization under curing period as the fly ash is being used as an substitute of cement in concrete which gains strength with curing.

Keywords: *Clayey soil, Base shear, Story drifts, Displacement, Time period and Stabilization*

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ABSTRACT:
Sustained and controlled release formulations have transformed drug delivery by offering more consistent therapeutic effects, improved patient compliance, and reduced side effects. Unlike conventional dosage forms that require frequent administration, these advanced systems are designed to release the drug at a predetermined rate over an extended period. **Sustained release** formulations aim to maintain drug concentrations within the therapeutic window for longer durations, while **controlled release** systems provide precise control over the timing, location, and rate of drug release. Various technologies such as matrix systems, reservoir systems, osmotic pumps, and biodegradable polymers are employed to achieve desired release profiles. These formulations are particularly valuable in the treatment of chronic conditions like hypertension, diabetes, and cancer, where maintaining steady plasma levels is critical. Additionally, innovations in nanotechnology and microencapsulation have expanded the scope of controlled release, enabling targeted delivery and stimulus-responsive release mechanisms. Despite their benefits, challenges such as formulation complexity, stability issues, and variable patient responses must be addressed. Regulatory considerations also play a crucial role in the development and approval of such dosage forms. Overall, sustained and controlled release formulations represent a significant advancement in pharmaceutical technology, offering the potential for more effective, safer, and convenient drug therapies.
Keywords: Sustained release, controlled release, drug delivery systems, therapeutic window, polymer technology

SYNTHESIS AND SAR OF ANTIHYPERTENSIVE AGENTS

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ABSTRACT:
The synthesis and structure–activity relationship (SAR) studies of antihypertensive agents play a pivotal role in the rational design and optimization of drugs used to manage high blood pressure. Antihypertensive agents act through various mechanisms, including inhibition of the renin-angiotensin system, calcium channel blockade, beta-adrenergic blockade, and diuretic effects. Chemical synthesis of these agents involves designing molecules that target specific receptors or enzymes such as angiotensin-converting enzyme (ACE), angiotensin II receptors (AT1), or calcium channels. SAR analysis helps in understanding the relationship between molecular structure and biological activity, guiding modifications to improve potency, selectivity, bioavailability, and safety. For instance, SAR studies of ACE inhibitors have revealed that the presence of a carboxyl or thiol group enhances enzyme binding, while for calcium channel blockers, modifications to the dihydropyridine ring affect selectivity and duration of action. In beta-blockers, the nature and position of aromatic substitutions influence β1 or β2 receptor affinity. Modern advancements in combinatorial chemistry, molecular modeling, and high-throughput screening have accelerated the identification of novel antihypertensive scaffolds with improved pharmacological profiles. Despite numerous effective agents available, continued SAR studies are essential to overcome issues like drug resistance, side effects, and poor patient adherence. The integration of synthesis and SAR remains a cornerstone in developing next-generation antihypertensive drugs that are more efficient, safer, and tailored to individual patient needs.
Keywords: Antihypertensive agents, synthesis, structure–activity relationship, ACE inhibitors, beta-blockers

TANAH'TA KARDEŞ REKABETİ: KOLLEKTİF KİMLİĞİNİN ETNO-TEOLOJİK TEMELLERİ

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ÖZET
Bu çalışma Tanah ekseninde kardeş rekabeti motifini kollektif kimlik oluşumu bağlamında incelemeyi hedeflemektedir. Tanah'ta merkezi bir motif olan kardeş rekabeti, Âdem ve Havva'nın çocukları Habil (Hevel) ve Kabil (Kayin) arasında gerçekleşen mücadele ile başlar ve İbrahim'in tarih sahnesine çıkması ile İsrailoğulları'nın etno-dinsel kimliğinin kurucu paradigmasına dönüşür. Bu bağlamda kardeşler arasında gerçekleşen rekabet, çoğu zaman basit aile içi bir anlaşmazlığın ötesinde; ilahi seçim, ahit, miras ve kimlik oluşumu gibi derin teolojik paradigmaları yapılandıran inşa edici anlatı işlevi görür. Özellikle Yaratılış kitabında Habil ve Kabil arasında temsil edilen kardeş rekabeti; tanrısal lütfa erişim/reddedilme diyalektiğinin, benlik inşasını nasıl şekillendirdiğini ortaya koyar. Tanah'ta ilahi lütfun koşullu doğası İsmail ile İshak arasında beliren rekabet ile devam eder. Tevrat, İsmail'i dışlarken İshak'ı merkeze alır. İsmail ve annesi Hacer çöle sürülürken İshak annesi Sare ile kutsanır. Öyle ki Yaratılış kitabında kodlanan kardeşler arasındaki rekabet, İshak'ın soyunu oluşturan İsrailoğulları ile İsmail'in soyunu oluşturan İsmailîler arasında düşmanlığın arketipini oluşturur. İshak'ın çocukları Yakup ve Esav arasındaki rekabet zahirî planda ilk oğulluk hakkı (bekhorah) üzerine temellendirilse de batınî anlamda Tanrı'nın vaatlerinin hangi soy üzerinden devam edeceğine yönelik varoluşsal bir kimlik bir mücadelesi etrafında şekillenmektedir. Yakup'un çocukları ile ilgili anlatı ise kardeşler arasındaki gerilimin bireysel veya ailevi trajediden ziyade ulusal kimlik bilincinin şekillenmesinde kurucu bir işlev üstlendiğini ortaya koymaktadır. Zira Yusuf, kardeşlerinin kendisine reva gördüğü ihaneti derin bir tevazu affederek, yalnızca kişisel bir uzlaşma değil; aynı zamanda Tanrı'nın İbrahim'e verdiği vaadin gerçekleşmesi için gerekli ulusal birliği de inşa etmiştir. Bu bağlamda tarihsel-fenomenolojik yöntem ile ele alınan çalışmada Tanah, Midraş ve Talmud ile birlikte modern Yahudi teologların yorumlarına başvurulmuştur. Araştırma neticesinde, Tanah literatüründe yer alan kardeş rekabeti motifinin kolektif Yahudi kimliğinin etno-teolojik temellerini inşa eden kurucu bir paradigma olduğu tespit edilmiştir.
Anahtar Kelimeler: Dinler tarihi, yahudilik, tanah, kardeş rekabeti

SIBLING RIVALRY IN TANAH: ETHNO-THEOLOGICAL FOUNDATIONS OF COLLECTIVE IDENTITY

ABSTRACT
This study aims to examine the motif of sibling rivalry in the Tanakh in the context of collective identity formation. The sibling rivalry, which is a central motif in the Tanakh, begins with the struggle between Abel (Hevel) and Cain (Kayin), the children of Adam and Eve, and turns into the founding paradigm of the ethno-religious identity of the Israelites with the emergence of Abraham on the stage of history. In this context, sibling rivalry is often more than a simple family dispute; it functions as the constructive narrative that structures deep theological paradigms such as divine election, covenant, inheritance and identity formation. The sibling rivalry represented between Abel and Cain, especially in the book of Genesis, reveals how the dialectic of access/rejection of divine grace shapes the construction of self. In the Tanakh, the conditional nature of divine grace continues with the rivalry between Ishmael and Isaac. While

the Torah excludes Ishmael, it centers Isaac. Ishmael and his mother Hagar are banished to the desert, while Isaac is blessed with his mother Sarah. In fact, the rivalry between the brothers codified in the book of Genesis forms the archetype of the enmity between the Israelites, the descendants of Isaac, and the Ishmaelites, the descendants of Ishmael. Although the rivalry between Isaac's children, Jacob and Esau, is based on the right of firstborn sonship (bekhorah) on the surface level, it is shaped by an existential struggle of identity over which lineage God's promises will continue. The narrative of Jacob's children, on the other hand, reveals that the tension between the brothers plays a constitutive function in shaping the consciousness of national identity rather than individual or familial tragedy. By forgiving his brothers' betrayal of him with deep humility, Joseph not only forges a personal reconciliation, but also the national unity necessary for the fulfillment of God's promise to Abraham. In this context, the study, which was handled with the historical-phenomenological method, used the Tanakh, Midrash and Talmud, as well as the interpretations of modern Jewish theologians. As a result of the research, it was determined that the motif of sibling rivalry in Tanakh literature is a constitutive paradigm that builds the ethno-theological foundations of collective Jewish identity.
Keywords: History of religions, judaism, tanakh, sibling rivalry

