



Book of Abstracts

19th International Conference & Expo on Life Sciences (ICELS-26)

18-20 May 2026



Jointly Organized By

Faculty of Sciences, PMAS-Arid Agriculture University Rawalpindi,
Evolution EduTech Pakistan & Himalaya Hemp & Health Pvt. Ltd.N

In Collaboration with

FJWU Rawalpindi, Rawalpindi Women University, NUST Islamabad and Abasyn University
Islamabad Campus

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BOOK OF ABSTRACTS

19th International Conference & Expo on Life Sciences (ICELS-26) Rawalpindi

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International Conference & Expo on Life Sciences (ICELS-26)

Theme: Bio-Innovations for a Changing Climate: Science, Sustainability and Solutions

Introduction

The University

The Pir Mehr Ali Shah Arid Agriculture University Rawalpindi (PMAS-AAUR), established in 1994, is a premier public-sector institution dedicated to education, research, and innovation in agriculture, life sciences, and environmental sustainability. With a strong mandate to address the challenges of arid and semi-arid regions, the University has played a vital role in advancing climate-smart agriculture,

biodiversity conservation, food security, public health, and sustainable natural resource management at national and international levels.

Faculty of Sciences

The Faculty of Sciences at PMAS-AAUR represents a multidisciplinary academic hub encompassing biological, chemical, physical, and environmental sciences. The Faculty has consistently aligned its academic and research agenda with global priorities such as climate change adaptation, ecosystem resilience, sustainable food systems, and bio-innovation.

Under the leadership of Prof. Dr. Rahmatullah Qureshi, Dean, Faculty of Sciences, the Faculty has achieved significant academic visibility and international engagement. Prof. Dr. Qureshi is a distinguished scientist with extensive contributions to plant biodiversity, ecology, ethnobotany, climate resilience, medicinal plants, and sustainable development. His vision emphasizes interdisciplinary research, international collaboration, capacity building of young scientists, and the translation of scientific knowledge into policy-relevant and societally beneficial outcomes.

During his tenure, the Faculty has successfully organized numerous national and international seminars, trainings, workshops, symposia, and conferences on emerging themes in life sciences, climate change, biodiversity-based solutions, environmental restoration, and sustainable agriculture. Besides, Prof. Dr. Rahmatullah Qureshi has actively strengthened the Faculty's international academic footprint through formal collaborations and strategic partnerships. Under his leadership, Memoranda of Understanding (MoUs) have been signed with leading global institutions, including the International Center for Research (ICR) at Colorado State University, USA, and Marmara University, Turkey. Furthermore, the Faculty is currently engaged in collaborative research with the University of Aberdeen, United Kingdom, particularly on innovative hemp-based projects focusing on sustainable agriculture, climate resilience, and bio-innovation. These initiatives have strengthened research culture, fostered academic-industry linkages, expanded international cooperation, and provided high-quality platforms for postgraduate students and early-career researchers.

Organizing International Conference & Expo on Life Sciences (ICELS-26) in collaboration with Himalaya Hemp & Health (Pvt.) Limited and Evolution EduTech Pakistan is a continuation of this academic legacy. ICELS-26 aims to bring together leading researchers, academicians, industry experts, and young scholars to discuss cutting-edge research and innovative solutions addressing climate change and sustainability challenges. The conference will serve as a global forum for interdisciplinary learning, collaboration, and scientific exchange, highlighting the critical role of life sciences in shaping a healthier and more resilient future.

Background and Rationale of Conference

Life Sciences are at the forefront of addressing some of the most pressing global challenges, including climate change, food insecurity, biodiversity loss, emerging diseases, and environmental degradation. Rapid climatic shifts are profoundly affecting biological systems, agricultural productivity, ecosystem services, and human health. In this context, scientific innovation, interdisciplinary research, and sustainable solutions are critical for building resilience and ensuring long-term planetary health.

The International Conference & Expo on Life Sciences (ICELS-26) represents a timely and strategic academic initiative to address pressing global challenges related to climate change, sustainability, and biological resilience. By integrating scientific excellence, interdisciplinary collaboration, and cultural exchange, the conference will contribute meaningfully to advancing life sciences research and promoting innovative solutions for a sustainable and climate-resilient future.

The ICELS-26 aims to provide a high-level international platform where researchers, academicians, industry professionals, policymakers, and young scientists can converge to share cutting-edge research, exchange innovative ideas, and explore practical solutions grounded in life sciences. Hosting ICELS-26 at PMAS-Arid Agriculture University, Rawalpindi, Pakistan's academic and policy hub will facilitate national and international participation, strengthen research networks, and highlight Pakistan's growing role in global scientific discourse.

Conference Overview

Conference Title: International Conference & Expo on Life Sciences (ICELS-26)

Theme: Bio-Innovations for a Changing Climate: Science, Sustainability and Solutions

Dates: 18th to 20th 2026 (Three Days)

Venue: Main Campus, PMAS-Arid Agriculture University, Rawalpindi, Pakistan

Jointly Organized By:

- PMAS-Arid Agriculture University Rawalpindi
- Evolution EduTech Pakistan
- Himalaya Hemp & Health (Pvt.) Limited

Objectives of the Conference

- To provide an international platform for sharing recent research and innovations in life sciences
- To promote interdisciplinary dialogue on climate change, sustainability, and biological systems
- To encourage collaboration among academia, industry, and policy institutions
- To strengthen the research capacity of young scientists and postgraduate students
- To highlight bio-innovations and nature-based solutions for climate resilience

Target Audience

- National and international researchers
- University faculty members and academicians
- Industry experts and professionals
- Policymakers and development practitioners
- PhD scholars, MPhil/MS students, and early-career scientists

Scope and Conference Fields

ICELS-26 will cover a broad spectrum of disciplines under Life Sciences and allied fields, including but not limited to:

- Biological Sciences
- Chemical Sciences
- Food, Pharmacy & Allied Health Sciences
- Agriculture & Veterinary Sciences

Conference Features

- Plenary and Keynote Lectures
- Parallel Technical Sessions
- Poster Presentations & Competition
- Science Models Exhibition
- Industrial Exhibition
- Sufi / Cultural Night
- Post-Conference Field Excursion to Galiyat Area, Khyber Pakhtunkhwa

Expected Outcomes

It is projected that through the conference event, Bio-Innovations for a Changing Climate: Science, Sustainability and Solutions, the population and scientific literacy will be improved and enhanced by communicating the problems of climate change and bio-based solutions, which will reinforce the relationship between scientific research and societal awareness. It will assist in determining critical issues and opportunities in terms of biodiversity conservation and its sustainable utilization in solving the problem of food insecurity. The expected results of the conference will be:

- Enforced domestic and global research partnerships.
- Proficiency development of youthful researchers and trainees, by means of being exposed to cutting-edge research and professional engagements.
- Improved national and international reputation of PMAS- Arid Agriculture University Rawalpindi in world life sciences research.
- Production of science-based policy relevant recommendations that will facilitate climate-resilient biological systems.
- High-quality conference proceedings and peer reviewed publications to the scientific literature.

Relevance to Faculty and Students' Needs and Scientific Significance in the Provincial Context

The Bio-innovations conference on a changing climate: science, sustainability and solutions is extremely pertinent to the scholarly, research, and practice demands of campus personnel and

students and directly pertinent to urgent provincial issues as far as climate change, food security, and environmental sustainability are concerned.

To faculty, the event offers a good platform to refresh scientific information, share research work, and integrate current research with new areas of need in climate-resistant agriculture, biodiversity protection, forestry, and biotechnology. It enables networking research, interdisciplinary research, and finding funding-oriented research theme that can respond to the provincial climate vulnerability like water scarcity, land degradation, diminishing crop productivity, and loss of biodiversity.

To students and young researchers in their early career stages, the conference facilitates building capacity by introducing them to modern bio-innovations, research techniques and practical applications of the biological sciences to real-life. Connection to senior scientists and policymakers boosts critical thinking and research orientation as well as career advancement especially in climate-smart agriculture, environmental management, and bio-based industries.

Provincially scientifically, the conference is directly concerned with the current needs, such as with climatic adaptation to arid and semi-arid conditions, sustainable use of plant genetic resources, ecosystem restoration, and agro-ecological system resilience. Climate stress is escalating in Punjab and other provinces including heat waves, unreliable rainfall, soil erosion, and food insecurity, which need the application of scientifically informed, locally responsive biological interventions. The conference enhances nature-based and bio-innovative strategies which can be used to enlighten provincial policies, extension services and development programs.

On the whole, the event will enhance the role of the biological sciences in solving provincial climate issues, connecting the academic community with policy and practice, and providing the faculty and students with appropriate knowledge and skills to make a meaningful contribution to sustainable development and climate resilience.

Impact on Society

This conference has direct societal impact by translating the scientific knowledge into practice with resilience to climate and sustainable development, which is the purpose of the conference titled Bio-Innovations for a Changing Climate: Science, Sustainability and Solutions. It enhances awareness and scientific literacy of the population by communicating the climate challenge and bio-based solution that creates a bridge between the research and societal awareness. Through the uniting of scientists, practitioners, and policymakers, the conference will promote relevance of policy and evidence-based decision-making on food security, ecosystem restoration and sustainable resource management. It also enhances resilience and livelihoods of communities based on nature-based solutions, climate-sensitive crops and bio-based industries especially to the rural and marginalized communities. The conference generally equips communities, informed policy, promotes innovations and industry connections, and enhances climate-resilient development; this highlights the importance of biological sciences in dealing with climate change.

Organizing Committees:

Patron in Chief

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Vice-Chancellor

PMAS-Arid Agriculture University, Rawalpindi

Patron/ Chief Organizer

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Message from the Patron-In-Chief

Prof. Dr. Qamar-uz-Zaman

Vice Chancellor, PMAS-Arid Agriculture University Rawalpindi

It gives me immense pleasure to welcome all the distinguished delegates, researchers, and students to the International Conference & Expo on Life Sciences (ICELS-26), hosted by our university. The theme – Bio-Innovations for a Changing Climate: Science, Sustainability and Solutions – could not be more relevant to a nation like Pakistan, which faces severe climate-induced challenges to agriculture, water security, and public health.

PMAS-AAUR has consistently championed research that bridges arid-region realities with cutting-edge science. This conference is a testament to our commitment to developing global partnerships, nurturing young scientists, and translating knowledge into actionable, climate-smart solutions. I extend my heartfelt appreciation to the Faculty of Sciences, our co-organizers – Evolution EduTech Pakistan and Himalaya Hemp & Health (Pvt.) Limited – and all participants for making this event possible.



I wish ICELS-26 great success and hope that the outcomes will contribute meaningfully to a resilient, sustainable future.

Prof. Dr. Qamar-uz-Zaman

Chief Patron, ICELS-26

Message from the Chief Guest (Inaugural Session)

Prof. Dr. Khalid Mehmood Khan (S.I.)

Ex-Vice Chancellor, PMAS-AAUR; Ex-President, Pakistan Academy of Sciences

It is an honour to be part of the inaugural ceremony of ICELS-26. The life sciences are at the heart of humanity's response to climate change – from developing drought-resistant crops to understanding ecosystem dynamics, from phytopharmaceuticals to bio-energy innovations. This conference brings together an exceptional assembly of minds from across the world, all committed to one goal: science-driven sustainability.

I commend the Faculty of Sciences, under the visionary leadership of Prof. Dr. Rahmatullah Qureshi, for organizing this timely event. I also applaud the participation of young researchers, whose fresh perspectives and creativity will shape the future of climate-resilient biological systems.

May the deliberations over the next three days inspire new collaborations, generate impactful ideas, and reinforce the role of science in building a better, greener world.



Prof. Dr. Khalid Mehmood Khan (S.I.)

Chief Guest (Inaugural Session), ICELS-26

Message from the Chief Guest (Concluding Session)

Prof. Dr. Muhammad Akmal

Chairman, Pakistan Science Foundation (PSF)

It is a privilege to address the concluding ceremony of ICELS-26. Over the past two days, this conference has showcased the very best of Pakistan's and the world's research in biological, agricultural, food, veterinary, and chemical sciences. The quality of presentations, the depth of discussions, and the enthusiasm of participants have been truly inspiring.

The Pakistan Science Foundation remains committed to supporting high-impact, collaborative research that addresses national priorities such as climate change adaptation, food security, and sustainable resource management. I encourage all researchers to translate the networks and ideas formed here into concrete project proposals that can drive real-world change.

My congratulations to the organizers for a seamless and intellectually rewarding event. I look forward to seeing the lasting legacy of ICELS-26 in the form of joint publications, industry linkages, and policy recommendations.

Prof. Dr. Muhammad Akmal

Chief Guest (Concluding Session), ICELS-26



Message by the Chief Organizer

Prof. Dr. Rahmatullah Qureshi

Dean, Faculty of Sciences, PMAS-Arid Agriculture University, Rawalpindi

Dear Colleagues, Esteemed Delegates, and Young Researchers,

Welcome to ICELS-26 – a platform born from the conviction that **bio-innovations** hold the key to surviving and thriving in a changing climate. Over the last two years, our Faculty has worked tirelessly to bring together an international community of scientists, policymakers, and industry professionals to share knowledge, forge partnerships, and design solutions.

The response we have received – from Türkiye, Morocco, Egypt, Iran, the USA, Uzbekistan, and across Pakistan – is a testament to the urgency of our theme and the strength of our scientific community. I am deeply grateful to our Chief Patron, Prof. Dr. Qamar-uz-Zaman, for his unwavering support; to our Chief Guests, Prof. Dr. Khalid Mehmood Khan and Prof. Dr. Muhammad Akmal, for gracing the conference; and to every presenter, session chair, and volunteer who made this event possible.



I urge you to actively engage in the technical sessions, the cultural evening, and the field excursion to Galyat. Beyond the formal programme, let this conference be a place where friendships are formed, ideas are cross-pollinated, and sustainable solutions are born.

Thank you for being part of ICELS-26. Together, we can turn science into sustainability.

Prof. Dr. Rahmatullah Qureshi

Chief Organizer, ICLES-26

It gives me immense pleasure to welcome all participants, researchers, academicians, industry professionals, and students to the 19th International Conference & Expo on Life Sciences (ICELS-26), Rawalpindi/Islamabad. This conference serves as a dynamic platform for scientific discussion, innovation, collaboration, and knowledge sharing in the fields of Life Sciences, Health Sciences, Food Sciences, Agriculture, Environmental Sciences, and emerging technologies. ICELS-26 aims to connect academia, industry, and young researchers under one platform to promote research culture, professional networking, and innovative solutions for future challenges.



Evolution EduTech Pakistan is committed to promoting education, research, technology, innovation, and academic collaboration through conferences, workshops, trainings, expos, and scholarly activities at national and international levels. Our mission is to empower students, researchers, and professionals by creating opportunities for learning, exposure, and industry-academia linkage, while our vision is to build a progressive knowledge-based society driven by innovation, scientific advancement, and sustainable development. We sincerely thank all collaborating institutions, organizing members, faculty, and participants for their trust, support, and valuable contribution toward making ICELS-26 a successful scientific gathering.

Khurram Iqbal
Founder & CEO,
Evolution EduTech Pakistan

Message from the Sponsoring Partner, Himalaya Hemp & Health (Pvt.) Ltd.

It gives me immense pleasure to extend warm greetings and best wishes to all distinguished participants, researchers, academicians, industry experts, and students attending the International Conference on Environmental and Life Sciences (ICELS-2026). On behalf of Himalaya Hemp & Health (Pvt.) Ltd., a proud spin-off company of Pir Mehr Ali Shah Arid Agriculture University Rawalpindi, I am honored to support and sponsor this prestigious scientific event.

Himalaya Hemp & Health (Pvt.) Ltd. was established with the vision of transforming scientific research into innovative, sustainable, and commercially viable solutions for human health, agriculture, and environmental well-being. Our mission is centered on promoting evidence-based natural products, industrial hemp technologies, nutraceuticals, herbal therapeutics, cosmetics, and eco-friendly bio-products through advanced research and development.