YAHUDİ GELENEĞİNDE SİYONİZM KARŞITLIĞI: ÜÇ YEMİN BAĞLAMINDA TEOLOJİK BİR DEĞERLENDİRME

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ÖZET
Bu çalışma, Yahudi geleneğinde Siyonizm karşıtlığını, "üç yemin" (*Shalosh Hashvuot*) bağlamında ele almayı amaçlamaktadır. Talmudik literatürde Tanrı, Yahudi halkı ve diğer uluslar (*goyim*) arasında yapıldığı kabul edilen bu yeminler, diaspora sürecinde mesihî kurtuluşu vurgulaması ve pasifist bir teoloji ortaya koyması açısından önemlidir. Zira Yahudi varoluşunu teolojik sınırlar içerisinde tanımlayan bu yeminler, hem Yahudilerin topluca Eretz Yisrael'e dönmelerini ve dünya milletlerine karşı isyan etmelerini hem de diğer ulusların Yahudilere orantısız güç kullanmalarını yasaklamaktadır. Kaynağını Şarkılar Şarkısı'nda tekrarlanan "Ant içiriyorum size ey Yeruşalim kızları!" ifadesinin midraşik yorumundan alan bu yeminler, diaspora koşullarına uyum sağlamayı kolaylaştıran bir çerçeve sunmaktadır. Zira, Roma'ya karşı gerçekleştirilen isyanların derin travmalara yol açan felaketlerle sonuçlanması gentile topluluklar ile Yahudi ulusu arasında yeni bir paradigma geliştirilmesini zorunlu kılmıştır. Bu çerçevede kutsal metinlerde yer alan savaş anlatılarının yönlendirici etkisini ortadan kaldırmak isteyen hahamlar, Yahudiler ile gentile uluslar arasında Tanrı'nın müdahil olduğu bir sözleşme inşa ederek hem Yahudilerin diğer uluslara hem de gentile toplulukların Yahudilere şiddet uygulamasını engelleyecek bir denge arayışı içerisinde olmuşlardır. Bu doğrultuda sürgünü günahın kefareti olarak yorumlayan hahamlar, kurtuluşu Tora çalışmak ve halakik yaşamın içselleştirilmesi ile açıklamışlardır. Diğer taraftan Filistin'de ulusal bir yurt kurma iddiasıyla ortaya çıkan Siyonizm, hem seküler milliyetçi yapıya sahip olması hem de sürgün Yahudiliğine özgü karakteristik unsurları modern değerlerle değiştirmeyi hedeflemesi nedeniyle eleştirilmiştir. Özellikle Üç Yemin'in ihlal edilmesi, Eretz Yisrael'de seküler bir devlet kurulması ve güç kullanımına dayalı militarist politikaların hayata geçirilmesi geleneksel Yahudilerin Siyonizm karşıtlığına neden olmuştur. Bu bağlamda Haham Joel Teitelbaum, Siyonizm'i ilahî takdire başkaldırı olarak değerlendirirken Haham Elchanan Wasserman, "şeytani bir ayartı" olarak nitelendirmiştir. Araştırma, tarihsel-fenomenolojik yöntemle ele alınmış; klasik Yahudi kaynakları Tanah, Midraş ve Talmud ile birlikte modern Yahudi teologların yorumlarına başvurulmuştur. Siyonizm karşıtlığının tarihsel, teolojik ve sosyo-politik düzeyde analiz edildiği çalışmada, günümüz İsrail-Filistin çatışmasının yalnızca siyasi değil, aynı zamanda teolojik bir gerilim barındırdığına işaret edilmiştir.
Anahtar Kelimeler: Siyonizm, anti-siyonizm, üç yemin, israil-filistin sorunu

ANTI-ZIONISM IN THE JEWISH TRADITION: A THEOLOGICAL ASSESSMENT IN THE CONTEXT OF THE THREE OATHS

ABSTRACT
This study aims to examine anti-Zionism in the Jewish tradition in the context of the "three oaths" (Shalosh Hashvuot). These oaths, which are considered to be made between God, the Jewish people and the Gentiles (goyim) in Talmudic literature, are important in terms of emphasizing messianic salvation in the diaspora process and presenting a pacifist theology. These oaths, which define Jewish existence within theological boundaries, forbid both the return of Jews en masse to Eretz Yisrael and rebellion against the nations of the world and the disproportionate use of force by other nations against Jews. Originating from the midrashic

interpretation of the repeated phrase “I swear to you, O daughters of Jerusalem!” in the Song of Songs, these oaths provide a framework that facilitates adaptation to the conditions of the diaspora. The fact that the revolts against Rome resulted in deeply traumatizing disasters necessitated the development of a new paradigm that regulated the relationship between gentile communities and the Jewish nation. In this framework, the rabbis, who wanted to eliminate the guiding influence of the war narratives in the sacred texts, sought a balance that would prevent both Jews from inflicting violence on other nations and gentile communities from inflicting violence on Jews by constructing a contract between Jews and gentile nations in which God intervened. Accordingly, the rabbis interpreted exile as atonement for sin and explained salvation through Torah study and the internalization of halakic life. On the other hand, Zionism, which emerged with the claim of establishing a national homeland in Palestine, was criticized both for its secular nationalist structure and for its aim to replace the characteristic elements of exilic Judaism with modern values. In particular, the violation of the Three Oaths, the establishment of a secular state in Eretz Yisrael and the implementation of militarist policies based on the use of force have caused traditional Jews to oppose Zionism. In this context, while Rabbi Joel Teitelbaum considered Zionism as a rebellion against divine providence, Rabbi Elchanan Wasserman characterized it as a “satanic temptation”. The research was conducted using the historical-phenomenological method, using the classical Jewish sources of the Tanakh, Midrash and Talmud, as well as the interpretations of modern Jewish theologians. In the study, which analyzed anti-Zionism at historical, theological and socio-political levels, it was pointed out that the current Israeli-Palestinian conflict contains not only political but also theological tension.
Keywords: Zionism, anti-zionism, three oaths, israel palestine problem

TEMPERATURE MANAGEMENT AND SAFETY ENHANCEMENT IN EV BATTERIES

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ABSTRACT

Increased electric vehicle (EV) adoption has emphasized the need for advanced battery safety mechanisms. This project proposes a dual-layer safety system involving real-time temperature monitoring and emergency braking to prevent thermal runaway in EV battery packs. Strategically positioned temperature sensors collect data, which is processed by an onboard microcontroller with Controller Area Network (CAN) capabilities. The system actively monitors thermal conditions and displays alerts on an LCD display upon detecting abnormal temperature increases.

In the first safety stage, when the temperature exceeds a preset warning threshold, the microcontroller issues a visual alert. In the second stage, if a critical threshold is surpassed, the microcontroller automatically sends an emergency message via a CAN transceiver (MCP2515) to initiate braking. This action helps bring the vehicle to a safe halt, preventing further thermal build-up and potential hazards.

The CAN protocol ensures real-time, fault-tolerant communication between the temperature monitoring system and the braking module. The system also includes provisions for logging thermal anomalies and system responses, supporting predictive maintenance and system optimization. The modular design allows for seamless integration with various EV platforms and battery architectures, making the system scalable and adaptable.

This intelligent thermal safety system not only enhances vehicle and passenger safety but also contributes to the development of smarter, more reliable battery management technologies.

Keywords: Thermal Management; CAN Communication; Emergency Braking; Battery Safety

THE IMPACT OF DICHLOROMETHANE (DCM) AND IT'S TOXIC EFFECTS ON *MUS MUSCULUS*

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Dichloromethane (DCM) is an industrial solvent that can affect hepatic and metabolic parameters in experimental animals.
This study investigates the toxic effects of a single oral administration of DCM and their monitoring after five days, through the evaluation of blood biochemical parameters, liver enzymes (ALT, AST), and glucose levels in *Mus musculus*. Two groups of *M. musculus*, each consisting of 3 mice of both sexes, were divided into a control group and an experimental group. The experimental group received a single oral dose of DCM (0.2ml), dialuted with vegetable oil (50 ml),via gavage. Lethal dose (100 mg/kg).From this dose the mice recived 0.4 ml solution.The mice were maintained under standard laboratory conditions, and after five days, blood samples were collected for biochemical analysis. Blood parameters were measured using the Sysmex XN-L330 hematology analyzer; ALT and AST levels were determined using spectrophotometric methods, and glucose levels were assessed using an automated analyzer.
The results indicate a marked increase in ALT and AST levels following DCM administration, suggesting hepatic stress. Glucose levels were significantly elevated, indicating a metabolic response to the compound. Additionally, hematological data revealed variations in RBC, HGB, and HCT, reflecting potential effects on the hematopoietic system. The data also showed an increase in body weight.
Based on these findings, it can be concluded that a single oral dose of DCM results in significant physiological and biochemical changes after five days. These data underscore the importance of long-term analyses to fully assess the toxic potential of dichloromethane and its impact on various biological organs and systems.
Keywords: Dichloromethane (DCM), *Mus musculus* ,toxic effects ,changes in biochemical parameters.