The theme and objectives of ICELS-2026 strongly align with our organizational philosophy of integrating science, sustainability, and innovation for societal progress. We firmly believe that scientific conferences such as ICELS provide an excellent platform for knowledge exchange, interdisciplinary collaboration, and the development of future research partnerships that can address global environmental and health challenges.

As a research-driven company, Himalaya Hemp & Health is actively engaged in R&D activities focusing on industrial hemp utilization, medicinal and aromatic plants, plant-based nutraceuticals, functional foods, herbal cosmetics, phytochemical extraction, and value-added natural products. Through collaboration with researchers and academic institutions, we aim to promote indigenous biodiversity, sustainable agriculture, green technologies, and commercialization of innovative bioresources.

Our company is also committed to supporting young scientists, entrepreneurs, and innovators by encouraging applied research and technology transfer. We strongly believe that Pakistan possesses enormous potential in medicinal plants, hemp-based industries, and natural product sciences, which can significantly contribute to economic development, environmental sustainability, and public health improvement.

Looking toward the future, Himalaya Hemp & Health (Pvt.) Ltd. envisions becoming a leading biotechnology and natural health enterprise at both national and international levels. We aim to expand our research portfolio, strengthen academia-industry linkages, establish modern processing and analytical facilities, and develop globally competitive products based on scientific excellence and sustainability principles.

I congratulate the organizers of ICELS-2026 for arranging this valuable scientific gathering and appreciate their efforts in promoting research culture and international collaboration. I am confident that this conference will generate meaningful scientific discussions and inspire innovative solutions for emerging challenges in environmental and life sciences.

I wish the conference great success and all participants a productive and enriching experience.

Prof. Dr. Rahmatullah Qureshi
Founder &CEO,
Himalaya Hemp & Health (Pvt.) Ltd.
Spin-off Company of PMAS-Arid Agriculture University Rawalpindi

Schedule of ICELS-26

(18-20 May 2026)

Inaugural Session

**Venue: Main Auditorium, PMAS Arid Agriculture University, Rawalpindi,
Pakistan**

Day 1, 18-05-2026

Time	Event/Activity
08:00 AM	Registration
09:00 AM	Seating of the Delegates and Guests
09:05 AM	Arrival of Chief Guest
09:10 AM	Recitation of Holy Quraan
09:15 AM	Naat-e-Rasool-e-Maqbool
09:20 AM	National Anthem
09:25 AM	Welcome Address By Prof. Dr. Rahmatullah Qureshi , Dean, Faculty of Sciences, PMAS-Arid Agriculture University Rawalpindi
09:35 AM	Speech By Prof. Dr. Raza Bhatti (T.I.) ,Vice Chancellor, Federal Ziauddin University, Islamabad, Pakistan
09:45 AM	<i>Speech By</i> Prof. Dr. Faqir Muhammad Anjum , Ex-VC, University of Gambia, CEO, IFINCA Pakistan
09:50 AM	Remarks from Mr. Khurram Iqbal Managing Director, Evolution EduTech, Pakistan
09:55 AM	<i>Vote of Thanks By</i> Prof. Dr. Qamar-uz-Zaman , Vice-Chancellor, PMAS-Arid Agriculture University, Rawalpindi
10:00 AM	Address by Chief Guest, Prof. Dr. Khalid Mehmood Khan (S.I.) Ex-VC, PMAS AAUR/ Ex-President, PAS
10:10 AM	Shields/souvenir Distribution
10:20 PM	Group Photo
10:20 AM	Plenary Technical Session (Keynote Talks) Chair: Prof. Dr. Raza Bhatti,VC, Federal Ziauddin University, Islamabad Co-Chair: Prof. Dr. Hassan Sher, Vice Chancellor, University of Swat
10:30 AM	Prof. Dr. Hassan Sher , Vice Chancellor, University of Swat, <i>Title:Maximizing Livelihood Opportunities through Introduction of High Value Medicinal Plants in District Swat, Pakistan; Study for Sustainable Development and to meet SDGs</i>
10:50 AM	Prof. Dr. Ikramullah Khan , Vice Chancellor, Hazara University, Mansehra Keynote Speaker <i>Title: Climate-Smart Marginalized Crops: Scale-Up Strategies and Industry Linkages</i>
11:10 AM	Mr. Dominic Ibarra , Deputy Facility Manager, US State Department, Title: Climate-Resilient Wastewater Reclamation through Dual Extended Aeration Systems
11:30 AM	Dr. Sadaf Javaria , Associate Professor, IFSN, Gomal University, Dera Ismail Khan, Title: From Compliance to Assurance: A Digital Governance Model for Halal Food Service Systems

11:50 AM	Visit to Science Models, Poster, Food Product Exhibition & Judgment
12:50 PM	Lunch & Prayers Break

2 Parallel Technical Sessions From 02:00 PM to 04:30 PM (18-05-2026)			
Technical Session - Food, Agriculture & Applied Sciences Day 1, (18-05-2026) (Venue: Agriculture Seminar Hall)			
Session Organizer: Prof. Dr. Asif Ahmad, Director, Institute of Food & Nutritional Sciences, PMAS-AAUR Co- Organizer: Dr. Rai Amir, Associate Professor, IFNS, PMAS-AAUR Moderator: Ms. Sowaba Muneer, IFNS, PMAS-AAUR			
<i>Chair: Prof. Dr. Faqir Muhammad Anjum, Ex-VC, University of Gambia, CEO, IFINCA Pakistan</i> <i>Co- Chair: Dr. Ijaz Ahmed, DG PCSIR, Lahore</i> Co-Chair: Dr. Sakhawat Ali, Ex DG PCSIR, Lahore			
No	Time	Details	Topic
1	02:00 PM	Prof. Dr Taherah Mohammadabadi (Foreign Speaker) , Faculty of Animal Science and Food Technology Agricultural Sciences and Natural Resources University, Iran	Camel milk: A nutritious superfood for the food security
2	02:15 PM	Prof. Dr. Muhammad Rafiq (Keynote Speaker) Department of Mathematics, Namal University Mianwali, Pakistan	Mathematical Modeling for Transmission Dynamics in Vector-Borne Plant Diseases
3	02:30 PM	Prof. Dr. Tariq Mukhtar, Dean, Faculty of Agriculture, PMAS-AAU	Harnessing novel Rhizobacteria and Botanicals for Eco-Friendly Management of Meloidogyne incognita in Tomato
4	02:45 PM	Dr. Muhammad Khalid Saeed (Invited Speaker) Principal scientific Officer (PSO), PCSIR, Labs Complex, Lahore	Development of Jamun (Syzygium cumini) Tea for diabetic patients and its organolaptic evaluation, TPC, antioxidant activity
5	03:00 PM	Prof. Dr. Aneela Javed Tenured Professor, Department of Biomedicine, ASAB, NUST	Evaluating the Therapeutic Efficacy of Targeted Nano-Drugs against brain cancer Using Integrated In Vitro and In Vivo Models
6	03:15 PM	Prof. Dr. Rabia Amir Tenured Professor Department of Agricultural Sciences and Technology, ASAB, NUST	Unraveling Plant Stress Networks: Strategies to Enhance Crop Productivity and Oil Quality
7	03:30 PM	Ms. Ambreen Najaf Department of Botany Rawalpindi Women University	Molecular Docking and Pharmacokinetic Profiling of Solanaceous Bioactive Compounds Against Major Cancer Targets

8	03:45 PM	Dr. Muhammad Tanveer Assistant Professor, Department of Mathematics and Statistics, University of Agriculture Faisalabad	Bifurcation and Fractal Analysis of a Climate-Driven Crop Interaction Model
9	04:00 PM	Dr. Muhammad Arshad Assistant Professor, Department of Mathematics and Statistics, University of Agriculture Faisalabad	Conservation Laws and Nonlinear Dynamical Analysis of the Higher-Order Dispersive Kundu–Eckhaus Equation with Applications in Optics
10	04:15 PM	Dr. Masood Iqbal Awan Associate Professor, Department of Agronomy, Constituent College, Depalpur–Okara, University of Agriculture Faisalabad, Pakistan	Evaluating Yield–Water Productivity Trade- offs in Rice under Continuous Flooding and Alternate Wetting–Drying Regimes
11	04:30 PM	Ms. Mahnoor Nisar Abbasi Department of Zoology Rawalpindi Women University	Melatonin: The hormone we are killing and it's killing us back
12	04:40 PM	Muhammad Sohaib Maqsood, Muhammad Awais Department of Mathematics, Namal University Mianwali, Pakistan	Numerical Modeling for Transmission Dynamics of Human Papillomavirus (HPV) and Cervical Cancer
13	04:50 PM	Ms. Ambreen Gul, ASAB, department of Biomedicine, NUST	Dual-Action Nanotherapeutics for Glioblastoma: Gold Nanocage-mediated Delivery of Silymarin Improves Tumor Targeting and Neurobehavioral Outcomes
14	05:00 PM	Concluding Remarks	
15	05:10 PM	End of Session	
16	05:20 PM		

Technical Session – Botanical Sciences Day 1, (18-05-2026) (Venue: KOICA Building)			
Session Organizer: Prof. Dr. Rahmatullah Qureshi, Dean, Faculty of Sciences, PMAS-AAUR Co-Organizer: Dr. Bushra Allah Rakha, Assistant Professor, Department of Zoology, Wildlife and Fisheries, PMAS Agriculture University Rawalpindi Moderator: Dr. Muhmmadi Bibi, Assistant Professor, Department of Botany, PMAS-AAUR			
Chair: Prof. Dr. Ikramullah Khan , Vice Chancellor, Hazara University, Mansehra Co- Chair: Prof. Dr. Manzoor Hussain Soomro , Advisor, ECO Science Foundation (ECOSF)			
No	Time	Details	Topic
1	02:00 PM Online	Prof. Dr. Muhammet Uzun (Keynote Speaker)	Advancing Environmental Resilience through Sustainable Hemp Innovations

		Center for Nanotechnology & Biomaterials Applications and Research, Marmara University	
2	02:15 PM Online	Dr. Ozodbek (Keynote Speaker) Institute of Botany, Academy of Sciences, Republic of Uzbekistan	Diversity and Economic Significance of Wild Crop Relatives in Uzbekistan
3	02:30 PM	Prof. Dr. Manzoor Hussain Soomro, Advisor, ECO Science Foundation (ECOSF)	Inquiry Based Learning and Farmer Field School Approach for Sustainable Conservation of Biodiversity & Ecosystems
4	02:45 PM	Dr. Mushtaq Ahmad (Invited Speaker) Department of Plant Sciences, Quaid-i-Azam University, Islamabad, Pakistan	Medicinal Plants biodiversity using Interdisciplinary approach towards health and food security
5	03:00 PM	Dr. Ibrar Shinwari, (Invited Speaker) International Islamic University, Islamabad	Application of Advanced Technologies for Biosecurity: Role of Botanicals
6	03:15 PM	Prof. Dr. Rahmatullah Qureshi (Invited Speaker) Dean, Faculty of Sciences, PMAS-AAUR	Hemp: Blessing or Curse?
7	03:30 PM	Ms. Mahrine Rashid Principal Scientific Officer National Herbarium of Pakistan (RAW) National Agricultural Research Centre	National Herbarium of Pakistan Rescuing Floral Biodiversity & Saving Healing Plants In The Botanical Conservatory
8	03:45 PM	Dr. Bushra Parveen Assistant Professor Department of Physics Rawalpindi Women University	Enhanced Pseudo-capacitive and Supercapattery Performance of La ₂ O ₃ /rGO Nanocomposite Electrodes: Electrochemical and impedance analysis
9	04:00 PM	Dr. Muhammad Imran Assistant Professor of Biochemistry Institute of Biochemistry and Biotechnology UVAS, Lahore, Pakistan	Identification, Characterization and Growth Optimization Studies of Lignin Degrading Bacterial Strain Isolated from Soil Samples Of District, Lahore
10	04:15 PM	Ms. Naheed Malik Lecturer Botany University of Wah	Characterization of Soil Bacteria as PGPR for Sustainable Agricultural Practices
11	04:30 PM	Ms. Iqra Mukhtar Department of Zoology Rawalpindi Women University	Measurement of Morphometric Characteristics of Apis dorsata from Two Areas of Punjab
12	04:40 PM	Ms. Bibi Sidra Department of Zoology Rawalpindi Women University	Role of Biochemical Biomarkers in the Early Identification of Breast Cancer
13	04:50 PM	Ms. Dania Bakhtawar Department of Zoology Rawalpindi Women University	Effect of Pyrazole Toxicity on the Blood Clotting in Chickens (Gallus gallus domesticus)
14	05:00 PM	Ms. Almeera Maryam Department of Zoology Rawalpindi Women University	Comparative Characterization and Milt Quality Assessment of Cirrhinus Mrigala and Labeo Rohita during Different Breeding Phases

15	05:10 PM	Ms. Esha Fatima Department of Zoology Rawalpindi Women University	Effects of Pyrazole Administration on Cardiac Histology in Chickens
16	05:20 PM	Concluding Remarks	

Cultural Evening Organizer: Dr. Baddar Naseem 1st Day, 18-05-2026 (Only for Guests and Conference Registered Participants) Organizer:	
Start Time: 06:00 PM	End Time: 07:30 PM

End of 1st Day

2nd Day 19-05-2026 (Venue: Agriculture Seminar Hall) 2 Technical Session From 09:30 AM to 12:30 PM
Combined Technical Session Day 2, (19-05-2026) (Venue: Agriculture Seminar Hall)

Session Organizer: Prof. Dr. Tariq Mukhtar, Dean, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan

Co-Organizer: Dr. Bushra Allah Rakha, Assistant Professor, Department of Zoology, Wildlife and Fisheries, PMAS Agriculture University Rawalpindi

Moderator: Dr. Naseeha Bibi Assistant Professor, UIBB, PMAS-AAUR

Chair: Prof. Dr. Zarrin Fatima Rizvi, VC, IISAT University, Gujranwala

Co- Chair: Dr. Muhammad Sajid Nadeem, Chairman, Zoology, Wildlife & Fisheries, PMAS-AAUR

Co- Chair: Dr. Noshin Ilyas, Chairperson, Department of Botany, PMAS-AAUR

No	Time	Details	Topic
1	09:00 AM	Prof. Dr. Katarzyna Kotwica-Mojzych(Keynote Speaker)	Dental Stem Cells- from tissue homeostasis to regenerative medicine
2	09.15 AM	Dr. Monier M. Abd El-Ghani (Keynote Speaker) Department of Botany and Microbiology, Faculty of Science, Cairo University, Giza 12613, Egypt	Medicinal Plants of Egypt
3	09.30 AM	Dr. Volkan Okatan (Keynote Speaker) Eskisehir Osmangazi Üniversitesi, Türkiye	Small Fruits, Big Solutions: Biostimulant-Driven Approaches to Climate-Resilient Horticulture
4	09:45 AM	Prof. Dr. Zarrin Fatima Rizvi, VC, IISAT University, Gujranwala	
5	10:00 AM	Dr. Mahmood Nasir (Invited Speaker) Forest Inspector General of Pakistan, Islamabad	Role of Forest Department in Conservation of Forest Ecosystem and Climate Resilience
6	10.15 AM	Prof. Dr. Shahzad Nasim (Invited Speaker) Dean The Begum Nusrat Bhutto Women University, Sukkur	The Blue Frontier: Sustainable Pathway for Marine Biodiversity and Blue Economy
7	10.30 AM	Prof. Dr. Shah Alam (Invited Speaker) Dean, Faculty of Agriculture, Agri. Univ. Peshawar	Study Putative factors in selected wheat genotypes against Green bug, Schizaphis graminum (Rondani).
8	10:45 AM	Prof. Dr. Humayun Shaheen (Invited Speaker) University of Muzaffarabad, AJK	Spatial Distribution, Community Structure and Conservation of Taxus wallichiana in Azad Jammu and Kashmir
9	11:00 AM	Dr. Shafique Ahmad (Invited Speaker) Poonchh University, Rawalakot, AJK	Plant Resilience in Changing Climate: Survival, Adaptation and Innovation
10	11:15 AM	Dr. Noureen Khan Department of Chemistry, Rawalpindi Women University, Rawalpindi	A Bioactive Compound from Myrtus communis: Isolation, Characterization, and Anti-Inflammatory Effects in Mouse Macrophages
11	11:30 AM	Dr. Tunzeel Iqbal	Effect of Morus alba Extract, Nanoparticles and Biochar-Coated Nanoparticles on Cicer

		Department of Chemistry, Rawalpindi Women University	arietinum Seed Priming and Seedling Germination with Varying Concentrations
12	12:30 PM	Mahroze Fatima Department of Fisheries and Aquaculture, University of Veterinary and Animal Sciences, Lahore	Temperature-Dependent Dietary Protein Requirements of Pangasianodon hypophthalmus: Effects on Growth, Feed Utilization, Body Composition, and Enzyme Activities
13		Concluding Remarks	

Technical Session - Biological & Chemical Sciences Day 2, (19-05-2026) (Venue: UIBB Seminar Hall)			
Session Organizer: <i>Prof. Dr. Muhammad Javaid Asad, Director, UIBB, PMAS-AAUR</i> Co-Organizer: <i>Prof. Dr. Arfan Yousaf, Dean, FA&VS, PMAS-AAUR</i> Moderator: <i>Dr. Muhmmadi Bibi, Assistant Professor, Department of Botany, PMAS-AAUR</i>			
Chair: Prof. Dr. Zabta Khan Shinwari , Vice Chancellor, Federal Urdu University, Karachi Co-Chair: Prof. Dr. Manzar Sohail , Chairman, Department of Chemistry, NUST Islamabad			
No	Time	Details	Topic
1	9:00 AM	Prof. Dr. Zabta Khan Shinwari (Keynote Speaker) Vice Chancellor, Federal Urdu University, Karachi	Medicinal Plants and Climate Resilience: Opportunities for Sustainable Health Security
2	9:15 AM Online	Dr. Moha Haddouch (Keynote Speaker) UNESCO Biosphere Reserves National Committee, Morocco	A circular economy approach to conserve biodiversity of aromatic and medicinal plants
3	9:30 AM	Prof. Dr. Raza Bhatti (Keynote Speaker) Vice Chancellor, Federal Urdu University, Islamabad	Botanical Gardens and Plant Biodiversity: Pathways toward Sustainability and Climate Resilience
4	9:45 AM	Dr. Zeyneb KILIÇ (Keynote Speaker) Adıyaman University, Türkiye	Determining the Water Level of Çamgazi Dam (Adıyaman) Reservoir Using Artificial Intelligence Methods; A Case Study of Türkiye
5	10:00 AM	Dr. Muhammet Uzun, Dr. Md. Humayun Kabir, Dr. Can Ketenci, Center for Nanotechnology & Biomaterials Applications and Research, Marmara University	Investigation of local hemp fiber characteristics for technical textile application

6	10:15 AM	Dr. Zafar A. Siddiqui, University of Modern Sciences, Hyderabad	The Impact on Food Waste on Food Insecurity in Pakistan: causes, consequences and solution
7	10:30 AM	Dr. Aliya Fazal Department of Chemistry, Fatima Jinnah Women University	Mechanisms of black gold desulfurization and room temperature ionic liquids
8	10:45 AM	Dr. Nosheen Masood HOD, Biotechnology Fatima Jinnah Women University Rawalpindi	Glutathione S transferases deletions and risk of different cancers
10	11:00 AM	Dr. Muhammad Kashif Majeed Assistant Professor Department of Chemistry, NUST Islamabad	Catalytic Insights into Thermostable MOFs and Sulfonated Carbon Materials
11	11:15 AM	Dr. Qurat Ul Ain Ali Assistant Professor, Department of Biotechnology, Shaheed Benazir Bhutto Women University, Peshawar	Overexpression of StDREB30 gene improves drought tolerance by modulating defense related genes in potato
12	11:30 AM	Anab Fatima, Dow University of Health Sciences, Karachi, Pakistan	Impact of Climate Change on Marine Biodiversity and Antibiotic Discovery
13	11:45 AM	Ms. Sanam Saleem Lecturer Physics UAF, Sub campus Okara	Electromagnetic surface modes on black phosphorus platforms for waveguide applications
14	12:00 PM	Ms. Faiza Ishtiaq Lecturer Chemistry UAF, Sub Campus Okara	Removal of safranin O from aqueous media
15	12:15 PM	Ms. Asma Mehak Department of Botany, PMAS-Arid Agriculture University Rawalpindi, Punjab Pakistan	Root-Knot Nematode the Hidden and Mysterious Plant Pathogen
	12:30	Concluding Remarks	

CONCLUDING CEREMONY Venue: Main Auditorium	
Guests to be seated	12:45 – 01:00 PM
Tilawat-e-Quran	1:00 – 1:05 PM
Remarks by Prof. Dr. Zabta Khan Shinwari, VC, FUUAST	1:05 – 1:15 PM
Concluding Remarks by Chief Guest, Prof. Dr. Mohammad Akmal Chairman, PSF	1:15 – 1:30 PM
Vote of Thanks by Prof. Dr. Rahmatullah Qureshi, Chief Organizer	1:30 – 1:40 PM
Shield & Certificate Distribution	1:40 – 2:00 PM
Lunch only For Guests	
Day 3	
ICELS-26 - Day – 3: FIELD EXCURSION May 20, 2026 (Wednesday)	
Field Excursion to Galyat, KPK	8.00 – 5.00

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Determining the Water Level of Çamgazi Dam (Adıyaman) Reservoir Using Artificial Intelligence Methods; A Case Study of Türkiye

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This study aims to predict the water level of the Çamgazi Dam reservoir using an advanced convolutional neural network and nonlinear regression approaches on hydrological and meteorological parameters. A long-term hydro-meteorological dataset was employed, and the developed AI model was evaluated with multiple performance metrics. Results show $R^2 \geq 0.96$ for all parameters, indicating high accuracy in predicting water level (elevation), reservoir volume, dimensionless V/h^3 ratio, as well as meteorological variables such as temperature, station pressure, relative humidity, and monthly rainfall. The nonlinear regression model relating the V/h^3 ratio to selected meteorological ratios achieved $R^2 = 0.849$, enabling physically interpretable insights into inter-variable interactions. Under extreme rainfall conditions, the model exhibits systematic under or overestimation and greater scatter at high relative humidity, identified as key limitations. This study highlights the potential of combining AI-based approaches with regression-based empirical models to contribute to related research and planning efforts.

Keywords: Convolutional neural network, Reservoir level, Water level prediction, Dam

Yapay Zeka Yöntemleri Kullanılarak Çamgazi Baraj (Adıyaman) Rezervuarının Su Seviyesinin Belirlenmesi; Türkiye Örneği

Bu çalışma, gelişmiş bir evrimsel sinir ağı ve hidrolojik ve meteorolojik parametrelere dayalı doğrusal olmayan regresyon yaklaşımları kullanarak Çamgazi Barajı rezervuarının su seviyesini tahmin etmeyi amaçlamaktadır. Uzun vadeli bir hidro-meteorolojik veri seti kullanılmış ve geliştirilen yapay zeka modeli, birden fazla performans ölçütüyle değerlendirilmiştir. Sonuçlar, tüm parametreler için $R^2 \geq 0,96$ olduğunu göstermekte olup, su seviyesi (yükseklik), rezervuar hacmi, boyutsuz V/h^3 oranı ve sıcaklık, istasyon basıncı, bağıl nem ve aylık yağış gibi meteorolojik değişkenlerin tahmininde yüksek doğruluk göstermektedir. V/h^3 oranını seçilen meteorolojik oranlarla ilişkilendiren doğrusal olmayan regresyon modeli, $R^2 = 0,849$ değerine ulaşarak değişkenler arası etkileşimlere ilişkin fiziksel olarak yorumlanabilir bilgiler sağlamaktadır. Aşırı yağış koşullarında, model sistematik olarak düşük veya yüksek tahmin ve yüksek bağıl nemde daha büyük dağılım göstermekte olup, bunlar temel sınırlamalar olarak belirlenmiştir. Bu çalışma, ilgili araştırma ve planlama çalışmalarına katkıda bulunmak için yapay zeka tabanlı yaklaşımların regresyon tabanlı ampirik modellerle birleştirilmesinin potansiyelini vurgulamaktadır.

Anahtar Kelimeler: Evrimsel sinir ağı, Rezervuar seviyesi, Su seviyesi tahmini, Baraj

Measurment of Morphometric Characteristics of Apis dorsata from Two Areas of Punjab

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The current study aimed to investigate the comparative morphometric characteristics of *A. dorsata* collected from different areas of Gujarkhan and Chakwal Tehsils. About 28 morphometric characteristics of these honey bees were examined. A total of 180 sample honey bees were collected

from different areas of Gujarkhan and Chakwal. The morphometric characteristics were measured by using standard morphometry procedure. Mean values of different morphometric characters recorded for *A. dorsata*, were body weight (0.036 and 0.029g), body length (8.95-8.54mm), body width (5.49-5.5mm), antenna length (4.20-4mm), proboscis length (5.80-5.13mm), length of forwing (13.2-13.6mm), width of forwing (4.7-4.8mm), cubital index (6.2-5.6um), length of hindwing (9.6-9.3mm), width of hindwing (3.4-3.01mm), number of humuli on hind wing (21.7-23.3), length of foreleg (7.92-8.36mm), length of middle leg (9.45-10.08mm), length of hindleg (13.75-14.8mm), length of femur (3.67-3.9mm), width of femur (29-28.6um), length of tibia (5-4.6mm), width of tibia (51.78-49.35um), length of basitarsus (4-3.8mm), width of basitarsus (53.23-52.47um), length of 2nd tergite (5.84-5.63mm), width of 2nd tergite (3.97-3.87mm), length of 3rd tergite (5.3-4.91mm), width of 3rd tergite (3.64-3.21mm), length of 4th tergite (4.76-4.16mm), width of 4th tergite (3.23-3mm) from Gujarkhan and Chakwal, respectively.

Keywords: *A. dorsata*, Morphometric characteristics, Cubital index, Humuli number

Role of Biochemical Biomarkers in the Early Identification of Breast Cancer

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One of the main causes of cancer-related morbidity and death for women globally is breast cancer, which is distinguished by its substantial genetic heterogeneity and inconsistent clinical results. Enhancing prognosis and directing treatment approaches depend on early identification and accurate molecular categorization. The landscape of breast cancer diagnosis and prognosis has changed in recent years due to the discovery and characterization of biochemical biomarkers. The aim of study to compare breast cancer and comprehend the biochemical properties of its biomarkers for the purpose of early diagnosis and detection. The levels of biochemical biomarkers in breast cancer patients and healthy controls were compared using a case-control study. The relationship between biomarkers and breast cancer risk was discovered using statistical analysis employing suitable procedures. According to the results, Serum uric acid, urea, creatinine, ALT, and ALP levels were considerably higher in cases than in healthy controls ($p < 0.05$). On the other hand, sodium, potassium, chloride, and total bilirubin were insignificant ($p < 0.05$). According to the experiment and clinical findings, cancer patients who have high uric acid are more likely to experience metabolic and inflammatory disturbances. When compared to controls, biochemical indicators exhibit a strong correlation with instances of breast cancer.

Keywords: Breast cancer, Biochemical biomarkers, Diagnosis, Tumor markers, Serum biomarkers

Advancing Environmental Resilience Through Sustainable Hemp Innovations

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As environmental concerns and resource depletion increasingly affect the textile industry, sustainable natural fibers have become essential alternatives to conventional materials. Among these, hemp (*Cannabis sativa L.*) has re-emerged as a promising eco-friendly fiber due to its low water consumption, minimal pesticide requirement, rapid growth cycle, and high biomass yield.

Compared to traditional fibers such as cotton, hemp offers significant environmental advantages while also providing durability, biodegradability, and high cellulose content. This study examines the potential of hemp fiber in sustainable and technical textile applications. The research highlights the role of hemp in supporting circular economy principles and reducing the environmental impact of textile production. In addition, recent developments in industrial hemp cultivation, processing technologies, and market interest are discussed, particularly in emerging textile markets such as Türkiye. Despite its advantages, challenges related to processing infrastructure, regulatory limitations, and industrial adaptation still restrict the widespread use of hemp fibers. Nevertheless, hemp is considered a strategic raw material for the future of sustainable textiles, offering significant opportunities for innovative, lightweight, and environmentally responsible textile products.

Keywords: Hemp fiber, Turkish Hemp, Sustainability, Innovations

Medicinal Plants of Egypt

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Egypt has a rich history of using medicinal plants, dating back to ancient times. Many of the medicinal plants used in Egypt today have been used for centuries, and their effectiveness has been proven through both traditional knowledge and scientific research. Some of the important medicinal plants include *Aloe vera*, *Coriandrum sativum*, *Foeniculum vulgare*, *Hibiscus sabdariffa*, *Matricaria chamomilla*, *Nigella sativa*, and *Zingiber officinale*. Medicinal plants are an important part of Egyptian culture and healthcare system. They are used to treat a wide range of diseases and conditions, and they offer a number of potential advantages over conventional pharmaceuticals.

Medicinal potential of selected non-edible fruit-bearing plants from Bangladesh

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Bangladesh harbors a rich diversity of medicinal plant resources, many of which remain underexplored despite their long-standing use in traditional healthcare systems. Among these, several non-edible fruit-bearing plants hold considerable therapeutic potential due to their unique phytochemical composition and ethnomedicinal relevance. This study reviews and synthesizes available knowledge on selected non-edible fruit-bearing plant species of Bangladesh, emphasizing their traditional medicinal uses, bioactive constituents, and pharmacological properties. These plants are widely employed in indigenous and folk medicine for the management of inflammatory disorders, infections, metabolic ailments, skin diseases, and gastrointestinal disturbances. Phytochemical investigations reveal the presence of diverse secondary metabolites, including alkaloids, flavonoids, tannins, saponins, terpenoids, and phenolic compounds, which underpin their reported biological activities such as antioxidant, antimicrobial, anti-inflammatory, antidiabetic, and cytotoxic effects. Recent experimental and preclinical studies provide scientific validation for several traditional claims, highlighting their potential as sources of novel therapeutic agents. However, gaps remain in terms of toxicological evaluation, standardization, and clinical validation. The talk underscores the need for systematic research integrating ethnobotany, phytochemistry, and pharmacology to promote the sustainable utilization and conservation of these valuable plant resources. Harnessing the medicinal potential of non-edible fruit-bearing plants may contribute to drug discovery, biodiversity conservation, and the development of plant-based therapeutics in Bangladesh and beyond.

Reproductive biobanking and conservation: improving sperm cryoresistance in wild ruminants

Julian Santiago Moreno

Reproductive biobanking, particularly sperm cryopreservation, is a pivotal tool for safeguarding the genetic diversity of threatened wild ruminants. However, its application is consistently hampered by the high sensitivity of sperm from these species to cryopreservation-induced damage, leading to poor post-thaw viability and fertility. This review synthesizes current research and identifies key strategies to improve sperm cryoresistance in nondomestic ruminants. We examine the fundamental sources of cryoinjury, including osmotic stress, intracellular ice formation, and oxidative damage, which are often exacerbated by species-specific sperm membrane composition and physiology. The paper critically evaluates advancements in cryopreservation protocols, focusing on the optimization of novel cryoprotectant agents (CPAs), cooling rates, and thawing procedures tailored to distinct phylogenetic groups. Furthermore, we highlight the role of seminal plasma composition and the potential of incorporating antioxidant supplements (e.g., enzymatic and non-enzymatic molecules) to mitigate oxidative stress during freeze-thaw cycles. The integration of biophysical assessments, such as membrane lipidomics and proteomic analysis of sperm, is discussed as a pathway to develop bespoke, species-specific cryopreservation media. By consolidating these multidisciplinary approaches, we propose a framework for enhancing cryopreservation efficacy, thereby strengthening the impact of genome resource banks on the genetic management and long-term conservation of vulnerable and endangered wild ruminant populations.