UNDERSTANDING HYDROPS: CAUSES, DIAGNOSIS, AND MANAGEMENT ACROSS LIFE STAGES

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ABSTRACT:
Hydrops fetalis, or simply hydrops, is a serious condition characterized by the abnormal accumulation of fluid in two or more body compartments, which can affect fetuses, newborns, and adults. This condition is often a symptom of an underlying medical issue and can manifest in areas such as the abdomen, lungs, heart, and skin. Hydrops is categorized into fetal, neonatal, and acquired types, each with distinct causes, including genetic disorders, cardiovascular conditions, infections, and other medical conditions like liver disease. In fetal hydrops, causes include chromosomal abnormalities, structural heart defects, and infections like parvovirus, while neonatal hydrops often results from heart failure, infections, or metabolic disorders. Acquired hydrops, common in adults, is frequently linked to heart failure, liver cirrhosis, or infections. Symptoms vary by age and type, but typically include edema, respiratory distress, and jaundice. Early diagnosis through imaging tools like ultrasound and echocardiography, alongside blood tests, is crucial for identifying the cause and determining the appropriate treatment. Management focuses on addressing the root cause, such as blood transfusions for fetal anemia or diuretics for heart failure in adults. Prevention of hydrops involves early prenatal care, screening for infections, genetic counseling, and the management of chronic conditions. Early detection and timely intervention are vital for improving outcomes and reducing long-term complications associated with hydrops.
Keywords: Hydrops fetalis, fluid accumulation, fetal hydrops, neonatal hydrops, acquired hydrops, early diagnosis

INTRODUCTION TO HYDROPS

Hydrops, or hydrops fetalis, is a serious medical condition characterized by the accumulation of fluid in at least two fetal compartments. While it most commonly affects fetuses, it can also be observed in newborns and, in rare cases, adults. This excessive fluid buildup leads to generalized swelling (edema) and is usually a symptom of an underlying pathological process rather than a standalone disease.

In fetuses, hydrops can be identified through prenatal imaging, especially ultrasound, which may reveal fluid in the abdomen, chest cavity, heart, or under the skin. When the condition is present at birth, it is termed neonatal hydrops. In adults, although less frequent, acquired hydrops may arise secondary to heart failure, liver disease, or severe infections.

Numerous factors can lead to hydrops, including genetic anomalies, cardiovascular conditions, immune system dysfunctions, and infections. One of the most recognized causes in newborns is Rh incompatibility, where maternal antibodies attack fetal red blood cells. However, in some instances, no specific cause can be identified.

Prompt diagnosis and management are critical to improving survival and long-term outcomes. Treatment typically involves targeting the root cause of the fluid buildup, and the prognosis depends on how quickly intervention begins and the nature of the underlying disorder.

TYPES OF HYDROPS

Hydrops is broadly categorized into three forms based on the time of onset:

1. Fetal Hydrops

Fetal hydrops refers to fluid accumulation in a fetus before birth. It is typically detected during routine ultrasounds, which may show ascites, pleural or pericardial effusion, or skin edema. The condition can be caused by chromosomal abnormalities (e.g., Turner syndrome), congenital infections (e.g., parvovirus B19, CMV), and heart defects. Rh incompatibility, a classic cause, results from maternal antibodies destroying fetal red blood cells.

Fetal hydrops is further classified into:

- **Immune hydrops** – caused by red blood cell incompatibilities.
- **Non-immune hydrops** – due to infections, structural defects, or metabolic issues.

2. Neonatal Hydrops

This form is diagnosed after birth and often presents with severe swelling, breathing difficulties, and signs of cardiac or respiratory distress. Causes can include congenital heart disease, metabolic disorders, or persistent fetal circulation. It may also result from lymphatic dysfunction such as congenital lymphedema.

3. Acquired Hydrops

Acquired hydrops occurs postnatally or in adults, usually as a secondary condition due to chronic diseases. In adults, it's commonly associated with heart failure, cirrhosis, or nephrotic syndrome. These systemic illnesses disrupt fluid balance, leading to pathological retention.

CAUSES OF HYDROPS

The etiology of hydrops is diverse and depends on the patient's age and overall health. Key categories include:

1. Genetic and Chromosomal Disorders

Genetic syndromes such as Down syndrome or Turner syndrome can impair fetal development and fluid regulation, leading to hydrops.

2. Cardiovascular Diseases

Heart defects in fetuses or heart failure in adults can disrupt circulation and promote fluid leakage into body cavities.

3. Infections

Intrauterine infections, particularly by viruses like parvovirus B19 and CMV, are known to impair fetal hematologic and cardiovascular systems, contributing to hydrops.

4. Hemolytic Disease of the Newborn

Caused by Rh incompatibility, this immune-mediated condition leads to severe anemia and subsequent hydrops.

5. Other Medical Conditions

Liver and kidney dysfunctions, as well as metabolic abnormalities, can lead to fluid retention and systemic edema. In some cases, no clear cause is identified (idiopathic hydrops).

Clinical Presentation

The symptoms of hydrops vary depending on the patient's age and the severity of fluid accumulation:

In Fetuses

Ultrasound may reveal:

- Ascites
- Skin thickening due to edema
- Fluid around the lungs or heart
- Polyhydramnios (excess amniotic fluid)

In Neonates

Common signs include:

- Generalized edema

- Respiratory distress
- Heart failure
- Jaundice, particularly in immune-mediated cases

In Adults

Symptoms are usually linked to systemic disease:

- Swelling of legs or abdomen
- Shortness of breath
- Fatigue due to poor perfusion and oxygenation

DIAGNOSIS

A thorough clinical evaluation combined with imaging and laboratory tests is essential. For fetuses, ultrasound is the primary diagnostic tool, supported by amniocentesis or fetal echocardiography if needed. Blood tests can help detect infections or hemolytic diseases.

In adults, diagnosis includes physical examination, blood work, echocardiography, CT or MRI scans, and possibly biopsy if malignancy is suspected.

TREATMENT AND MANAGEMENT

Management strategies vary depending on the underlying cause:

Fetal Hydrops

- Intrauterine transfusion for anemia
- Antiviral therapy for infections
- Surgical correction of anomalies if possible
- Delivery planning if prognosis is poor

Neonatal and Adult Hydrops

- Diuretics to reduce fluid
- Cardiac medications like ACE inhibitors or beta-blockers
- Treatment of underlying conditions (e.g., dialysis for kidney failure, antiviral drugs for infections)
- Paracentesis or thoracentesis in severe cases

Prevention and Risk Reduction

Preventive strategies include:

- Early prenatal care and screening for infections and genetic conditions
- Rh immunoglobulin administration to Rh-negative mothers
- Managing chronic diseases like hypertension or diabetes in adults
- Nutritional support to prevent protein-energy malnutrition
- Routine fetal monitoring in high-risk pregnancies

CONCLUSION

Hydrops is a multifactorial condition with potentially serious consequences. Whether occurring in the womb, at birth, or in adulthood, it reflects an underlying disturbance in fluid homeostasis that must be thoroughly investigated. Advances in diagnostic imaging and prenatal care have improved early detection, enabling timely interventions that enhance outcomes. Tailoring treatment to the underlying cause and maintaining vigilant monitoring are essential in the effective management of hydrops.

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KAZAKISTAN'IN KUZEY BÖLGELERİNDE BUĞDAY ÜRETİMİNİN EKONOMİK ANALIZI: VERIMLILIK, İHRACAT VE ULUSLARARASI KARŞILAŞTIRMA

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ÖZET
Bu makale, 2015–2023 yılları arasında Kuzey Kazakistan'daki buğday üretiminin ekonomik analizini sunmaktadır. Çalışma kapsamında Akmola, Kostanay ve Kuzey Kazakistan bölgelerinin buğday verimliliği, ekim alanları, bitkisel üretim değerleri ve hasat miktarları resmi istatistiklere dayanarak değerlendirilmiştir. Ayrıca, 2021 yılında yaşanan aşırı kuraklığın üretim üzerindeki etkisi detaylı biçimde incelenmiş, sulama altyapısının yetersizliği, sigorta kapsama oranlarının düşüklüğü ve finansman sorunları gibi yapısal sınırlılıklar vurgulanmıştır. Buğday ihracatının yönleri, başlıca ithalat ortakları ve dış ticaret yapısı da analiz edilerek, Kazakistan'ın bölgesel ve uluslararası buğday pazarındaki konumu açıklanmıştır. Özellikle Özbekistan ve Tacikistan gibi komşu ülkelere yoğun ihracat yapılmakta olup, düşük verimlilik seviyesi nedeniyle Kazakistan'ın küresel pazarda rekabet gücü sınırlı kalmaktadır. Makalede ayrıca Kazakistan'ın verimlilik açısından Kanada, Ukrayna, Rusya ve Türkiye gibi ülkelerle karşılaştırmalı analizi yapılmış ve önemli performans farklarına dikkat çekilmiştir. Elde edilen bulgular, ülkenin buğday üretiminde sürdürülebilirliği sağlamak amacıyla verimlilik artırıcı yapısal reformlara ve yatırımlara ihtiyaç duyduğunu ortaya koymaktadır. Sonuç bölümünde, sulama sistemlerinin geliştirilmesi, kaliteli tohum kullanımı ve tarımsal sigorta sistemlerinin iyileştirilmesi gibi politika önerileri sunulmuştur.
Anahtar Kelimeler: buğday, verimlilik, ihracat, ekonomi, Kuzey Kazakistan, kârlılık, tarım

ECONOMIC ANALYSIS OF WHEAT PRODUCTION IN NORTHERN KAZAKHSTAN: PRODUCTIVITY, EXPORTS, AND INTERNATIONAL COMPARISON

ABSTRACT
This article presents an economic analysis of wheat production in Northern Kazakhstan during the period 2015–2023. The study examines official statistics on wheat yields, sown areas, crop production values, and harvest volumes across the Akmola, Kostanay, and North Kazakhstan regions. Special attention is given to the impact of the severe drought in 2021, highlighting structural limitations such as insufficient irrigation infrastructure, low crop insurance coverage, and financing challenges. The paper also analyzes the structure of wheat exports, identifies key import partners, and evaluates Kazakhstan's position in regional and global wheat markets. The findings show that despite significant export flows to neighboring countries such as Uzbekistan and Tajikistan, Kazakhstan's low yield levels limit its international competitiveness. A comparative assessment is conducted with major wheat-producing countries like Canada, Ukraine, Russia, and Turkey, revealing substantial gaps in productivity. These results underscore the urgent need for structural reforms and investment in productivity-enhancing measures to ensure the sustainability of wheat production in Kazakhstan. The conclusion offers policy recommendations including the development of modern irrigation systems, the use of high-quality seeds, and the improvement of agricultural insurance mechanisms as essential strategies for strengthening the country's grain sector and securing long-term export potential.
Keywords: wheat, productivity, export, economy, Northern Kazakhstan, profitability, agriculture

CHICORY PLANT: EXTRACTION, PURIFICATION, AND USES IN HERBAL DRUG TECHNOLOGY

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ABSTRACT:
The chicory plant (Cichorium intybus L.) is a versatile plant with a long history of culinary and medicinal applications. This abstract will outline common methods for the extraction of valuable compounds from chicory, including solvent extraction (e.g., using water, ethanol) from various plant parts like roots, leaves, and flowers, often optimized for specific targets like inulin, sesquiterpene lactones, or polyphenols. Purification techniques such as filtration, liquid-liquid extraction, chromatography, and ultrafiltration are employed to isolate and concentrate these bioactive constituents.The uses of chicory and its extracts are diverse. The root is well-known as a coffee substitute and a significant source of inulin, a prebiotic dietary fiber widely used in the food industry. Other extracts exhibit antioxidant, anti-inflammatory, antimicrobial, and potentially antidiabetic and anticancer properties. Different parts of the plant are also used in traditional medicine for various ailments, including digestive issues and liver disorders. This abstract will provide an overview of the extraction and purification processes used to obtain valuable compounds from the chicory plant and highlight the broad range of their applications in food, nutraceuticals, and potentially pharmaceuticals.
Keywords: Cichorium intybus, chicory, extraction, purification, inulin, uses, medicinal properties.

ANALYSIS OF TENSILE CHARACTERISTICS IN EPOXY COMPOSITES: ASSESSING TWARMAT AND WOVEN GLASS FIBER REINFORCEMENTS

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ABSTRACT
This study aims to assess the tensile characteristics of a novel TWARMAT hybrid fabric, comprising aramid and E-glass fibers with a weight of 600 g/m². Additionally, a conventional 205 g/m² plain glass fabric, 160 g/m² plain carbon fibers fabric are also tested for comparison. Various laminated plates are manufactured with different fiber mass fractions. Our results reveal that TWARMAT exhibits superior stiffness and density ratios in comparison to E-glass fibers, with carbon fibers showing the highest ratio. Remarkably, only three E-glass woven layers with a fiber mass fraction (Mf) of 0.6 exceed the ultimate tensile strength of a single carbon ply with Mf=0.2 by 11.6%, with in contrast a 36.8% rise in density. To further confirm the experimental results, the rule of mixtures (ROM) is utilized. The close agreement between the two sets of data, with mean relative errors of 5.5% and 1.05% for Young's modulus and density respectively, confirms the reliability of our methods. Additionally, fitted functions are developed in this work for Young's modulus and density curves based on fiber mass fractions Mf using ROM. The conducted analysis reveals that the carbon fiber fabric composite demonstrates the most favorable rigidity-to-lightness (E/ρ) ratio, reaching a peak of approximately 65.7% compared to TWARMAT at Mf=0.58 and 74% compared to E-glass at Mf=0.78. Furthermore, hybrid TWARMAT exhibits a maximum estimated increase of 27% at Mf=0.86 compared to the traditional E-glass fiber. These findings underscore the significance of selecting appropriate materials to achieve optimal stiffness and lightness, rendering them suitable for various applications, including aeronautics, marine, and sports.
Keywords: Composite Materials; Tensile mechanical properties; Glass-carbon-aramid fiber; Epoxy-matrix composites; rule of mixture.

ACCESS AND USE OF INFORMATION AND COMMUNICATION TECHNOLOGY AMONG RICE FARMERS IN ISHIELU, EBONYI STATE, NIGERIA

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Abstract:
The study assessed the use of information and communications technology among rice farmers in Ishielu, Ebonyi State, Nigeria. A multistage sampling procedure was used to select a hundred and twenty respondents for the study. Data were analysed with frequencies, mean scores, and regression analysis. Results show that 63.3% of the respondents were above 30 years old, and 22.2% did not have formal education. The main sources of agricultural information were mass media (67%), extension services (34%), and fellow farmers (32%). Most of the respondents (66.67%) had access to information and communication technology. Some of the challenges of accessing information and communication technology include high cost (73.4%), low level of digital literacy (67.3%), and inadequate access to power supply (54.8%). Factors that influenced rice farmers' access to information communications technology include education (β=0.782), income (β=0.035), membership in cooperative society (β=0.310), and extension contacts (β=-0.073). The study concludes that rice farmers have access to ICTs and recommends that the government should subsidize the cost of ICT and improve power supply in rural areas.
Keywords: Mass media, extension contact, power supply.

Introduction

Information and Communication Technology (ICT) is currently at the front burner of discussions relating to agricultural development amidst the challenges of climate change and food insecurity. The lack of a functional agricultural information delivery system is a major constraint to agricultural development in Nigeria (Agou et al., 2023).

In Nigeria, the importance of the rice industry cannot be overemphasized based on the vital role it plays in human nutrition, source of employment and income generation at large (Agou et al., 2023). The role of information and Communications Technology (ICT) in disseminating agricultural information, innovation and ideas in the study area has never been recognized even though researchers are still trying to bridge the gap between the research stations and these rural farmers (rice farmers). This has consequently marginalized agriculture and farming families which has resulted in low productivity despite the efforts in communicating agricultural information to the farmers. The above-mentioned problems call for the use of ICTs to support agricultural extension services because ICT tools like computers, mobile phones, radio, television, newspapers etc. can be very effective in delivering timely and relevant information to farmers, even to those living in remote areas. The study therefore investigated the access and use of information and communication technology among rice farmers in

Ishielu, Ebonyi State, Nigeria. Specifically, the study described the socio-economic characteristics of rice farmers, ascertained their access to ICT tools, determined the factors influencing farmers' access to ICT tools, and profiled the challenges of utilization of ICTs among farmers.

Hypothesis:

There is no significant association between the socio-economic characteristics of the rice farmers and their access to ICT tools in the study area.

Methodology

This study was conducted in the Isielu Local Government Area of Ebonyi State. Ishielu is a Local Government Area (LGA) in Ebonyi state, Nigeria. The community lies between longitude 7 0 51' 36" E and latitude 60 14' 48" N. Ishielu has two climate seasons, the rainy season from March to October and the dry season from November to February. The annual rainfall is approximately 230 millimetres and the atmospheric temperature ranges from (25^0 C to 42^0 C) (Omonona *et al*., 2015). The required sample size for this study was determined through the use of the popular Taro-Yamane (1964) formula which states as:

$$n = \frac{N}{1 + N(0.05)^2}$$

Where

n= sample size

N = population of the study

e= error term or margin at 5%

To compute the sample size for this study, N = 12, 000, e = 0.05

$n = \frac{4698}{1+4698(0.05)^2} = \frac{4698}{1+11.75} = \frac{4698}{12.75}$ = 400

Four hundred rice farmers were selected to take part in the survey. A simple random sampling technique were adopted to pick the final 120 respondents so as to minimize error. The purpose of the simple random sampling is to ensure that members of the population have equal right of being selected. Data were collected through the use of interview schedule and analyzed with descriptive and inferential statistics.