Climate-Resilient Wastewater Reclamation through Dual Extended Aeration Systems: Performance Assessment for Sustainable Water Security in Semi-Arid Regions of Pakistan

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Increased water scarcity and water stress due to climate change are becoming critical water issues in the semi-arid regions, which calls for innovative and sustainable wastewater reclamation solutions. The study compares the operational efficiency and environmental sustainability of two full-scale extended aeration wastewater treatment plants (WWTPs) with treatment capacities of 65,000 gallons per day and 52,000 gallons per day respectively, treating wastewater for a large diplomatic compound in Islamabad, Pakistan. The systems aimed to recover wastewater for reuse in non-potable purposes, including landscape irrigation, to minimize reliance on freshwater for irrigation and promote circular water management. Treatment facilities are both designed with integrated unit operations, such as flow equalization, primary screening, aerobic biological treatment, secondary clarification, tertiary filtration and chlorination-dechlorination processes. Several physicochemical and microbiological parameters such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), removal efficiency of pathogens, pH and dissolved oxygen (DO) were monitored in the influent and effluent samples, for nine months. The results showed high efficiencies of treatment in both treatment systems. Both WWTPs successfully achieved high removal efficiencies with 85.4%, 86.4%, 90.0% and 99.99% for BOD, COD, TSS and pathogen reduction at WWTP-01 and 93.4%, 94.2%, 96.7% and 99.98% at WWTP-02. Both pH ranges (7.4-7.5) and dissolved oxygen concentrations (6.7-6.8 mg/L) of the treated effluent were stable and in acceptable limits for irrigation re-use and discharge to environment. The two systems recovered around 161.66 million liters of wastewater per year, which greatly reduced the potable water consumption and helped to protect the environment and conserve resources. The results demonstrate that extended aeration systems are a scalable, cost-effective and climate-smart solution for wastewater management in water-stressed areas. Moreover, the research highlights

how decentralized wastewater reclamation technologies can play a role in sustainable urban infrastructure, ecosystem protection, and water security in the face of climate change.

Keywords: Extended aeration system, Wastewater reclamation, Water reuse, climate resilience, Biological wastewater treatment, semi-arid regions, Water security, Environmental sustainability.

Population Dynamics, Habitat Partitioning, And Threats To Two Francolin Species Across Riverine–Scrub–Agro Ecosystems In Pakistan

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Francolins play a pivotal ecological role in the semi-arid ecosystem of South Asia; however, increasing habitat loss and various biotic and abiotic pressures are affecting their distribution and population dynamics. This study investigated the population status, habitat associations, seasonal variation, and perceived threats to the Grey Francolin (*Ortygornis pondicerianus*) and Black Francolin (*Francolinus francolinus*) in the semi-arid landscapes of southern Khyber Pakhtunkhwa and adjoining Punjab, Pakistan. A total of 80 stratified sampling sites were selected across four districts, including Dera Ismail Khan, Lakki Marwat, Tank, and Mainali, using 1-km-long line transects covering major habitat types: riverine vegetation, agriculture, scrubland, and semi-desert. A total of 1,452 individuals were recorded during the surveys, including 832 Grey Francolins (57%) and 620 Black Francolins (43%). Habitat analyses show a clear ecological distinction between the two species. Grey Francolin was most abundant in scrubland habitat (47%), followed by agricultural landscapes (28%). This indicates its adaptability to open vegetation and agro-ecosystems. In contrast, Black Francolin showed a strong association with riverine vegetation (49%) as they tend to prefer dense shrub cover and near water. A seasonal pattern shows peak abundance in April–May, coinciding with the breeding season and low detection rates in winter. The density of the shrub layer also influenced species occurrence; Grey Francolin prefers areas with moderate shrub cover (30–50%), whereas Black Francolins were mainly associated with dense shrub vegetation (>50%) near water bodies. Diversity indices indicated balanced coexistence of both species in agricultural mosaics, while riverine and scrub habitats showed species-specific dominance. Community surveys identified several anthropogenic pressures, with hunting (81%), agricultural expansion (76%), and overgrazing (71%) reported as the most significant threats. Habitat degradation through fuelwood extraction and loss of riverine vegetation particularly affected Black Francolin populations. These findings highlight the importance of maintaining habitat heterogeneity, conserving riverine vegetation, and regulating hunting to support sustainable francolin populations in semi-arid ecosystems.

Keywords: Galliform birds, Grey Francolin, Black Francolin, habitat partitioning, dynamics, disturbance, Southern Khyber Pakhtunkhwa.

Valuation of Industrial Hemp (*Cannabis sativa* L.) for Sustainable and Circular Bio-Based Materials

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Industrial hemp (*Cannabis sativa* L.) is re-emerging as a strategic bio-based resource with significant potential to support sustainable and circular material systems across multiple sectors, including textiles, composites, pharmaceuticals, cosmetics, food, and advanced biomaterials. Global market analyses indicate strong growth in the hemp fiber sector, driven largely by expanding legalization, technological innovation, and increasing

demand for low-impact raw materials. The global hemp fiber market is projected to reach approximately USD 26.4 billion by 2026, with an estimated compound annual growth rate of over 35%, reflecting both economic opportunity and environmental relevance. Against the backdrop of the European Green Deal and the Sustainable and Circular Textiles Strategy, environmental claims such as “eco-friendly” and “green” are increasingly regulated, emphasizing lifecycle-based performance, climate neutrality, resource efficiency, and circularity. This policy shift is especially pertinent given that more than 73% of global textile fibers are petroleum-based, the sector accounts for roughly 20% of industrial water pollution, and laundering of synthetic textiles contributes substantially to microplastic release and carbon emissions. Furthermore, less than 1% of clothing is currently recycled into new garments, underscoring the urgency for alternative fiber systems. This study evaluates industrial hemp as a renewable and multifunctional raw material within circular bio-based production frameworks. Hemp production trials are discussed from seed selection and cultivation through fiber processing and end-product development, with particular emphasis on textile applications. The valorization of by-products, including hurd, shives, and seed-derived materials, is also assessed to demonstrate integrated zero-waste pathways. The findings highlight industrial hemp as a viable solution for reducing environmental impacts while supporting sustainable material innovation aligned with global climate and circular economy goals.

Diversity and Economic Significance of Wild Crop Relatives in Uzbekistan

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Wild relatives of cultivated plants constitute a critical genetic reservoir for sustainable agriculture, food security, and climate resilience. Uzbekistan, located at the crossroads of major biogeographical regions of Central Asia, harbors a rich floristic diversity that includes numerous wild crop relatives of cereals, legumes, fruits, vegetables, and forage species. This study provides an overview of the diversity, distribution, and economic importance of wild relatives of cultivated plants in Uzbekistan, highlighting their role in supporting agricultural productivity and adaptation to environmental stresses. These species possess valuable traits such as tolerance to drought, salinity, extreme temperatures, and pests, making them essential resources for crop improvement and breeding programs under changing climatic conditions. In addition to their genetic value, many wild relatives contribute directly to local livelihoods through traditional uses in food, medicine, fodder, and fuel. However, increasing anthropogenic pressures, including land-use change, overgrazing, and habitat fragmentation, threaten their persistence. The communication emphasizes the need for comprehensive documentation, in situ and ex situ conservation strategies, and the integration of wild crop relatives into national biodiversity and agricultural policies. Safeguarding this floristic heritage is vital for ensuring long-term agricultural sustainability and enhancing the resilience of food systems in Uzbekistan.

Integration of Traditional Wisdom in Modern Bio-Innovation

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The integration of traditional wisdom with modern bio-innovation provides a robust and sustainable framework for addressing contemporary challenges in human health, agriculture, and environmental sustainability. Medicinal plant resources, shaped through centuries of empirical use by indigenous and local communities, represent a critical foundation for bio-innovation. Ethnobotany plays a central role in documenting, preserving, and scientifically interpreting this knowledge, thereby guiding the discovery of novel bioactive compounds and plant-based therapeutic solutions. This abstract highlights how ethnobotanical knowledge of medicinal plants contributes to modern advancements in pharmacology, biotechnology, nutraceuticals, and functional foods. Traditional uses of plants for managing metabolic, infectious,

inflammatory, and chronic diseases offer valuable leads for phytochemical screening, metabolomic profiling, and molecular validation. When combined with contemporary tools such as genomics, bioassays, and bioprocess engineering, ethnobotanical insights accelerate drug discovery, support the development of standardized herbal formulations, and promote evidence-based integration of traditional medicine into modern healthcare systems. The study further emphasizes the role of medicinal plant resources in climate-resilient agriculture, sustainable livelihoods, and circular bio-economies. Ethical considerations—including intellectual property rights, community participation, and benefit-sharing—are underscored as essential components of responsible bio-innovation. By bridging ethnobotany and medicinal plant science with modern biotechnology, bio-innovation can become more culturally grounded, scientifically rigorous, and ecologically sustainable, contributing to biodiversity conservation and improved human well-being in the face of global change.

A circular economy approach to conserve biodiversity of aromatic and medicinal plants

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A circular economy approach to conserve biodiversity of aromatic and medicinal plants (AMPs) is a systems-based approach that aims to reduce waste and pollution and to keep materials in use for as long as possible. This approach can be applied to the entire value chain of AMPs, from cultivation and harvesting to processing, distribution, and consumption. A circular economy approach is a promising way to conserve the biodiversity of AMPs. By keeping materials in use for as long as possible to ensure that AMPs are available for future generations. This talk shall highlight various latest approaches used for the sustainability of these germplasm resources for future generations.

Maximizing Livelihood Opportunities through Introduction of High Value Medicinal Plants in District Swat, Pakistan; Study for Sustainable Development and to meet SDGs

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This study examined opportunities to maximize farm income through introduction of high value medicinal plants in the war-stricken district of Swat. The tested hypothesis was the establishment of ex-situ experimental production plots which has supposedly provided theoretical frame work for the development of skills in horticultural production and marketing among people in the valley and helps rebuild commercial connections between this region and the rest of Pakistan. This project was aligned with the overall attainment of the Millennium Development Goals, Sustainable Development Goals of the Government of Pakistan and the Global Strategy for Plant Conservation agreed in 2002 under the United Nation Convention on Biological Diversity. The project involves a substantial agricultural extension component with farmers in three villages of District Swat. The project has covered a range of interventions such as local awareness campaigns, capacity-building training, and community mobilization for conservation of threatened species, formation of “medicinal and aromatic plants (MAPs) Producer Associations who are directly linked to big buyers for maximizing their net income. Moreover, the project also established demonstration plots of the selected high value MAPs for economic analysis/feasibility (in terms of cost comparisons/opportunity cost between cultivation of cereal/cash crops and the selected high value MAPs and regular monitoring and evaluation of the adoption by farmers of improved agricultural practices. Additional emphases have been placed on developing reliable marketing channels. In this context, and also in order to address different aspects of biodiversity uses for economic growth, the project has also worked to adapt appropriate strategies and

technology recommended in Sustainable Development Goals by Government of Pakistan (<https://www.cbd.int/doc/world/pk/pk-nbsap-v2-en.pdf>). The study has also incorporated evaluation of its performance in introducing standardized production technology and appropriate post-harvest management, which represent the prime 'engines of growth' for the local economy. These strategic economic development areas are entirely based upon, and closely interlinked, with the management and conservation practices of high value MAPs, and intact landscapes.

Hemp-A menace or blessing of nature

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Hemp (*Cannabis sativa* L.) is a natural gift of the nature that meets the major needs of human well-being. It is the most valuable, versatile, and earliest plant on this planet which is cultivated as a source of medicine and textiles. The plant is native to Central Asia, Xinjiang, and Pakistan and may extend to north and northeastern Tibet, Mongolia, and southern Siberia. This is one of the oldest plants grown for food, fiber, and medicine. It is now cultivated for food, drugs, and medicine, as well as for the production of rope, paper, fiber, and oil. It is grown as a medical and recreational crop in more than 50 nations due to its wide range of therapeutic benefits. This is a trillion-dollar crop with over 50,000 uses worldwide that can create local economies and reduce poverty. This is the only plant on our planet that meets the 2030 agenda for sustainable development goals (SDGs) supporting 3Ps (i.e. People, Planet, and Profits) covering all 17 objectives. Historical records indicate that this crop was cultivated in the tribal belt of the countries in the early seventeenth century. The experiment for the execution of the hemp project was carried out at the Institute of Hydroponics Agriculture, Rawat, Punjab, Pakistan by using four native hemp germplasm. This communication shall highlight the potential of this crop and the latest updates on the initiation of the hemp project in Pakistan.

Keywords: Hemp, Botany, Ecology, Ethnobotany, Phytochemistry, Pharmacological properties.

Green Synthesis, characterization and biological evaluation of nano-particles using extracts of medicinally important *Trillium govanianum* and *Angelica glauca*

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Green synthesis is a method of synthesizing nanoparticles using natural materials, such as plant extracts. This method is more environmentally friendly and sustainable than traditional methods of nanoparticle synthesis, which often use toxic chemicals. *Trillium govanianum* and *Angelica glauca* are two medicinal plants that have been shown to be effective in synthesizing nanoparticles. Extracts from these plants contain a variety of bioactive compounds that can act as reducing and capping agents. Green synthesis of nanoparticles using extracts of *Trillium govanianum* and *Angelica glauca* is a promising approach for the production of nanoparticles with a variety of biological activities. These nanoparticles have the potential to be used in a variety of applications, including medicine, agriculture, and environmental remediation. More research is needed to fully characterize and evaluate the biological activities of these nanoparticles. However, the preliminary results are promising and suggest that green synthesized nanoparticles from *Trillium govanianum* and *Angelica glauca* have the potential to be used to develop new and effective treatments for a variety of diseases.

Climate-Smart Marginalized Crops: Scale-Up Strategies and Industry Linkages

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Climate change, land degradation, and water scarcity have placed immense pressure on global food systems, particularly in arid and semi-arid regions. In this context, climate-smart marginalized crops—traditionally underutilized or region-specific species—offer significant potential to enhance food security, improve resilience, and promote sustainable agricultural practices. These crops, including drought-tolerant cereals, pulses, oilseeds, and nutraceutical plants, are adapted to harsh environments and require lower inputs while providing high nutritional, economic, and ecological value. This talk explores strategies for scaling up climate-smart marginalized crops, emphasizing integrated approaches that combine agronomic optimization, germplasm improvement, mechanization, post-harvest processing, and digital agriculture tools. Effective scale-up requires not only improved cultivation practices but also the establishment of robust value chains, market access, and industry linkages that connect smallholder farmers to regional, national, and global markets. Public-private partnerships, policy incentives, and capacity-building programs are critical to mainstream these crops into commercial agriculture while maintaining biodiversity and ecosystem health. Furthermore, industry linkages play a pivotal role in ensuring economic viability and adoption of climate-smart crops. Integration with food processing, nutraceuticals, biofuel production, and pharmaceutical industries can transform marginalized crops into high-value commodities, generating income for rural communities and contributing to climate-resilient agricultural systems. By combining scientific innovation, participatory governance, and market-oriented frameworks, the promotion of climate-smart marginalized crops offers a pathway toward sustainable agriculture, enhanced food security, and resilient livelihoods under a changing climate.