Results and Discussion

Socio-economic characteristics

Results presented in Table 1 show that the majority of the respondents (63.34%) were above thirty years while about 22.2% did not have any form of formal education. This implies that respondents were at their youthful age and should make effective use of ICTs. The results agree with Izuogu et al. (2021) that the majority of the rice farmers in Ebonyi state are below 40 years. Also, the low percentage of respondents without formal education will support the efficient use of ICT tools in rice production. Oparaojiaku et al (2024) reported that the use of ICTs by farmers is directly related to access to formal education.

Table 1: Respondents' socio-economic characteristics

Characteristics	Frequency	Percentage
Age (years)		
< 20	23	19.17
21-30	53	44.17
31-40	12	10.00
41-50	13	10.83
51-60	13	10.83
>60	6	5.00
Level of Education		
No formal education	27	22.20
Primary	54	45.00

Secondary	32	26.70
Tertiary	7	5.80
Marital Status		
Married	83	69.17
Single	23	19.17
Divorced	4	3.33
Widowed	10	8.33
Years of farming experience		
< 5	23	
>5 - <10	42	
>10 - < 15	11	
>15 - < 20	26	
>20 - < 35	12	
> 25	6	

Source: Field Survey

Sources of Agricultural Information

Table 2 shows that the major sources of agricultural information among rice farmers in the study area include the mass media (67.00%), extension services (34.00%), cooperative societies (33.30%), and friends and family (32.00%).

The result is supported by Oyero *et al*. (2018) and Trendov *et al*. (2019) who reported an increase in the use of mass media by farmers. Early publications reported that one of the major hindrances to farmers' access to agricultural information is the difficulty in accessing information and messages. Effective agricultural extension and advisory services will assist in the reduction of information dissymmetry that relates to the use of ICT in rice cultivation and raise farmers' awareness of the benefits of ICTS. However, the agricultural extension services in Nigeria have been reported to be dwindling since the withdrawal of the World Bank counterpart fund (Izuogu *et al*., 2015).

Table 2: **Rice farmers' sources of information**

Sources	Frequency	Percentage
Mass media	80	67.00
Extension services	40	34.00
Cooperative Society	39	33.30
Family and friends	38	32.00

Source: Field survey. * Multiple responses were recorded

Access to Information Communication Technology

Table 3 shows that the majority (66.67%) of the respondents had access to information communication technology (ICT). Most of the rice farmers had radio access (72.50%). Other ICT tools that rice farmers accessed were telephone (38.33%), television (33.33%), and desktop computers (19.17%) among others. Few (5%) respondents had projectors in the study area. This implies that rice farmers can use various forms of ICTs in their production activities. Atasie and Izuogu (2017) reported that farmers rarely use projectors in the study area. This they attributed to the absence of technical skills and the high cost of projector machines.

Table 3: Access to ICTs

Access	Frequency	Percentage
Yes	80	66.67
No	40	33.33
Access to ICT tools		
Radio	87	72.50
Telephone	46	38.33
Desktop computer	23	19.17
Laptop computer	12	10.00
Internet	23	19.17
Television	40	33.33
Projector	6	5.00

Source: Field survey * Multiple responses were recorded

Table 4: Challenges of Accessing ICTs Among rice farmers

Results presented in Table 4 show some of the challenges encountered by rice farmers in the course of using ICTs. The majority of the respondents identified the high cost of the tools (73.40%), lack of tools (68.33%), scarcity of extension officers (65.00%), insufficient infrastructure (60.00%) and inappropriate tools (55.83%) as the challenges facing their use of ICTs. the result implies that rice farmers are encumbered with several challenges in their use of Information and Communications Technology and these challenges may hinder their optimal utilization of these tools. The findings are in line with Atasie et al. (2019) who observed that farmers' willingness to use ICT facilities is dampened by several challenges including their inability to afford these tools. Izuogu et al. (2024) highlighted the challenges of insufficient extension workers in the south-eastern part of Nigeria including difficulties in adopting innovative communication packages by rural farmers.

Table 4: Respondents' challenges in using ICTs

Challenge	Frequency	Percentage
Costly ICT tools	88	73.40
Lack of ICT tools	82	68.33
The shortfall of extension officers	78	65.00
Farmers lack digital literacy	81	67.30
Inadequate rural infrastructure	72	60.00
Poor access to the power supply	68	54.80
Inappropriate ICT tools	67	55.83
Low level of internet services	56	46.67
Absence of pioneers in ICT use	34	28.33

Source: Field Survey

Determinants of access to ICTS among rice farmers

Entries in Table 5 represents the Probit estimate of factors influencing farmers' access to ICTs in the study area. In keeping with the study hypothesis, income, education, membership in cooperative society and extension contact influenced farmers' access to ICT facilities. Essentially, the more farmers joined cooperative organizations, the more the likelihood of their accessing ICTs. Atasie et al (2015) opined that membership in an association can influence the extent to which farmers use innovations as they are expected to get information on farm inputs and other advisory services through these associations. Level of education was positively related to the access to ICTs. Izuogu et al (2015) reported that acquiring formal education increased innovation adoption, reduced the vulnerability of farmers, and achieved results consistent with the primary goal of any agricultural information dissemination system

The result also shows that respondents' income had a significant positive influence on their access to ICTs. This implies that as the farmers' income increases, the more the tendency of the farmers to access ICT facilities. The findings agree with Oparaojiaku et al. (2024) and Orji et al. (2025) that higher revenues enable farmers to diversify their sources of agricultural information with a positive bias toward ICTs and digital tools.

Extension contact had a negative influence on farmers' access to ICTs. This implies that the more contacts rice farmers had with extension officers, the higher the likelihood of their not accessing ICTs. This does not agree with Njoku et al. (2025) and Izuogu et al. (2020) who reported that as farmers contact with extension services increased, the likelihood of their motivation for innovative communication tools increased. The difference may be attributed to extension officers' use of their official ICT equipment during extension visits which may create reluctance among farmers to acquire their personal ICT tools.

Table 5: Factors influencing rice farmers' access to ICTs

Variables	Coefficient	Value of p
Gender	-0.296	0.252
Perception of ICTs	-0.332	0.232
Education	0.782	0.024 **
Marital status	0.030	0.231
Income	0.035	0.002***
Membership in a cooperative society	0.310	0.005 ***
Extension contact	-0.073	0.013 **
Constant	-1.632	0.173
	F = 3.81	0.004

Source: Field Survey

Conclusion

Farmers in Ishielu Local Government of Ebonyi state are aware of the use of ICTs in rice cultivation with the mass media playing a very pivotal role in disseminating ICT- relate information. Although the majority of the respondents had access to ICTs in the study area, several challenges hindered their optimal use of these facilities. Income, educational level, and membership in cooperative society influenced farmers' use of ICTs. The study recommends that the government should provide subsidies to facilitate easy access to ICTs by farmers. The extension system should encourage farmer education to motivate rice farmers to adopt ICTs.

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ACETYLCHOLINE, MOLECULAR CHARACTERISTICS, AND APPLICATIONS

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Abstract:
Acetylcholine (ACh) is a vital neurotransmitter in both the central and peripheral nervous systems, playing a key role in a wide array of physiological and pharmacological processes. Structurally, acetylcholine is a small, quaternary ammonium compound synthesized from choline and acetyl-CoA by the enzyme choline acetyltransferase. It is stored in synaptic vesicles and released at cholinergic synapses, where it binds to two main receptor types: nicotinic and muscarinic acetylcholine receptors.In the peripheral nervous system, acetylcholine mediates neuromuscular transmission, autonomic nervous system responses, and parasympathetic activities, such as heart rate modulation, glandular secretion, and smooth muscle contraction. In the central nervous system, it contributes to memory formation, attention, and learning, with cholinergic deficits being strongly implicated in neurodegenerative diseases such as Alzheimer's disease.Pharmacologically, the modulation of acetylcholine activity has led to the development of therapeutic agents such as anticholinesterases (e.g., donepezil, neostigmine), muscarinic agonists and antagonists (e.g., pilocarpine, atropine), and nicotinic receptor modulators. These drugs are used in managing conditions including myasthenia gravis, glaucoma, Alzheimer's disease, and bradycardia.The significance of acetylcholine in both physiological regulation and clinical application underscores its value in neuroscience and pharmacology. Its mechanisms continue to be the focus of intensive research, with the potential for novel therapies targeting cholinergic pathways in diverse diseases.
Keywords: Acetylcholine, neurotransmitter, cholinergic system, muscarinic receptor, nicotinic receptor, neuromuscular junction, memory, Alzheimer's disease, acetylcholinesterase, pharmacology.