Inquiry Based Learning and Farmer Field School Approach for Sustainable Conservation of Biodiversity & Ecosystems

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Social and economic development has been and remains the target and priority of each entity, community and country around the globe. Biodiversity is directly related to food security and sustainability of ecosystems and the services that they provide to humans. Science education and science literacy of youth, students and communities at large play a vital role to prepare societies to ensure conservation and sustainable growth of biodiversity and ecosystems, leading to socioeconomic development of people. Recent epidemic of COVID-19 has particularly underscored the importance of science education and literacy for all. Science education and literacy of public at large also enables and empowers communities to tackle the future global challenges, including the climate change. In fact, the World Economic Forum report on jobs in 2023 emphasizes that the skill of learning and the “Critical Thinking” is the top most skill in demand in 2023. And to nurture critical and innovative thinking amongst the young students as well as the communities, becomes very crucial. In this respect, though there are various ways of teaching and learning, the Inquiry Based Science Education (IBSE)-hands-on and minds-on approach, especially for the science subjects including biodiversity conservation and sustainability, has been recognized globally, as the best methodology for learning of the scientific and technological processes and natural phenomena taking place in the environment around us. IBSE has become a brand for teaching and learning at different levels around the world. IBSE by the global network- Inter-Academy Partnership (IAP) or La main a la pate (LAMAP) - the French brand, have been quite popular in many countries including Pakistan, which has led to establishment of an Office of Climate Education (OCE) - a UNESCO Category 2 Centre in Paris in the wake of 2015 Paris Agreement on Climate Change. Under the Belt and Road Initiative of China, we have the “Belt and Road International Science Education Consortium (BRISEC)” that emphasizes on maker camps for the youth. IBSE way of teaching and learning instills the willingness of learners to explore new ideas and rely on the evidence and logic for conclusion and decision

making. IBSE develops understanding of different science concepts through learner own physical and mental activity. In the IBSE approach, different facts, questions, problems and scenarios are presented to the learners for investigation by using their own skills of observation, raising investigative questions, planning and conducting investigations/experiments, reviewing evidence in the light of what is already known, drawing conclusions and communicating and discussing results. Thus, the learners work just like scientists. The process with communities is facilitated by the biodiversity expert facilitators. The Inquiry approach, may it be practiced at schools, universities, protected areas, biodiversity sanctuaries, Biosphere Reserves or Farmer Field Schools (FFS), nurtures inquisitiveness among learners/participants and could ensure sustainable conservation and use of biodiversity leading to socioeconomic development as a whole. The practical IBSE modules developed by experts and pedagogy specialists, can be incorporated in the syllabi of schools, colleges and universities, as well as for educating the communities directly living on biodiversity in the biodiversity hotspots or around biosphere reserves. This would in-turn lead to their sustainable socio-economic development. The key players in the whole system are the “teachers”, who need to be trained and retrained in a fast technologically developing world. I hope the National Academy of Higher Education (NAHE) of HEC also takes note of this and incorporates into their training methodologies. This presentation will highlight the basic concepts of inquiry science education in educational institutions and beyond in Biosphere Reserves and Farmer Field Schools (FFS), and emphasize on hands-on minds-on learning for biodiversity conservation and use on sustainable basis.

Role of Forest Department in Conservation of Forest Ecosystem and Climate Resilience

Mahmood Nasir

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Forests are critical components of terrestrial ecosystems, providing essential ecological services including biodiversity conservation, carbon sequestration, water regulation, soil protection, and livelihood support. In the context of accelerating climate change, the role of the Forest Department has expanded from traditional forest management to a more integrated mandate encompassing ecosystem conservation and climate resilience. This abstract examines the multifaceted role of Forest Departments in safeguarding forest ecosystems through policy formulation, sustainable forest management, protection of natural habitats, and restoration of degraded landscapes. Emphasis is placed on institutional functions such as forest governance, law enforcement, monitoring and inventory of forest resources, and implementation of afforestation and reforestation programs. The Forest Department plays a pivotal role in enhancing climate resilience by promoting climate-smart forestry practices, conserving carbon-rich ecosystems, and facilitating ecosystem-based adaptation strategies. Through community engagement, joint forest management, and integration of indigenous knowledge, forest agencies strengthen social-ecological resilience while reducing vulnerability of forest-dependent communities. Furthermore, Forest Departments contribute to national and international climate commitments by supporting REDD+, biodiversity action plans, and climate change mitigation and adaptation frameworks. Overall, effective Forest Department interventions are central to maintaining forest ecosystem integrity, enhancing adaptive capacity to climate change, and ensuring sustainable development. Strengthening institutional capacity, improving inter-sectoral coordination, and adopting science-based management approaches are essential to maximize the contribution of Forest Departments toward long-term forest conservation and climate resilience.

Weeds as Precursor of Climate-Resilient Crops

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Climate change poses a critical threat to global food security by intensifying abiotic and biotic stresses on cultivated crops. In this context, wild plant species, particularly agronomic weeds, emerge as a vital and underutilized genetic reservoir for breeding climate-resilient crops. Weeds, through natural selection in harsh and marginal environments, have evolved robust adaptive traits—such as deep root architecture, drought and heat tolerance, water-use efficiency, allelopathy, and resistance to pests and diseases. This review posits that these “weedy” species can serve as strategic genetic precursors for the next generation of resilient crops. This talk analyzed the key physiological, biochemical, and genetic mechanisms underlying the stress resilience of model weed species and discussed the potential for translating these traits into major food crops through advanced breeding techniques, including genomic selection, marker-assisted backcrossing, and gene editing. The paper also addresses the challenges associated with utilizing weed germplasm, such as linkage drag and yield penalties, and proposes a framework for the systematic identification, characterization, and introgression of beneficial weedy alleles. By harnessing the genetic heritage of weeds, we can accelerate the development of crop varieties capable of sustaining productivity under the increasingly volatile conditions of a changing climate, thereby contributing to the future stability of agricultural systems.

Medicinal Plants biodiversity using Interdisciplinary approach towards health and food security

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Medicinal plants biodiversity is important towards health and food security. In current era due to fast climatic changes the, food and health security are important topics of discussion around the world and Pakistan particularly. Scientists in the World exploring alternative food and health resources for sustainable development. Innovations and emerging technologies are the solution to find out sustainable utilization of plant diversity. Pakistan is host to three of the world biggest and most spectacular mountain ranges, the Himalaya, the Karakoram and the Hindukush (HKH). This project confined to explore the commercial products obtained from plant diversity which play an important role in socio-economic welfare and sustainable development of livelihood in Pakistan. This area is endowed with a great diversity of flora and fauna due to variations in altitude, rainfall and climate. The native communities have centuries old knowledge about the plant resources utilization and depends upon directly or indirectly on these resources to meet their daily needs in the form of biomass energy, biofuels, nutraceuticas, pharmaceuticas, vegetables, fruits, medicines, wood, timber, fodder, nuts, honey, spices, food and many other NTFPs. Currently, biodiversity in this region is strongly influenced by dynamic climatic changes like rise in global temperature, pollution, fluctuation in rainfall, population pressure, agricultural expansion, deforestation, extensive livestock grazing, resource demand, and commercial timber extraction that intensify the rates of habitat loss, habitat degradation, and wildlife exploitation. Species richness and threats suggest that this area needs strong and prompt conservatory management of biodiversity. The study recommend the development of national parks, wild life sanctuaries, botanical gardens and herbaria based on in -situ and ex-situ conservation strategies in in Northern areas of Pakistan to protect regional biodiversity for global acceptance. Indeed, conservation of biodiversity is fundamental to achieving sustainable development in this area particularly and world generally. Maintaining biodiversity is not only crucial for the sustainability in agriculture, energy, forestry, fisheries, wildlife, tourism, health, irrigation and power sectors Pakistan, but is also life line for the downstream people in other parts of Pakistan.

Effect of Pyrazole Toxicity on the Blood Clotting in Chickens (*Gallus gallus domesticus*)

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The poultry industry plays a vital role in the global economy by providing affordable animal protein, supporting rural livelihoods, and contributing significantly to agricultural GDP. Broiler chickens, in particular, are widely reared due to their rapid growth and high feed conversion efficiency. Pyrazole, a heterocyclic organic compound with diverse pharmacological and toxicological properties, has been reported to influence various physiological systems, including hematological parameters. Blood clotting factors—assessed through clotting time (CT), bleeding time (BT), prothrombin time (PT), and activated partial thromboplastin time (APTT)—are critical indicators of hemostatic function. The present study aimed to evaluate the effect of pyrazole on blood clotting factors in broiler chickens. Twenty (1-day-old) broiler chicks were randomly divided into two groups (n=10 each) following acclimatization: a control group receiving normal saline and a treatment group administered pyrazole (50 mg/kg body weight) on alternate days for 30 days. On the final day, CT and BT were measured by pricking brachial vein with the help of capillary tubes and filter paper methods, respectively. Blood samples were collected via cardiac puncture for PT and APTT estimation. Results demonstrated a significant increase in CT, BT, PT, and APTT values in the pyrazole-treated group compared to controls ($p < 0.05$), indicating an anticoagulant effect.

Keywords: Pyrazole, Blood clotting factors, Prothrombin time, Activated partial thromboplastin time, Hemostasis, Poultry economics.

Comparative Characterization and Milt Quality Assessment of *Cirrhinus Mrigala* and *Labeo Rohita* during Different Breeding Phases

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The quality of reproduction of *Cirrhinus mrigala* (Mrigal) and *Labeo rohita* (Rohu) in their reproductive phases was studied by analysis of milt quality parameters such as the motility of sperm, the duration of motility, sperm concentration, sperm abnormality, seminal pH and milt volume. Samples were collected from mature male brooders during three different phases of the breeding season - early (June), mid (July) and late (August). The milt was gathered by the stripping method from the Fish Seed Hatchery, Fateh Jang, Pakistan. The study showed that sperm motility and motility duration of sperm was significantly higher during mid-breeding phase in the study, which was shown by a significant increase in sperm motility of *C. mrigala* from 48.33% in June to 60.00% in July and motility duration of *L. rohita* from 53.33% to 63.33%. These parameters were reduced towards the late phase of breeding. Sperm concentration and the volume of milt showed slight variation over the breeding period for the two species. However, seminal pH remained stable around at 7.0 for *C. mrigala* and 7.0 to 8.0 for *L. rohita* during the various phases. Sperm abnormalities were low in both cases but there was a slight increase in abnormalities in the late phase by *L. rohita*. The results show the importance of the mid-breeding phase of the reproductive cycle (July) to collect milt as it provides the best conditions for sperm motility and reproductive potential. These results reveal pertinent information on species-specific and phase-related sexual reproduction which is necessary for optimizing broodstock management and improving fertilization efficiency as well as artificial breeding methods in carp aquaculture.

Keywords: *Cirrhinus mrigala*, *Labeo rohita*, breeding season, reproduction

Effects of Pyrazole Administration on Cardiac Histology in Chickens

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Pyrazole is a bioactive chemical compound with potential toxicological implications; however, its cardiotoxic effects remain inadequately investigated. The present study aimed to evaluate the histological alterations induced by pyrazole in the cardiac tissue of chickens. A total of 20 newly hatched chicks were acquired from a hatchery in Islamabad. The animals were randomly allocated into two groups (n=10 per group): control group and a pyrazole-treated group. Group I was control group given normal saline. While group II was administered with Pyrazole at the dose of 50 mg/kg body weight. The exposure was given for 4 weeks on alternate day. During the experimental period, animals were given feed and water ad libitum. After the administration of the last dose, animals were killed humanely, and heart was dissected out. The tissues of heart were processed for the histology. The tissue sections of heart were stained with conventional hematoxylin and Eosin (H&E) stain. Results showed that upon microscopic evaluation significant histological alterations in the pyrazole-treated group compared to the controls were evident. The major findings included Zenker's necrosis of myocardial fibers, vacuolar degeneration of cardiomyocytes, and disruption of normal myocardial architecture. In contrast, the control group exhibited normal cardiac histoarchitecture with intact muscle fibers and preserved cellular morphology. These findings demonstrate that administration of pyrazole at 50 mg/kg body weight induces marked cytoarchitectural damage in chickens, suggesting its potential cardiotoxic properties. Further investigations involving biochemical and molecular assessments are warranted to elucidate the underlying mechanisms of toxicity.

Keywords: Pyrazole, Chicks, Cardiac histology, H&E staining

A study on Pyrazole-Induced Neurotoxicity Toxicity in Chickens (*Gallus gallus domesticus*)

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This experimental study was conducted to evaluate the effects of Fipronil and Pyrazole on brain histology and behavioral changes in one-day-old broiler chicks. A total of newly hatched broiler chicks were obtained from a local hatchery and reared under standard laboratory conditions for a period of one month. The chicks were randomly divided into three groups: Group I (Control), Group II (Fipronil-treated), and Group III (Pyrazole-treated). The experimental groups received doses on alternate days according to their body weight, while the control group was maintained without treatment. Throughout the experimental period, behavioral parameters were carefully observed and recorded to assess any neurological or functional alterations. At the end of the study, brain tissues were collected for histological examination. Tissue samples were processed, sectioned, and stained to prepare microscopic slides for detailed evaluation of structural changes. The results demonstrated notable histopathological alterations in the treated groups compared to the control group, along with observable behavioral abnormalities. The findings suggest that exposure to Fipronil and Pyrazole induce neurotoxic effects in broiler chicks, affecting both brain structure and behavior. This study highlights the potential neurological risks associated with these compounds and emphasizes the need for careful monitoring of their exposure in poultry.

Keywords: Fipronil, Pyrazole, Neuroprotection, Antioxidant, Poultry toxicology, Histopathology

Effects of Pyrazole-Induced Reproductive Toxicity in Chickens (*Gallus gallus domesticus*)

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The widespread use of pyrazole-based insecticide in agriculture and veterinary practices has raised concerns due to their endocrine-disrupting and reproductive toxic effects in non-target species, including poultry. Current study was designed to study the toxic effect of pyrazole on the gonadal histology. In poultry, such

toxicants are associated with reduced hormone levels, altered gonadal histology, decreased sperm quality and impaired reproductive performance. One day old chicks were acquired from a hatchery in Islamabad. They were divided into 2 groups of ten (N=10) animals each. Group I was the control group, given normal saline and Group II was administered with pyrazole (50mg/kg b.w). The treatment was given for 4 week on alternate day. During the experimental period, animals were given feed and water ad libitum. After the administration of the last dose animals were killed humanly and gonads were dissected out. The tissues were processed for the histological studies. Conventional hematoxylin and eosin (H&E) staining was used for the the observation. Results showed that normal gonadal architecture was present in the gonad sections of control animals while there were noticeable changes in the interstitium (interstitial space), characterized by the accumulation of interstitial pigment in the tissues of the animals exposed to Pyrazole. The study concludes that Pyrazole can change the tissue histology if exposed chronically.

Keywords: Chicks, Pyrazole, Gonads, histology

Climate Change and Dengue Transmission: Climatic Drivers, Geographic Expansion, and Future Projections

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Dengue fever is one of the fastest-growing diseases that is spread through vectors, and climate change is becoming one of the leading factors that define the dynamics of dengue transmission and its distribution across the globe. The review critically assesses more recent evidence on the association between climatic variables and epidemiology of dengue, involving global systematic reviews and national studies of particular regions, especially in South and Southeast Asia and Pakistan. Temperature, precipitation, and humidity become the key climatic factors that affect the survival of vectors, their reproductive activity, biting, and the multiplication of the virus. An increase in temperature increases mosquito growth and reduces the extrinsic incubation, increasing the potential of transmission. The changed precipitation patterns provide quality breeding conditions, whereas the influence of extreme weather conditions like flooding also increases the risk of outbreaks. Different Shared Socioeconomic Pathways (SSPs) used to make projections predict significant increases in the intensity of transmission, magnitude of epidemics, and length of seasons towards the end of the twentieth century, particularly with high-emission paths (SSP5 -85). Modelling research estimates strong rises in the peak incidence and the basic reproductive number (R_t) alongside prolonged periods of epidemics. Geographical invasion of high-altitude areas and other non-endemic temperate areas is expected, and indications have shown that there has been a significant spatiotemporal change in Pakistan. The process of urbanization and human movement also increases transmission risks associated with climatic factors. Although there have been advances in predictive modelling and climate-based surveillance models, there still exist implementation gaps as far as proper adaptation mechanisms are concerned. Having more resilient climate-sensitive surveillance systems, incorporating more predictive analytics into the communal health planning, and a multi-sectoral control approach will continue to be the key to reducing future disease burden. Without concerted climate response and adjustment readiness, the dengue diffusion is expected to escalate significantly in a global climate of warming.

Keywords: Dengue fever, climate change, epidemiology of dengue, basic reproductive number, multi-sectoral control

Antibiotic Activity Of Clove (*Syzygium aromaticum*)

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This research lays out the process of checking the antibiotic activity of clove (*Syzygium aromaticum*) against different bacteria. Theoretically, my paper tried to take from the big pool of nature a potent weapon against the increasing number of antibiotic-resistant bacteria. Clove, being a household spice and herbal remedy in Pakistani culture, I, therefore, chose it for my research idea. In the experiment, I made clove extracts by grinding dried cloves into powder and soaking them separately in ethanol and distilled water to get alcoholic and aqueous extracts, respectively. After filtration, the extracts were tested against different types of bacteria using the agar well diffusion method. The bacteria chosen for this research were some Gram-positive and Gram-negative bacteria, such as *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Bacillus subtilis*. The findings uncovered the fact that clove extract exhibits powerful antibacterial properties, with the most susceptibility of Gram-positive bacteria such as *Staphylococcus aureus* and *Bacillus subtilis*. Gram-negative bacteria like *Escherichia coli* exhibited intermediate sensitivity, whereas *Pseudomonas aeruginosa* was hardly sensitive due to its high resistance caused by the structure of its outer membrane. The potent antibacterial capacity of clove is mainly attributed to the presence of eugenol, which ruins the bacterial cell membrane and prevents enzyme activity. Basically, I inferred from the present study that clove possesses the antibacterial property and can act as a natural antimicrobial agent. Advanced work on higher concentrations and purified compounds could be a great step in the development of plant-based drugs. This little study helped me to increase my awareness about natural antibiotics and microbial sensitivity testing.

Prognostic Value of Inflammatory Hematologic Markers in Predicting Disease Severity and Clinical Outcomes in Patients with Acute Leukemia at Initial Presentation

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Background: Acute leukemia represents a group of aggressive hematologic malignancies characterized by uncontrolled proliferation of immature hematopoietic cells requiring rapid diagnosis and timely therapeutic intervention. Despite major advances in molecular genetics and targeted therapy, early prognostic assessment at the time of initial presentation remains a clinical challenge, particularly in resource-limited healthcare settings. Current risk stratification systems largely depend on cytogenetic and molecular analyses; however, these investigations are expensive, time-consuming, and not universally available. Consequently, there is increasing interest in identifying inexpensive and readily available prognostic biomarkers derived from routine laboratory investigations. Cancer progression is closely linked with systemic inflammation and immune dysregulation. Inflammatory indices calculated from complete blood count parameters—including neutrophil-to-**lymphocyte** ratio (NLR), platelet-to-lymphocyte ratio (PLR), and red cell distribution width (RDW)—have emerged as promising predictors of survival and treatment response across multiple malignancies. Elevated inflammatory markers reflect tumor-associated immune activation, cytokine release, and alterations within the tumor microenvironment that influence disease progression and therapeutic outcomes. Studies in hematologic malignancies demonstrate that increased NLR and RDW are associated with poorer survival and advanced disease status, highlighting their potential role as accessible prognostic tools. PubMed +1 Given that these biomarkers are routinely available at hospital admission, evaluating their prognostic significance in acute leukemia may allow early risk stratification before advanced molecular results become available.

Aim: To evaluate the prognostic significance of inflammatory hematologic markers measured at initial presentation in predicting disease severity, treatment response, and clinical outcomes among patients diagnosed with acute leukemia.

Objectives: To determine the association between inflammatory markers and baseline disease severity in acute leukemia. To evaluate the relationship between inflammatory indices and early treatment outcomes. To assess the predictive value of these markers for complications, intensive care requirement, and mortality. To explore whether routine hematologic parameters can serve as cost-effective prognostic indicators in clinical practice.

Methodology: Study Design

A retrospective observational cohort study conducted at a tertiary care teaching hospital. Study Population: Adult patients newly diagnosed with: Acute Myeloid Leukemia (AML), Acute Lymphoblastic Leukemia (ALL) Confirmed through bone marrow examination and standard diagnostic criteria.

Data Collection: Clinical and laboratory data will be obtained from hospital medical records at the time of initial presentation prior to initiation of chemotherapy. Collected variables will include:

Complete blood count parameters, Neutrophil-to-lymphocyte ratio (NLR), Platelet-to-lymphocyte ratio (PLR), Red cell distribution width (RDW), Lactate dehydrogenase (LDH), C-reactive protein (CRP), Demographic and clinical characteristics

Outcome Measures:

Primary outcomes: Overall survival, Early mortality, Treatment response following induction chemotherapy

Secondary outcomes: Infection rate, Requirement of intensive care admission, Duration of hospitalization

Transfusion requirement

Statistical Analysis: Patients will be stratified into high- and low-inflammatory marker groups based on predefined cut-off values. Statistical analysis will include:

Kaplan–Meier survival analysis, Cox proportional hazards regression, Multivariate risk adjustment, Receiver operating characteristic (ROC) curves will be used to evaluate predictive performance.

Expected Results: It is hypothesized that elevated inflammatory indices at diagnosis will correlate with:

Increased disease burden, Poor chemotherapy response, higher complication rates, Reduced overall survival, Inflammatory biomarkers may therefore function as early indicators of aggressive disease biology.

Significance: Early prognostic assessment remains critical in acute leukemia management. Although molecular profiling has revolutionized hematology, reliance on sophisticated testing limits accessibility in many regions worldwide. Routine inflammatory markers offer an attractive alternative due to their affordability, rapid availability, and reproducibility. Evidence from oncology research consistently demonstrates that systemic inflammatory response markers possess strong prognostic value, reflecting interactions between malignant cells and host immune mechanisms.

Nature: If validated, this study could contribute toward developing simplified prognostic models integrating routine laboratory parameters into early clinical decision-making. Such an approach may assist clinicians in identifying high-risk patients requiring aggressive monitoring and individualized therapeutic strategies.

Innovation:

Utilizes routinely available laboratory data.

Eliminates dependence on expensive molecular diagnostics.

Provides rapid prognostic assessment at admission.

Highly applicable to both developed and developing healthcare systems.

Easily reproducible across institutions.

Clinical and Global Impact

The proposed research aligns with modern hematology priorities emphasizing personalized medicine, early risk stratification, and equitable healthcare delivery. Implementation of inexpensive prognostic tools may improve treatment planning, optimize resource allocation, and ultimately enhance survival outcomes in acute leukemia patients worldwide.

Keywords: Acute Leukemia, Inflammation, Neutrophil-to-Lymphocyte Ratio, Prognostic Biomarkers, Hematologic Malignancy, Risk Stratification, Clinical Hematology.

Utilization Of Araucaria Heterophylla Gum (Norfolk Island Pine) In The Development Of Paracetamol Controlled-Release Matrix Tablets

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This study aimed to evaluate the potential of Araucaria heterophylla gum as a naturally occurring release-retarding biocompatible polymer for the production of controlled-release matrix tablets. Paracetamol was the model medication used to assess how well the gums maintained therapeutic levels. The physicochemical properties of the extracted gum were thoroughly explained. The drug-excipient compatibility was investigated using Fourier Transform Infrared spectroscopy. Matrix tablets were made with varying concentrations (10%, 20%, and 30% w/w). Compressibility and flow characteristics were evaluated as pre-compression parameters to confirm adherence to pharmacopeial limitations. In-vitro drug release tests were conducted using a UV-Visible spectrophotometer to measure absorbance and determine release kinetics. A statistical technique to evaluate the relationship between different formulations was the Pearson correlation coefficient. FTIR spectroscopy confirmed that the medication and natural polymer were compatible, and there was no observable interaction between the functional groups of Araucaria heterophylla gum and paracetamol. Every pre-compression blend displayed results within the allowed range for both flowability and compressibility. Among the formulations assessed, the one containing 20% gum had the best controlled-release profile, functioning as a matrix system and providing a steady drug release for the required amount of time. Araucaria heterophylla gum seems to be promising natural alternative to synthetic polymers for controlled-release applications. The good optimization of second formulation having 20% gum concentration w/w, which met the criteria for a successful matrix tablet formulation, is highlighted in the study.

Keywords: Araucaria heterophylla gum, controlled-release, FTIR spectroscopy, formulations, matrix tablets, paracetamol

Hot-Water Extract Of *Moringa Oleifera* Leaves Protects Erythrocytes From H₂O₂-Induced Hemolysis

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Stress is the body overall psychological and physical response to challenges, while oxidative stress is a cellular-level imbalance between damaging free radicals and protective antioxidants. Oxidative stress caused by reactive oxygen species (ROS), particularly hydrogen peroxide (H₂O₂), represents a major mechanism of erythrocyte membrane damage leading to hemolysis. The use of medicinal plants has grown significantly in the world due to growing concerns about toxicity, adverse effects, and the high cost of synthetic drugs. *Moringa oleifera*, a medicinally significant plant rich in water-soluble bioactive compounds including quercetin, kaempferol, chlorogenic acid, flavonoids, phenolic acids, and antioxidant peptides, has demonstrated substantial antioxidant and cytoprotective potential in prior research. However, the erythroprotective capacity of its hot-water extract against H₂O₂-induced hemolysis remains insufficiently characterized. Fresh goat blood was obtained. At the same time, fresh leaves of *Moringa oleifera* from locally grown plants were harvested. The leaves were then washed. Blood was centrifuged at 3000 rpm for 5 minutes to separate red blood cells and plasma. This was followed by centrifugation of the supernatant, and the layer of packed erythrocytes was taken off without stirring. The process was repeated twice with the addition of normal saline. The pellet of RBCs was then washed, and the suspension of the 2 percent erythrocytes with normal saline was made. Two hot-water extract preparations were tested in triplicate: a dilute extract (0.2 g leaf powder in 80 ml distilled water) and a concentrated extract (0.2 g leaf powder in 40 ml distilled water). Hemolysis was quantified spectrophotometrically. The concentrated extract reduced hemolysis to 17.5%

compared to 100% in the positive control, representing an 82.5% inhibition (mean OD = 0.35 vs. 2.0). The dilute extract recorded a mean OD of 1.1, while the concentrated extract yielded 0.36, demonstrating a clear concentration-dependent protective response. One-way ANOVA confirmed statistically highly significant differences between groups. The research thus validates that *Moringa oleifera* possesses significant antioxidant activity and can be used as a natural antioxidant to protect against cellular damage caused by oxidative stress. Further research can investigate whether *Moringa oleifera* extracts can help reduce hemolysis associated with medical conditions such as anemia or other oxidative stress-related diseases.

Keywords: *Moringa oleifera*, erythroprotection, oxidative hemolysis, hydrogen peroxide, hot-water extract, antioxidant activity

Extraction And Ftir Characterization Of Chitin From Houseflies (*Musca Domestica*) And Crickets (*Acheta Domesticus*) As Alternative Sustainable Sources

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As Chitin is the second most abundant biopolymer in nature after cellulose, and has diverse applications in different fields of life, such as agriculture, medicine, biosensors, manufacturing, wastewater treatment, cosmetics, textile mills, and numerous aspects of daily life, its extraction is a more valuable process, which is the first section of this review. Extraction is primarily conducted from marine sources, such as crustaceans, but is only available in sufficient amounts due to seasonal unavailability. As a result, there is a great need for alternative chitin sources. Therefore, insects are the best choices since, out of 1.3 million species in the world, 900,000 are insects, making them the most abundant species in the world. Also, they have shorter reproductive cycles than crustaceans, have high chitin content, availability, and a short lifespan. Therefore, thought to have an indistinguishable chitin concentration, making them a potential new source for chitin extraction. Because they are readily available and can be obtained in adequate quantities, the cricket species *Acheta domesticus* and *Musca domestica* in particular show enormous potential as alternate sources of chitin extraction. Extraction of chitin mainly involves two steps: Demineralization, which involves acid treatment (HCl), and Deproteinization, which involves Alkali treatment (NaOH). The second section of this review involves characterization of the chemical structure of extracted chitin by using the Fourier Transmission Infrared Radiation (FTIR) technique, which determines the degree of acetylation, crystallinity index, etc. Finally, the extracted chitin of both species was compared to identify and differentiate their chemical structure for future uses. As a result, *Achetadomesticus* comprises high crystallinity due to a higher degree of acetylation and is best suited for high-purity chitin yield, while *Musca domestica* has a lower crystallinity index due to a lower degree of acetylation but is referred to as the best selection for future application, as it can be easily converted into useful products like chitosan.

Keywords: Chitin, polymer, extraction, availability, potential, alternatives

Development and optimization of a sustainable polyoxometalate-kaolinite-based catalyst for efficient desulfurization of model and real fuel using Box–Behnken design

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The oxidative desulfurization of dibenzothiophene in model and actual fuels was examined using an environmentally friendly catalyst, H 4 SiW 12 O 40 @f-kaolinite. A catalyst was obtained by first functionalizing

kaolinite clay with (3-aminopropyl) triethoxysilane to form f-kaolinite, and then $H_4SiW_{12}O_{40}$ was immobilized on the surface of the catalyst. Fourier transform infrared spectroscopy, Raman spectroscopy, UV-visible spectroscopy, X-ray diffraction, energy-dispersive X-ray spectroscopy and scanning electron microscopy were all used to establish the successful synthesis and structural characteristics of the catalyst. The Box-Behnken design was used to optimize the effects of critical reaction parameters, such as catalyst dosage, temperature, and oxidant concentration, on the conversion of dibenzothiophene. The sulfur content in the model fuel was reduced to 78.3 ppm under optimal conditions (70 °C, 70 mg catalyst, and 8 mL H_2O_2), with a conversion efficiency of 92.17. The ANOVA results showed that the quadratic model ($R^2 = 0.99$) adequately explained the system, and the p-value of 0.2302 indicated no statistically significant lack of fit relative to pure error. Moreover, the $H_4SiW_{12}O_{40}$ @f-kaolinite catalyst decreased the concentration of dibenzothiophene in the sample of a real fuel oil to 224 ppm as opposed to 354 ppm. The heterogeneous nanocatalyst was also highly stable and reusable, with its elemental composition and catalytic performance remaining intact and constant after five consecutive reactions, and thus can have a significant impact on the desulfurization of fuels with an environmentally friendly approach.

In vitro therapeutic applications of selected probiotic bacterial strains

*Amin, A., Ghori, I., Irfan, H. Bibi, M. (2023).
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Live probiotic bacteria are defined as viable nonpathogenic strains which, when given in sufficient amounts to a host, enhance the health of that host. These bacteria are very helpful in treating ailments, including allergies, stomach issues, and infectious diseases. The probiotic species isolated from green cabbage and brought back to life in vitro were assessed as free radical scavengers, especially using DPPH and ABTS radicals. Furthermore, their anti-diabetic effects were evaluated through the factor of pigpancreatic lipase test and alpha-amylase inhibition assay. The scavenging actions of the probiotic strain against ABTS and DPPH radicals are maximum for MB694 followed by C56 strain results in statistically significant findings. Strain MB694 has also accomplished the best sugar hydrolyzing mechanisms and achieved remarkable results in the isolation process, thus it is known to have potential therapeutic roles in diabetes management based on its antidiabetic activity. The performance of porcine pancreatic lipase activity assay indicated that MB694 was able to hydrolyze lipids efficiently, which might be in favor of its antidiabetic potential. The results using statistical analysis are formidably significant. These findings highlight the potential medical relevance of probiotics. Finally, the high potent strain MB694 showed significant results and its sequence was matched with *Bacillus mycoides* after 16S-RNA sequencing.