EBEVENYLERİN SAĞLIK İNANCI, ANTİBİYOTİK ALGISI VE AŞI TUTUMLARI ARASINDAKİ İLİŞKİ

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Öz: Bu araştırma, ebeveynlerin sağlık inancı, antibiyotik algısı ve aşı tutumları arasındaki ilişkiyi belirlemek amacıyla yapılmıştır. Araştırma, Türkiye'nin Doğu'sunda üçüncü basamak bir üniversitesi hastanesinde 347 ebeveyn ile Ekim 2024-Ocak 2025 tarihleri arasında, tanımlayıcı ve ilişki arayıcı türde yürütülmüştür. Araştırmaya katılmayı kabul eden ebeveynlerden Kişisel Bilgi Formu, Ebeveyn Sağlık İnanç Ölçeği (EBSİÖ), Anne ve Babaların Antibiyotik Algıları Ölçeği (ABANA), Çocukluk Çağı Aşıları Hakkında Ebeveyn Tutumları Ölçeği (PACV) kullanılarak veriler toplanmıştır. Katılımcıların 37.42±09.05 ve eşlerinin yaş ortalaması 37.33±09.87'dir.Katılımcıların %64.5'i aşılar ile ilgili eğitim almış, %92.7'si çocuğuna çocukluk çağı aşılarını yaptırmıştır. Ebeveynler orta düzeyde sağlık inancı, ortanın altında antibiyotik algısı ve orta düzey aşı tutumuna sahip oldukları bulunmuştur. Katılımcıların cinsiyeti, eğitim düzeyi ve hastaneye başvurma sıklığı ile EBSİÖ, ABANA ve PACV toplam puanı arasında istatistiksel olarak anlamlı bir fark olduğu belirlenmiştir ($p<0.05$). Ebeveynlerin PACV Ölçeği'nin toplam puanına göre %54.46'sının aşı tereddütlü olduğu saptanmıştır. Katılımcıların EBSİÖ puanları ile ABANA arasında orta düzeyde pozitif bir ilişki, PACV ile ise zayıf düzeyde pozitif bir ilişki bulunmuştur ($p<0.05$). EBSİÖ toplam puanının PACV'nin %2.2'sini, ABANA toplam puanının ise PACV'nin %2.4'ünü açıkladığı belirlenmiştir. Bulgulara göre ebeveynlerin sağlık inançları, antibiyotik algısı ve aşı tutumlarını güçlendirmek ve bilimsel temelli bilgilere dayalı kararlar almalarını sağlamak amacıyla farkındalık çalışmalarının yapılması, sağlık çalışanlarının konu ile ilgili bilgi düzeylerinin arttırılması için eğitimler ile güçlendirilmesi ve bireysel danışmanlık hizmetlerinin artırılması önerilmektedir.
Anahtar Kelimeler: *Ebeveyn, çocuk, sağlık inancı, antibiyotik algısı, aşı tutumu*

THE RELATIONSHIP BETWEEN PARENTS' HEALTH BELIEFS, ANTIBIOTICS PERCEPTIONS AND VACCINE ATTITUDES

Abstract: This study was conducted to determine the relationship between parents' health beliefs, perceptions of antibiotics, and attitudes toward vaccination. The research was conducted as a descriptive and correlational study with 347 parents at a tertiary university hospital in Eastern Türkiye between October 2024 and January 2025. Data were collected from parents who agreed to participate using the Personal Information Form, the Parental Health Belief Scale (PHBS), Parents' Perceptions of Antibiotics Scale (PPAS), and the Parent Attitudes about Childhood Vaccines (PACV) Scale. The mean age of participants was 37.42±09.05, and the mean age of their spouses was 37.33±09.87. Among the participants, 64.5% had received education about vaccines, and 92.7% had vaccinated their children with

childhood vaccines. It was found that the parents had a moderate level of health beliefs, a below-moderate perception of antibiotics, and a moderate attitude toward vaccines. Statistically significant differences were found between participants' gender, education level, and frequency of hospital visits and the total scores of the PHBS, PPAS, and PACV scales ($p<0.05$). Based on the total PACV scores, 54.46% of parents were identified as vaccine-hesitant. A moderate positive correlation was found between PHBS and PPAS scores, and a weak positive correlation between PHBS and PACV scores ($p<0.05$). It was determined that PHBS total scores explained 2.2% of the variance in PACV scores, while PPAS total scores explained 2.4%. Based on the findings, it is recommended to carry out awareness-raising initiatives to strengthen parents' health beliefs, perceptions of antibiotics, and vaccine attitudes, to provide training programs to enhance healthcare professionals' knowledge on the subject, and to increase the availability of individual counseling services to support evidence-based decision- making.
Keywords: Parent, child, health belief, perception of antibiotics, vaccine attitude

DESTEK VEKTÖR MAKİNELERİ VE SMO, MBO İLE PSO KULLANILARAK OPTİMİZASYONU: KARŞILAŞTIRMALI BİR ÇALIŞMA

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ÖZET
Destek Vektör Makineleri (SVM'ler), yüksek boyutlu uzaylarda optimal ayırıcı hiper düzlemleri bulma yetenekleri sayesinde, özellikle sınıflandırma ve regresyon problemlerinde etkili olan sağlam ve yaygın olarak kullanılan denetimli öğrenme algoritmalarıdır. SVM eğitiminin temelinde, sınıflar arasındaki marjı maksimize ederken sınıflandırma hatasını minimize etmeyi amaçlayan konveks bir optimizasyon probleminin çözülmesi yer alır. Bu probleme yönelik geleneksel yöntemlerden biri olan Sıralı Minimal Optimizasyon (SMO), analitik ayrıştırma yoluyla verimli çözümler sunar. Ancak, günümüzde veri setlerinin karmaşıklığı ve boyutu giderek artmakta; veri dağılımları daha düzensiz, çok modlu ve doğrusal olmayan hâle gelmektedir. Bu tür durumlarda, geleneksel yöntemlerin performansı sınırlı kalabilmektedir. Bu nedenle, Parçacık Sürü Optimizasyonu (PSO) ve Göçmen Kuşlar Optimizasyonu (MBO) gibi doğrusal olmayan yöntemler, çok boyutlu ve yerel minimumlara takılma ihtimali yüksek problemlerde daha esnek ve etkili çözümler sunabilmektedir.
Bu çalışmada SVM amaç fonksiyonunun çözümünde SMO, MBO ve PSO yöntemleri kullanılmıştır. SMO, SVM'ler için özel olarak tasarlanmış deterministik bir algoritmayken; MBO ve PSO, sırasıyla kuşların ve parçacıkların doğal hareketlerinden esinlenen, popülasyon tabanlı metasezgisel algoritmalardır. Her bir algoritma sentetik bir veri kümesi üzerinde ayrı ayrı uygulanmıştır. Uygulama sürecinde algoritmaların performansları üç temel kriter üzerinden değerlendirilmiştir: sınıflandırma doğruluğu, yakınsama hızı ve hesaplama verimliliği. Sınıflandırma doğruluğu, modelin veri noktalarını doğru sınıflara atama yeteneğini ölçerken; yakınsama hızı, algoritmanın en uygun çözümü bulmak için ihtiyaç duyduğu iterasyon veya zaman miktarını ifade etmektedir. Hesaplama verimliliği ise algoritmanın işlem süresi ve bellek kullanımı dikkate alınarak değerlendirilmiştir.
Anahtar Kelimeler: Destek Vektör Makineleri, Sıralı Minimal Optimizasyon, Parçacık Sürü Optimizasyonu, Göçmen Kuşlar Optimizasyonu, Dual (ikili) Problem

SUPPORT VECTOR MACHINES AND THEIR OPTIMIZATION USING SMO, MBO, AND PSO: A COMPARATIVE STUDY

ABSTRACT
Support Vector Machines (SVMs) are robust and widely used supervised learning algorithms that are particularly effective in classification and regression problems due to their ability to find optimal separating hyperplanes in high-dimensional spaces. At the core of SVM training lies the solution of a convex optimization problem that aims to maximize the margin between classes while minimizing classification error. One of the traditional methods for solving this problem, Sequential Minimal Optimization (SMO), provides efficient solutions through

analytical decomposition. However, the complexity and size of datasets are increasing, and data distributions are becoming more irregular, multi-modal, and non-linear. In such cases, the performance of traditional methods can be limited. Therefore, non-linear methods such as Particle Swarm Optimization (PSO) and Migrating Birds Optimization (MBO) can offer more flexible and effective solutions for high-dimensional problems that are prone to local minima.
In this study, SMO, MBO, and PSO methods were used to solve the SVM objective function. While SMO is a deterministic algorithm specifically designed for SVMs, MBO and PSO are population-based metaheuristic algorithms inspired by the natural behavior of birds and particles, respectively. Each algorithm was individually applied to a synthetic dataset. During the implementation process, the performance of the algorithms was evaluated based on three main criteria: classification accuracy, convergence speed, and computational efficiency. Classification accuracy measures the model's ability to assign data points to the correct classes, while convergence speed refers to the number of iterations or the amount of time required to reach the optimal solution. Computational efficiency was evaluated by considering the algorithm's processing time and memory usage.
Keywords: Support Vector Machines, Migrating Birds Optimization, Particle Swarm Optimization, Sequential Minimal Optimization, Dual Problem