Numerical Modeling for Transmission Dynamics of Human Papillomavirus (HPV) and Cervical Cancer

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In this work, a dynamical model for the transmission dynamics of HPV infection and its progression to cervical cancer is analyzed both analytically and numerically. A novel, unconditionally convergent mathematical model is proposed, incorporating multiple numerical methods, including Euler's method, Non-Standard Finite Difference (NSFD) method, and MATLAB built-in solver ODE45. These methods are employed to simulate the system and verify the convergence or divergence based on infection rates and other key parameters such as the population dynamics, infection rate, and the transmission coefficient. The results from the proposed methods are compared with well-known techniques like the Forward Euler and ODE45 methods. Unlike Euler method, which may diverge for certain step sizes, the NSFD method ensures stability and convergence, accurately predicting the system behavior over time. Additionally, this model is integrated into a web-based

platform where individuals can assess the risk of HPV infection and its dynamics within a population using real-time Pap smear image analysis and mathematical modeling. The platform generates predictions based on the analysis, helping to detect early signs of cervical cancer and aid in better decision-making.

Keywords: HPV infection, Cervical Cancer, Numerical Methods, Convergence, Pap smear analysis, Web-based Platform, Early Detection, Prediction System.

Ecology and Threats to *Commiphorawightii* in Thar Desert of Pakistan

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Commiphorawightii (*Burseraceae*), commonly known as guggal, is a slow-growing, perennial shrub native to the arid and semi-arid regions of the Thar Desert of Pakistan and adjoining areas of western India, where it occurs on dry, rocky substrates under open canopies. The species has high ethnobotanical and medicinal value due to its oleo-gum resin, widely used in traditional medical systems such as Unani, Ayurvedic, and Siddha, and in pharmaceutical applications. However, *C. wightii* is currently assessed as Critically Endangered at the regional level, with wild populations having declined by over 80% across its range due to a combination of ecological and anthropogenic pressures. Ecologically, the species exhibits low natural regeneration and poor seed germination, compounded by long juvenile phases and limited dispersal, resulting in reduced recruitment and fragmented population structure in the Thar Desert landscape. Genetic studies indicate low within-population genetic diversity and high differentiation among populations, further underscoring vulnerability to environmental change and demographic stochasticity. Key threats to *C. wightii* include unsustainable harvesting of resin through destructive tapping methods that often kill individual plants, habitat loss and degradation from land-use change, overgrazing by livestock, which inhibits seedling survival, and reduced recruitment resulting from population fragmentation. The commercial exploitation driven by local and international resin markets has exacerbated the decline, with poor seed setting and lack of active cultivation further limiting recovery potential. Conservation of *C. wightii* in the Thar Desert requires integrated strategies that combine in-situ protection of remnant populations, regulation of resin extraction, habitat restoration, and community-based participatory management. Ex-situ propagation, genetic conservation, and policy measures to control trade and promote sustainable use are also essential to prevent further loss of this ecologically and culturally significant species.

Cultivating A Sustainable Future: How Plant Sciences Propel Progress Toward Sdg Goals

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In an era marked by pressing global challenges such as climate change, food security, and environmental conservation, the role of plant sciences in achieving the Sustainable Development Goals (SDGs) has become increasingly significant. This abstract offers a glimpse into the comprehensive exploration of how plant sciences are instrumental in advancing the SDGs. By investigating the potential of innovative agricultural techniques, the development of climate-resilient crops, and the preservation of biodiversity, this research sheds light on the crucial role that plant sciences play in forging a sustainable future. The abstract introduces key findings and highlights the synergistic relationship between plant sciences and the attainment of the SDG objectives. As we delve into the pages of this work, readers will uncover the profound impact that these sciences have in transforming our world towards a more sustainable and equitable future. The achievement of the Sustainable Development Goals (SDGs) is an intricate interplay of multiple factors, with plant sciences playing a pivotal role in advancing these objectives. In the context of SDG-1, which aims to eradicate poverty,

it is evident that impoverished communities, often residing in rich biodiversity areas, possess valuable resources that can be harnessed sustainably to alleviate poverty. However, these indigenous populations often sell these treasures at meager prices, receiving little in return. Addressing SDG-1 not only combats poverty but also has a cascading effect on SDG-2 (Zero Hunger) and SDG-3 (Good Health and Well-Being). By providing proper guidance and support, it can enhance food security, nutrition, and sustainable agriculture, including the cultivation of off-season vegetables and high-value medicinal plants. To tackle SDG-3, which focuses on promoting good health and well-being, there is a need to address the skepticism surrounding herbal medicine. The lack of scientific validation and clinical trials for herbal products has hindered their acceptance in healthcare. Clinical trials are essential for assessing the safety and efficacy of therapeutic strategies, guiding healthcare decision-making. This relates to SDG-4 (Quality Education) and SDG-5 (Gender Equality) as well, as the research into herbal medicine can empower women and children who are often the primary collectors of medicinal plants. The path to achieving the initial six SDGs involves engaging indigenous communities in sustained, inclusive, and sustainable economic growth, thereby connecting with SDG-8 (Decent Work and Economic Growth) and SDG-9 (Industry, Innovation, and Infrastructure). Bridging the resource-rich but technology-limited poorer countries with the developed world is essential to reduce inequality (SDG-10) and subsequently work towards SDGs 13 to 16, which deal with climate action, life below water, life on land, and peace, justice, and strong institutions. International partnerships are a critical enabler for these efforts (SDG-17). One pressing challenge is how science can effectively serve impoverished populations. The misidentification and adulteration of herbal materials can compromise the effectiveness of herbal products and even lead to accidental poisonings. Ongoing research efforts include molecular barcoding of medicinal plants, exploring therapeutic applications of these plants, and investigating the bio-synthesis of nanoparticles. These scientific endeavors not only enhance the safety and efficacy of herbal products but also underscore the potential of plant sciences in promoting a sustainable and healthier world while advancing the SDG agenda.

Detection And Characterization Of Microplastics In Commercial Dairy Products Milk, Yougart And Cheese By Using Advanced Analytical Techniques

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Plastic has become an indispensable part of our daily lives since its inception. Polyvinyl chloride (PVC), polyethylene terephthalate (PET), polypropylene (PP), polystyrene (PS), and polyethylene (PE) are among the polymers with which they are made. Particles of plastic smaller than 5 mm in diameter are known as microplastics, or MPs. Microplastic (MP) contamination in dairy products, such as milk, cheese, and yoghurt, has caused severe concerns due to the potential risks to food safety and human health. Detecting and analysing microplastics in locally accessible dairy products in Dera Ismail Khan, Pakistan, was the goal of this investigation. Twelve milk samples in all, divided into branded, cowshed, and local dairy farm milk categories, were analysed using Fourier and light microscopy. The findings revealed a total of 613 MPs, with branded milk having the greatest proportion (42.1%), suggesting that processing and packaging are significant sources of contamination. Fibers, foams, and fragments of different colours were common MP forms, and the polymers found were mostly polypropylene (PP), polyethylene (PE), and polyethylene terephthalate (PET). Due to their exposure to plastic wrappers, containers, and processing machinery, yoghurt and cheese were found to pose similar dangers. From production to storage, many dairy products are susceptible to MP contamination, particularly when kept in plastic packaging. The study comes to the conclusion that long-term health effects, especially for children and pregnant women, may result from ongoing MP usage, including gastrointestinal problems and hormone imbalances. To lower MP contamination in dairy products and safeguard human

health, significant advancements in food handling procedures, safer packaging options, and regulatory oversight are crucial.

Keywords: Plastics, microplastics, milk, yogurt, cheese, dairy products, food contamination, FTIR analysis, polyethylene (PE), polypropylene (PP), polyethylene terephthalate (PET), plastic packaging, food safety, human health, Dera Ismail Khan.

Medicinal mushroom diversity in Pakistan

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Medicinal mushrooms are a valuable resource for human health and well-being. The diversity of medicinal mushrooms in Pakistan is a testament to the country rich natural heritage. Pakistan has a rich diversity of medicinal mushrooms, with over 100 species identified so far. These mushrooms are found in a variety of habitats, including forests, grasslands, and agricultural areas. Some of important medicinal mushrooms in Pakistan include: *Agaricus blazei* murill, *Auricularia auricula-judae*, *Ganoderma lucidum*, *Grifola frondosa*, *Hericium erinaceus*, *Lentinus edodes*, *Pleurotus ostreatus* and *Trametes versicolor*. These mushrooms have been used in traditional medicine for centuries to treat a variety of conditions, including cancer, heart disease, diabetes, and immune system disorders. In recent years, there has been a growing interest in the scientific study of medicinal mushrooms. Researchers have found that medicinal mushrooms contain a variety of bioactive compounds with potential health benefits. The research on medicinal mushrooms is still in its early stages, but the potential health benefits of these mushrooms are promising. With its rich diversity of medicinal mushrooms, Pakistan is well-positioned to contribute to the growing body of research on these valuable natural products.

Phytochemical Profile And Antimicrobial Activity Of Polyherbal Extracts Of *Nigella Sativa*, *Zingiber Officinale*, And *Cinnamomum Verum* Against Gastrointestinal Pathogens

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Background and Objective: Antimicrobial resistance in gastrointestinal pathogens, especially *Salmonella typhi* and *Escherichia coli*, has become a global health emergency. Conventional antibiotics are losing efficacy, and there is an urgent need for alternative, multitargeted therapies. Polyherbal formulations, derived from plants with long traditional use, offer a promising strategy. This study aimed to evaluate the phytochemical composition and antimicrobial activity of binary and ternary extracts of *Nigella sativa* (black seed), *Zingiber officinale* (ginger), and *Cinnamomum verum* (Ceylon cinnamon) against *S. typhi*, *E. coli*, and *Aspergillus* spp., and to identify the most potent extract combinations.

Methods: Plant powders (5 g each) were extracted individually and in binary and ternary mixtures using four solvents of varying polarity: methanol, ethanol, chloroform, and n-hexane. A total of 15 formulations were prepared. Extract yields were calculated gravimetrically. Antibacterial activity was assessed by broth microdilution to determine minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC). Antifungal activity against *Aspergillus* was evaluated using disc diffusion. Synergistic interactions were analysed via the fractional inhibitory concentration index (FICI). The most active extracts were subjected to gas chromatography mass spectrometry (GC-MS) for phytochemical profiling.

Results: None of the extracts showed any inhibitory activity against *Escherichia coli* under the tested conditions. In contrast, strong and selective bactericidal activity was observed against *Salmonella typhi*. Nine

polyherbal formulations exhibited MIC values ≤ 10 mg/mL with an MBC/MIC ratio of 2, confirming a bactericidal nature. The lowest MIC of 3 mg/mL was recorded for several combinations: the ternary methanol extract of all three plants; the ethanol binary extracts of *N. sativa* + *Z. officinale*, *N. sativa* + *C. verum*, and *Z. officinale* + *C. verum*; and the chloroform binary extracts of *N. sativa* + *Z. officinale* and *Z. officinale* + *C. verum*, as well as the chloroform ternary extract. Methanol and ethanol extracts also demonstrated strong antifungal activity against *Aspergillus*, while chloroform extracts showed moderate effects and hexane extracts were inactive. Synergy analysis revealed that binary combinations were as potent as ternary mixtures, indicating that adding a third plant did not consistently enhance activity. GC–MS profiling of the most potent extracts identified a diverse range of bioactive compounds, including phenolics, terpenoids, cinnamaldehyde, and fatty acid derivatives, known for their membranedisrupting and quorumsensing inhibitory properties.

Conclusion: Polyherbal extracts of *N. sativa*, *Z. officinale*, and *C. verum* selectively and potently kill *Salmonella typhi* (MIC as low as 3 mg/mL) but are inactive against *E. coli*, highlighting strainspecific susceptibility. Ethanol and chloroform binary combinations are as effective as more complex ternary mixtures, offering simplified, costeffective candidates for further development. The strong antifungal activity of polar extracts against *Aspergillus* broadens their therapeutic potential. These findings provide a scientific foundation for the traditional use of these spices against typhoid fever and justify in vivo and clinical studies to combat antimicrobial resistance.

Keywords: Polyherbal extracts, *Nigella sativa*, *Zingiber officinale*, *Cinnamomum verum*, *Salmonella typhi*, Bactericidal activity, Selectivity, GC–MS, Antimicrobial synergy

Thermal Stress and Student Well-Being: A Quantitative Study of Heat Exposure, Climate Anxiety, and Interpersonal Behaviour

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Rising global temperatures are increasingly recognized not only as an environmental challenge but also as a psychosocial stressor capable of influencing emotional and behavioral functioning. Exposure to sustained heat has been associated with heightened irritability, physiological strain, and increased psychological distress, potentially shaping how individuals interpret everyday demands and navigate social interactions. Within university environments where students routinely manage academic pressures alongside complex social dynamics, thermal stress may represent an under examined environmental factor influencing psychological well-being and interpersonal behaviour. Conceptually, this study is informed by the General Adaptation Syndrome, which posits that prolonged exposure to environmental stressors can trigger adaptive physiological and psychological responses that may affect emotional stability and behavioral outcomes. Using a cross-sectional quantitative design, this study examined associations between perceived heat exposure, climate-related psychological distress, and behavioral responses among university students. A convenience sample of 120 undergraduate participants completed a structured self-report questionnaire including demographic items and validated psychometric measures such as the Climate Change Anxiety Scale, the Perceived Stress Scale, and a brief irritability assessment measuring emotional reactivity and frustration during periods of elevated ambient temperature. Participants also reported their subjective experiences of heat exposure during recent high-temperature days. Data were analyzed using descriptive statistics to summarize response patterns and Pearson correlation analyses to examine relationships between perceived heat exposure, climate-related anxiety, stress levels, and irritability. The findings aimed to provide preliminary insight into how everyday climatic stressors might influence students' emotional states and interpersonal responses. Furthermore this study aimed to encourage educational institutions to consider environmental and structural

interventions such as improved thermal comfort in learning spaces and adaptive institutional policies to mitigate heat-related psychological strain and support student well-being.

Harnessing Bio-Innovations: Revolutionizing Food Systems for A Changing World

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As global populations surge and lifestyles shift, bio-innovations are reshaping food systems to meet evolving needs. Cutting-edge biotechnologies are transforming food production, processing, and nutrition. Precision fermentation is crafting alternative proteins and bioactive compounds for sustainable nutrition, while synthetic biology is engineering crops with enhanced traits like drought resistance and nutrient enrichment to combat climate stress. Smart packaging with biodegradable materials and sensors is extending shelf life and reducing waste. Additionally, Nutraceutical and functional foods are being tailored to promote health and longevity with bioactive like probiotic and omega-3s. These innovations address food security, sustainability, and personalized nutrition challenges. For instance, lab-grown meats reduce environmental footprints, while gene-edited super foods tackle micronutrient deficiencies. However, hurdles like regulatory approval, consumer acceptance, and ethical concerns persist. Interdisciplinary collaboration and responsible scaling are critical to realizing these technologies potential. By merging biology, AI, and green chemistry, bio-innovations can create resilient food ecosystems, empowering healthier, sustainable living in a rapidly changing world.