PLASTİK, REKONSTRÜKTİF VE ESTETİK CERRAHİDE SON TEKNOLOJİ: YAPAY ZEKA VE HEMŞİRELİK YAKLAŞIMLARI

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ÖZET
Yapay zeka (YZ), kavramaya ilişkin bilişsel fonksiyonları yerine getirmek için programlanmış makinelerde insan zekasının bir simülasyonu olarak ifade edilebilir. Plastik, rekonstrüktif ve estetik cerrahide YZ, meme rekonstrüksiyonu, rinoplasti, ekstremite rekonstrüksiyonu, maksillofassiyal yüz rekonstrüksiyonu, doku transferleri, yara bakımı ve skar yönetimi, yanık derecesinin belirlenmesi gibi girişimlerde kullanılmaktadır. YZ, plastik cerrahi alanına büyük veri analitiği, makine öğrenimi, derin öğrenme, doğal dil işleme ve yüz tanıma gibi teknolojiler, plastik cerrahlara tanı doğruluğunu artırmak, cerrahi planlamayı optimize etmek ve hasta sonuçlarını iyileştirmek için önemli araçlar sağlamaktadır. YZ'nın avantajları arasında, daha erken tespit ve teşhis yoluyla iyileştirilmiş hasta bakımı ve iş akışı sağlayarak tıbbi hataları, maliyeti, morbidite ve mortaliteyi azaltarak, plastik cerrahi bilimsel yayınlarına entegrasyonu, verimli veri analizini sağlayarak, cerrahi planlamayı iyileştirerek, sonuçları tahmin ederek ve kanıta dayalı ilerlemeleri kolaylaştırarak alanda yeniliği sağlaması bulunmaktadır. Dezavantajları arasında ise hasta mahremiyetinin korunması ve veri güvenliği açısından risk oluşturması, veri ihlalleri, hastaların kişisel bilgilerinin yetkisiz kişilerin eline geçmesine neden olması, YZ modellerinin eğitildikleri verilerdeki önyargıları yansıtabileceği ve yapay sinir ağı ve evrişimli sinir ağı gibi tekniklere dayalı kararları alırken plastik cerrahların denetimini gerektirmesi bulunmaktadır. Klinik veri sağlama sürecinde, plastik cerrahlar tıbbi etik ilkelere kesinlikle uymalı, hastaların mahremiyetini korumalıdır. Hemşirelerin YZ teknolojilerine uyum sağlaması, hasta bakımının kalitesini artırmak ve etik standartları korumak açısından kritik öneme sahiptir. YZ, cerrahi hastalarının bakımında hemşirelere destek sağlayarak, rutin işlerin otomasyonunu ve hasta verilerinin analizini kolaylaştırmaktadır. Bu durum, hemşirelerin zamanlarını daha fazla hasta bakımına ayırmalarına olanak tanır. Hemşireler, YZ'yı etkin bir şekilde kullanabilmek için sürekli eğitim almalı, hasta için faydalarının ve zararlarının farkında olarak yapay zekanın potansiyelinden en iyi şekilde yararlanmalı ve bunu hasta bakımına yansıtmalıdır.
Anahtar Kelimeler: Plastik, rekonstrüktif ve estetik cerrahi, yapay zeka, hemşire

THE LATEST TECHNOLOGY IN PLASTIC, RECONSTRUCTIVE AND AESTHETIC SURGERY: ARTIFICIAL INTELLIGENCE AND NURSING APPROACHES

ABSTRACT
Artificial intelligence (AI) can be expressed as a simulation of human intelligence in machines programmed to perform cognitive functions related to cognition. In plastic, reconstructive and aesthetic surgery, AI is used in interventions such as breast reconstruction, rhinoplasty, limb reconstruction, maxillofacial facial reconstruction, tissue transfers, wound care and scar management, and determining the degree of burns. Technologies such as big data analytics, machine learning, deep learning, natural language processing and facial recognition are

providing plastic surgeons with important tools to improve diagnostic accuracy, optimize surgical planning and improve patient outcomes. The advantages of AI include enabling innovation in the field by reducing medical errors, cost, morbidity and mortality by enabling improved patient care and workflow through earlier detection and diagnosis, integration into plastic surgery scientific publications, enabling efficient data analysis, improving surgical planning, predicting outcomes and facilitating evidence-based advances. Among the disadvantages are that it poses a risk in terms of patient privacy protection and data security, data breaches, causing patient's personal information to fall into the hands of unauthorized persons, artificial intelligence models can reflect the biases in the data they are trained on and require the supervision of plastic surgeons when making decisions based on techniques such as artificial neural network and convolutional neural network. In the process of providing clinical data, plastic surgeons should strictly follow the principles of medical ethics and protect the privacy of patients. Nurse's adaptation to AI technologies is critical to improve the quality of patient care and maintain ethical standards. AI supports nurses in the care of surgical patients by facilitating the automation of routine tasks and the analysis of patient data. This allows nurses to spend more time on patient care. In order to use AI effectively, nurses should receive continuous training, be aware of its benefits and harms for the patient, use the potential of AI in the best way and reflect it to patient care.
Keywords: Plastic, reconstructive and aesthetic surgery, artificial intelligence, nurse

Giriş

Yapay zeka (YZ), makinelere akıl yürütme yeteneği, problem çözme, kelime ve nesneleri ayırt edebilme ve kendi kendine fikir üretebilme gibi kognitif fonksiyonlar kazandırır. Bu sebeple YZ, kavramaya ilişkin bilişsel fonksiyonları yerine getirmek için programlanmış makinelerde insan zekasının bir simülasyonu olarak ifade edilebilir (Murphy vd., 2020; Barone vd., 2024). Görüntüleme ve tanı teknolojilerinde, cerrahi enstrümantasyon, cerrahi navigasyon ve robotik cerrahi uygulamaları gibi alanlarda ileri düzeyde teknolojik gelişmelerin meydana gelmesi, YZ'nın da cerrahi uygulamalar üzerinde kademeli olarak gelişimini sağlamaktadır (Barone vd., 2024).

Plastik Cerrahide Yapay Zekanın Kullanımı

Plastik, rekonstrüktif ve estetik cerrahi kapsamında YZ, meme rekonstrüksiyonu, rinoplasti, ekstremite rekonstrüksiyonu, maksillofassiyal yüz rekonstrüksiyonu, doku transferleri, yara bakımı ve skar yönetimi, yanık derecesinin belirlenmesi gibi cerrahi girişimlerde kullanılmaktadır (Erdem vd., 2023; Maita vd., 2024; Eldaly vd., 2022; Fung vd., 2024; Espinosa Reyes vd., 2024).

YZ'nın plastik cerrahi alanında çok sayıda uygulaması vardır. YZ'nın sağladığı büyük veri analitiği, makine öğrenimi, derin öğrenme, doğal dil işleme ve yüz tanıma gibi teknolojiler, plastik cerrahlara tanı doğruluğunu artırmak, cerrahi planlamayı optimize etmek ve hasta sonuçlarını iyileştirmek için önemli araçlar sağlamaktadır (Jarvis vd., 2020; Patcas vd., 2018; Murphy vd., 2020). Örneğin YZ'nın, yüz germe ve yüz transseksüel cerrahisi gibi birden fazla girişimde, hastanın cerrahi girişim öncesi ve sonrası durumunu nesnel olarak karşılaştırma amacıyla evrişimli sinir ağları modellerini kullanan bilgisayar görüşünden yararlanma gibi kullanım alanları bulunmaktadır (Espinosa Reyes vd., 2024).

YZ'dan yararlanırken klinik veri sağlama sürecinde, plastik cerrahlar tıbbi etik ilkelere kesinlikle uymalı, hastaların mahremiyetini korumalı ve hastalar bilgilendirilmiş onam imzalamalıdır. YZ, yapay sinir ağı ve evrişimli sinir ağı gibi tekniklere dayalı kararları alırken plastik cerrahların denetimini ve düzeltmesini gerektirir. YZ, derin öğrenme ve karar alma sürecinde, plastik cerrahlardan gelen geri bildirimler yoluyla ilerler. Aynı zamanda YZ'nın klinik çalışmalara uygun olup olmadıklarının değerlendirilmesi için plastik cerrahlara ihtiyaç vardır (Luan vd., 2021; Kiwan vd., 2024).

Yapay Zekanın Plastik Cerrahide Kullanımının Avantajları

YZ'nın avantajları arasında, YZ teknolojisinin daha erken tespit ve teşhis yoluyla iyileştirilmiş hasta bakımı ve iş akışı sağlayarak tıbbi hataları, maliyeti, morbidite ve mortaliteyi azaltması bulunmaktadır (Erdem vd., 2023; Nogueira vd., 2025). YZ'nın plastik cerrahi bilimsel yayınlarına entegrasyonu, verimli veri analizini sağlayarak, cerrahi planlamayı iyileştirerek, sonuçları tahmin ederek ve kanıta dayalı ilerlemeleri kolaylaştırarak alanda yeniliği sağlamaktadır (Murphy vd., 2020; Mir, 2023; Nogueira vd., 2025). YZ araştırmacıları ve plastik cerrahlar arasındaki devam eden iş birliği, hasta bakımını iyileştirmeyi, cerrahi hassasiyeti artırmayı ve plastik cerrahi uygulamasında yeniliği teşvik etmektedir (Mir, 2023). Aynı zamanda YZ, karmaşık klinik ve araştırma zorluklarını çözmek için yüksek hacimli sayısal ve görsel klinik verileri verimli bir şekilde analiz etmektedir (Liang vd., 2020).

Yapay Zekanın Plastik Cerrahide Kullanımının Dezavantajları

YZ'nın dezavantajları olarak YZ sistemlerinin etkin çalışabilmesi için büyük miktarda hasta verisine ihtiyaç duyulduğundan hasta mahremiyetinin korunması ve veri güvenliği açısından risk oluşturması (Singh vd., 2024; Murphy vd., 2020), veri ihlallerinin olabilmesi, hastaların kişisel bilgilerinin yetkisiz kişilerin eline geçmesine neden olması, YZ modellerinin eğitildikleri verilerdeki önyargıları yansıtabileceği söylenebilir (Nogueira vd., 2025). Eğer eğitim verileri belirli bir demografik grubu temsil etmiyorsa, YZ sistemleri bu gruplar için doğru tahminler yapamayabilir ve bu da tedavi planlamasında hatalara yol açabilir. YZ sisteminin nasıl bir sonuca vardığı tam olarak anlaşılamayabilir. Bu şeffaflık eksikliği, yanlış kararların sorumluluğunun kime ait olduğu konusunda belirsizlik yaratır (Treger vd., 2025; Vargas vd., 2024; Singh vd., 2024; Murphy vd., 2020). Tıbbi uygulamalarda kullanımıyla ilgili mevcut düzenlemeler yetersiz kalabilir. Bu da etik ve yasal sorunlara yol açabilir (Kiwan vd., 2024). Örneğin, YZ destekli bir cerrahi müdahalede oluşan komplikasyonların yasal sorumluluğu belirsiz olabilir. YZ modellerinin çoğu, gerçek klinik ortamda yeterince test edilmediğinden modellerin güvenilirliği ve etkinliği konusunda soru işaretlerinin oluşması muhtemeldir. Klinik doğrulama olmadan, YZ sistemlerinin rutin hasta bakımında kullanılması riskli olabilir. Tıbbi uygulamalarda YZ'ya aşırı güvenmek, hekim-hasta ilişkisini zayıflatabilir ve empati gibi unsurların zayıflamasına neden olabilir. Bu da hasta memnuniyetini ve tedaviye uyumu olumsuz etkiler. YZ sistemleri, karmaşık anatomik yapıları doğru bir şekilde analiz etmekte zorlanabilir. Özellikle rekonstrüktif cerrahi gibi hassas alanlarda, YZ'nın sınırlamaları nedeniyle yanlış veya eksik bilgilerle karşılaşılabilir. Cerrahların YZ sistemlerini etkin bir şekilde kullanabilmesi için özel eğitim almaları gerekmektedir. Bu tür eğitimlerin eksikliği ve süreksizliği, YZ'nın doğru ve güvenli kullanımını engelleyebilir (Treger vd., 2025; Vargas vd., 2024; Singh vd., 2024; Murphy vd., 2020).

Erdem ve ark., kliniklerinde plastik cerrahi bölümünde çeşitli nedenlerle (meme rekonstrüksiyonu, ev kazası sonrası sağ el beşinci parmak tendon kesisi, infraklavikular blok uygulanması) cerrahi girişim planlanan üç hastada, anestezi ve analjezi amacıyla YZ destekli ultrasonografi rehberliğinde gerçekleştirdikleri periferik sinir bloku deneyimlerini literatür doğrultusunda sunma amacıyla yaptıkları olgu sunumunda, blok sırasında YZ destekli ultrasonografi kullanımının anatomik yapıların rahatlıkla görüntülenebilmesine ve bu sayede kullanılan lokal anestezik dozunun, blok için gerekli girişim sayısı ve blok uygulanma süresini, vasküler ve plevral ponksiyon riskinin azalmasıyla komplikasyon riskini de önemli oranda azalttığını, YZ destekli ultrasonografi kullanımının bölgesel anestezi uygulamalarında yenilikçi bir simülasyon ortamı sağladığını ve anesteziyolojide klinik eğitimi geliştirmek için yeni bir araç olabileceğini vurgulamışlardır (Erdem vd., 2023).

Fung ve ark.'nın yaptığı derlemede, maksillofasiyal ve yüz plastik ve rekonstrüktif cerrahisinde YZ'nın hasta kayıtlarını otomatik olarak güncellemek, ameliyat öncesi planlama için 3D modeller üretmek, sefalometrik analizler yapmak ve orofarengeal malignitelerin tanısal değerlendirmesini sağlamak gibi işlevleri olduğunu belirtmişlerdir (Fung vd., 2024).

Maita ve ark.'nın, YZ'nın meme rekonstrüksiyonundaki yararlılığını değerlendirme amacıyla yaptıkları sistematik inceleme ve meta-analiz çalışmasında, MEDLINE (Medical Literature Analysis and Retrieval System), EMBASE (Excerpta Medica database), Scopus ve Google Scholar çevrimiçi veri tabanları incelenmiş ve 23 makale çalışmaya dahil edilmiştir. Sonuç olarak, meme rekonstrüksiyonunda YZ'nın, perioperatif süreçte hastaların danışmanlığını optimize ederek cerrahın olumsuz sonuçları öngörmesine yardımcı olabildiği, zamanında müdahalelerin yapılmasına olanak tanıdığı ve ameliyat sonrası yükü azalttığı, bunun da en başarılı sonuçların elde edilmesini ve hasta memnuniyetinin artırılmasını sağladığını bildirmişlerdir (Maita vd., 2024).

Plastik Cerrahide Yapay Zekanın Kullanımına Hemşirelik Yaklaşımları

Hemşirelerin YZ teknolojilerine uyum sağlaması, hasta bakımının kalitesini artırmak ve etik standartları korumak açısından kritik öneme sahiptir. YZ, cerrahi hastalarının bakımında hemşirelere destek sağlayarak, rutin işlerin otomasyonunu ve hasta verilerinin analizini kolaylaştırmaktadır. Bu durum, hemşirelerin zamanlarını daha fazla hasta bakımına ayırmalarına olanak tanır. Hemşirelerin YZ'yı etkin bir şekilde kullanabilmeleri, teknolojik yeniliklere uyum sağlayabilmeleri ve hasta bakımında YZ potansiyelinden en iyi şekilde yararlanabilmeleri için bu konuda sürekli eğitim almaları gerekmektedir. YZ'nın hemşirelik bakımına entegrasyonu, veri gizliliği, hasta mahremiyeti ve algoritmik önyargılar gibi etik sorunları da beraberinde getirebilir. Hemşireler, bu tür etik ikilemleri tanımlayarak, hasta haklarını ve güvenliğini koruma sorumluluğuna sahiptir. YZ'nın sunduğu avantajlara rağmen, hemşirelik bakımında insani dokunuşun ve empatik iletişimin önemi devam etmektedir (Çeçen Çamlı, 2024; Akgerman vd., 2022).

Sonuç olarak, plastik cerrahide YZ'nın entegrasyonu, dikkatli bir değerlendirme ve uygun düzenleyici çerçevelerin oluşturulmasını gerektirir. Hemşireler, son teknoloji olan YZ'nın kontrendikasyonlarının, hasta için faydalarının ve zararlarının farkında olarak YZ'nın potansiyelinden en iyi şekilde yararlanmalı ve hasta bakımına yansıtmalıdır.

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