Keywords: Innovation, Sustainable, Nutrition, Collaboration, Ecosystems

AI-Integrated Biosensors for Early Detection of Climate-Induced Stress in Crops: A Bio-Innovation for Sustainable Agriculture

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Climate change is worsening environmental stresses such as drought, salinity, and severe temperatures, which greatly threaten agricultural output and global food security. The absence of tools that can identify plant stress early on, before obvious physiological damage and yield loss, is one of the main obstacles to climate-resilient agriculture. New possibilities for creating intelligent systems that can track plant health using biochemical indicators are presented by recent developments in plant biochemistry, biosensor technology, nano biotechnology, and artificial intelligence. This paper proposes the creation of an AI-integrated biosensor platform capable of identifying early biochemical signals linked with climate-induced stress in crops. The biosensor will target key plant stress biomarkers such as Absciscic Acid, Reactive Oxygen Species, and Proline, which are produced in plants during drought, salinity, and temperature stress. Nanomaterial-based sensing elements linked with enzyme or antibody recognition mechanisms would enable quick, sensitive, and real-time detection of these biochemical indicators within plant tissues. The obtained biosensor data will then be processed by AI-driven predictive algorithms capable of identifying stress patterns and forecasting probable crop damage before apparent symptoms occur. By merging biochemical sensing with intelligent data analytics, the proposed approach intends to establish a smart early-warning framework for climate stress in agriculture. Ultimately, this bio-innovation contributes to

sustainable agricultural systems by improving crop resilience, minimizing productivity losses, and supporting global food security under changing climate conditions.

Overexpression of StDREB30 gene improves drought tolerance by modulating defense related genes in potato

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Potato is one of the most important food crops because of its rich nutritional value, high yield and for its role as a global food source. However, potatoes suffer annual losses in yield and production due to water shortages. These losses are more profound nowadays due to climate change, thus, it is important to generate climate change resilient smart crops. Dehydration responsive element binding transcription (DREB) factors play a major role in modulating plant defense signaling pathways and regulating various downstream stress-responsive genes in response to major abiotic stresses. Thus, these genes are instrumental in minimizing the losses due to abiotic stresses, furthermore, overexpression of genes can generate multi-stress tolerant crop plants and help the plants to survive under harsh climatic conditions. In our previous study the overexpression of StDREB30 gene, a member of A-6 group of DREB genes resulted in the generation of drought tolerant transgenic potato plants. In the current study we unraveled the underlying molecular mechanisms of StDREB30 regulation in response to 14 days of drought stress by analyzing the transcriptional regulation of downstream drought responsive genes in potato plants. Results of expression analysis showed a higher transcript abundance of drought responsive genes i.e., PIP, SIAREB5, StTH, StDREB1, SAP and NAC transcriptional factors in the StDREB30 overexpressing plants as compared to control plants after drought stress. At the start of drought stress, at Day 0 the StDREB30 overexpressing potato plants and control plants showed no significant difference in the transcript accumulation of PIP, SIAREB5, StTH, StDREB1, SAP and NAC genes. However, after the exposure of potato plants to 14 days of drought stress there was significant upregulation in the expression of the above drought responsive genes in the StDREB30 overexpressing transgenic plants. PIP, NAC, SIAREB5, StDREB1, StTH, gene showed 2, 1, 3, 2 and 1.5 fold higher expression in transgenic potato plants as compared to their wild counterparts, respectively. These results show that StDREB30 gene enhances the drought tolerance capacity of potato plants by regulating the expression of downstream genes and establishes StDREB30 as a strong candidate gene that provide protection to plants against drought stress by triggering the expression of cascade of downstream drought responsive genes. Altogether, this research provides valuable resources to delve the underlying mechanism regulation and potential exploitation of StDREB30 in genetic improvement of drought stress tolerance in plants.

Identification, Characterization And Growth Optimization Studies Of Lignin Degrading Bacterial Strain Isolated From Soil Samples Of District, Lahore

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In Pakistan, lignocellulosic biomass poses a significant environmental challenge, as a large proportion of this waste originates from the paper, pulp, and agricultural industries. However, efficient conversion of lignocellulosic material remains difficult due to the limited availability of effective biocatalysts capable of facilitating biorefining processes. This research activity was designed to identify and isolate indigenous bacterial strain capable of lignin degradation. Five bacterial isolates were obtained from soil samples collected near a plantation site in Nasir Park, Lahore. Among these, one isolate, designated as strain “C,” demonstrated strong lignin-degrading potential. The strain exhibited substantial decolorization of methylene blue dye and rapid growth on minimal salt medium (MSM) supplemented with 1% alkaline lignin. Molecular and biochemical characterization identified the isolate as *Serratia liquefaciens*, confirmed after sequencing results. Phylogenetic analysis revealed that strain “C” stayed closely correlated to the *Enterobacter* genus, showing 98.78% sequence similarity. Optimal growth conditions for the isolate were achieved with 3% rice bran, 4% molasses, and 5% wheat bran at 37°C and pH 7. The locally characterized lignin-degrading bacterium shows promise for application in biorefining and industrial lignin degradation processes.

Keywords: *Serratia liquefaciens*, Mineral salt Media, lignin degrading bacteria, Methylene blue dye, LB media

Allelopathic Impact of Fig Leaf Extracts on Germination and Seedling Development of Medicinal Herbs: Implications for Agroforestry Design

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Agroforestry systems enhance ecological sustainability; however, allelopathic interactions may influence crop compatibility. This study investigated the physiological impact of *Ficus carica* leaf aqueous and methanolic extracts (5% and 10% w/v) on seed germination kinetics and early seedling development of *Foeniculum vulgare*, *Ocimum basilicum*, and *Mentha* spp. Under controlled laboratory conditions. Germination dynamics were quantified using germination percentage (GP), mean germination time (MGT), mean germination rate (MGR), coefficient of velocity of germination (CVG), germination index (GI), and germination time coefficient of variation (CVt). Statistical analysis was performed using one-way ANOVA followed by post hoc comparisons, with significance set at $p < 0.05$. *Ocimum basilicum* demonstrated physiological stability across all treatments, with no statistically significant variation in GP, MGT, MGR, CVG, GI, or CVt ($p < 0.05$), indicating tolerance to fig-derived allelochemicals. In contrast, *Foeniculum vulgare* exhibited treatment-specific sensitivity. Aqueous extracts significantly reduced GP and GI at 10% concentration ($p < 0.05$), while methanolic extracts showed no significant inhibitory effects ($p < 0.05$), suggesting that water-soluble allelochemicals predominantly mediate germination suppression. Germination kinetics further indicated delayed radicle emergence under aqueous treatments. *Mentha* spp. seeds failed to germinate in all experimental and control groups, indicating dormancy or compromised viability. Pot trials corroborated laboratory findings, with basil displaying normal seedling vigor and fennel showing partial growth suppression under aqueous treatments. Collectively, these findings demonstrate species-specific physiological responses to *F. carica* allelochemicals and provide

evidence-based guidance for crop selection in fig-based agroforestry systems. Further biochemical characterization of active compounds is required to elucidate underlying mechanisms.

Keywords: Allelopathy, Fig tree extracts, Medicinal plant germination, Agroforestry systems, Seedling development

National Herbarium of Pakistan Rescuing Floral Biodiversity & Saving Healing Plants In The Botanical Conservatory

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Botanical gardens have long served as crucial institutions for the conservation and study of plant species, playing a significant role in biodiversity conservation. With an increasing global recognition of the importance of plant-based resources, particularly medicinal plants, botanical gardens have become key players in safeguarding the diversity of these invaluable plants. Medicinal plants, known for their therapeutic properties, have been used by humans for centuries in traditional medicine and as sources of pharmaceutical drugs. However, due to factors such as habitat destruction, overharvesting, climate change and the loss of traditional knowledge, many medicinal plants are facing the threat of extinction. In this context, botanical gardens provide an essential platform for the conservation of medicinal plant diversity, ensuring the preservation of these plants for future generations. The conservation of medicinal plant species in botanical gardens is not only vital for maintaining the genetic diversity of plants, but also for supporting research, education and sustainable use. Botanical gardens offer a controlled environment where medicinal plants can be cultivated, studied and propagated without the stress faced in their natural habitats. National Herbarium of Pakistan presently conserved more than two hundred & fifty plant species cultivated over an area of four acres. This conservatory has a good representation of some climbers, cacti/ succulents, hydrophytes, monocots/ grasses, palms and shrubs or trees. 43% family representatives including five pteridophytes families, seven gymnosperm families, thirteen monocot families and eighty five dicot plant families are conserved in the Botanical Conservatory and offering a safe haven for regional and narrow endemic species, rare and threatened species, wild edible plants and crop wild relatives, wild ornamental plants and wild medicinal plants. National Herbarium of Pakistan, rescuing the plant biodiversity by preserving more than one hundred thousand herbarium specimen.

Keyword: Flora of Pakistan, botanical garden, herbarium, plant conservation

Development of a Thermostable Peptide–Anthocyanin Conjugate from Plant-Derived By Products via non covalent interaction.

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The sustainable conversion of agro-industrial by-products into functional biomaterials represents an emerging strategy for developing value-added bioactive systems. In this study, a novel peptide–anthocyanin conjugate was developed using peptides derived from banana peel and anthocyanins extracted from grape pomace. Conjugation was achieved exclusively through spontaneous non-

covalent interactions, without chemical cross-linking, enzymatic modification, or microbial fermentation. Controlled mixing and incubation promoted intermolecular associations, including hydrogen bonding, electrostatic attraction, and hydrophobic interactions, resulting in the formation of a stable molecular complex. Experimental observations confirmed successful conjugate formation, accompanied by enhanced thermal stability compared to free anthocyanin. Under heat exposure, the conjugated system demonstrated improved color retention, reduced visible degradation, and greater structural persistence, indicating a protective effect of the peptide matrix on anthocyanin integrity. This stabilization suggests the formation of a protective microenvironment that limits thermal destabilization. These findings establish a simple and eco-friendly approach for improving anthocyanin stability while promoting the valorization of plant-derived by-products, with promising applications in functional foods, nutraceutical formulations, and natural pigment stabilization technologies.

Keywords: Peptide–anthocyanin conjugate, Non-covalent interaction, Thermostability, Agro-waste valorization, Natural pigment stabilization.

Bifurcation and Fractal Analysis of a Climate-Driven Crop Interaction Model

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Biological and climatic nonlinear interactions between species and variability tend to produce complex dynamical systems with high sensitivity to parameter variations, especially in climate-stressed conditions. In this paper, we examine a two-dimensional climate-dependent nonlinear logistic interaction model of crop growth dynamics with ecological stress or competing factors. The discrete-time model developed includes parameters for intrinsic growth rates, interspecies interactions, and climate forcing, allowing for the examination of realistic biological systems responses to environmental perturbations. A detailed mathematical analysis is carried out by finding the equilibrium points and studying the local stability of these points using the Jacobian matrix and eigenvalue methods. The conditions for the loss of stability are derived, and the qualitative changes in the system behavior are described using bifurcation theory. Specifically, the equations for flip (period doubling) and Neimark-Sacker bifurcations are obtained to describe the emergence of oscillations and quasi-periodic behavior in the biological system. The stability of the bifurcating solutions is studied using normal form analysis. For the purpose of analyzing the global dynamics, fractal analysis is performed in the parameter space using iterative computational techniques, which uncover Mandelbrot and Julia sets. Numerical simulations show the existence of invariant closed orbits, multistability, and chaotic attractors for biologically relevant parameter values. The findings of this research clearly show that small climatic disturbances can cause large qualitative changes in the dynamics of the system, thus underlining the need for nonlinear mathematical modeling in the study of resilience and stability of climate-sensitive agro-ecosystems. This research offers a rigorous interdisciplinary approach that combines high-level dynamical systems theory with applications in the life sciences.

Artificial Intelligence and Machine Learning in Plant Breeding: From High-Throughput Phenotyping to Predictive Crop Design

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Artificial intelligence (AI) and machine learning (ML) are rapidly reshaping modern plant breeding by enhancing predictive accuracy, accelerating selection cycles, and enabling data-driven crop improvement. The increasing availability of high-dimensional datasets from genomics, phenomics, and environmental monitoring platforms has created new opportunities for computational models to uncover complex, nonlinear relationships governing trait expression. This review synthesizes current advancements in AI-assisted genomic selection, high-throughput phenotyping, and predictive breeding frameworks. Supervised learning algorithms, unsupervised clustering approaches, and deep learning architectures are evaluated for their capacity to improve trait prediction, optimize selection indices, and support ideotype development. Special attention is given to drone-assisted phenotyping, hyperspectral imaging, and AI-based stress response modeling, which collectively enhance the resolution of genotype–phenotype interactions and increase genetic gain under diverse environmental conditions. Beyond trait prediction, AI-driven platforms are strengthening breeding decision-support systems, improving large-scale metadata integration, and enhancing data security and transparency through blockchain-enabled traceability. Despite these advances, challenges remain, including limited access to standardized high-quality datasets, model interpretability concerns, multi-scale data integration complexity, and ethical considerations surrounding AI deployment in agriculture. Strategic interdisciplinary collaboration among breeders, geneticists, computational scientists, and policymakers is essential to fully realize the potential of AI-enabled precision breeding. Integrating AI and ML into breeding pipelines offers a transformative pathway toward developing climate-resilient, resource-efficient cultivars that support sustainable agricultural systems and global food security.

Keywords: Meta data, deep learning, big data, prediction models, plant breeding

Conservation Laws and Nonlinear Dynamical Analysis of the Higher-Order Dispersive Kundu–Eckhaus Equation with Applications in Optics

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The nonlinear dispersive Kundu–Eckhaus equation plays a significant role in modeling the propagation of nonlinear wave packets in dispersive media, particularly in nonlinear optics. This work presents an analytical investigation of the nonlinear dynamics of the dispersive Kundu–Eckhaus equation using the F-expansion method and the double exponential approach. A variety of new exact and multi-wave solutions are derived, including rational solitons, bright and dark solitons, periodic solitary waves, and other nonlinear wave structures. These solutions are obtained through appropriate ansatz functions supported by symbolic computation, together with logarithmic and traveling-wave transformations. The resulting wave profiles provide deeper insight into the complex physical mechanisms governing nonlinear wave propagation in dispersive media. Graphical representations are used to illustrate the dynamical behavior of selected solutions, facilitating a clearer understanding of their physical characteristics. In addition, conservation laws are derived and

employed to evaluate conserved quantities such as energy, momentum, and power, confirming the exactness and stability of the obtained solutions. The presented results are novel and demonstrate the effectiveness, simplicity, and applicability of the proposed analytical methods to a broad class of nonlinear evolution equations.

Integrated Analysis of Physicochemical Parameters and Microbiological Contamination in Drinking Water Sources of District Kasur, Punjab, Pakistan

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Access to safe drinking water is essential for public health, yet contamination of potable water remains a major concern in developing regions. This study investigated the physicochemical properties and microbial contamination of drinking water sources in District Kasur, Punjab, Pakistan. A total of 100 water samples were collected from four tehsils—Kasur, Chunian, Pattoki, and Kot Radha Kishan—using GPS-based sampling. Samples were analyzed for pH, temperature, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), biochemical oxygen demand (BOD), chloride concentration, and microbial content. Microbiological assessment targeted *Escherichia coli*, *Klebsiella*, and *Shigella* using colony-forming unit enumeration and standard biochemical tests. Physicochemical analysis showed that many water quality parameters exceeded safe limits. The pH ranged from 6.52 to 8.9, with 42% of samples outside the recommended range. Electrical conductivity (EC) varied between 600 and 4030 $\mu\text{S}/\text{cm}$, and 68% of samples were above safe levels. Total dissolved solids (TDS) exceeded standards in 61% of samples, while chloride concentrations were too high in 55% of samples. Water temperature ranged from 23.5 to 25.5 °C, which can influence bacterial growth. Dissolved oxygen (DO) was below 5 mg/L in 47% of samples, suggesting possible water quality deterioration. Microbial testing revealed contamination in 76% of samples. *E. coli* was most common in bore pumps, (mean 31 CFU $\pm$ 13), while *Klebsiella* was found in 5–40% of samples and *Shigella* in 8–30%. Spatial maps showed that Chunian and Pattoki had higher risks of both physicochemical and microbial contamination compared to Kasur and Kot Radha Kishan. Overall, the findings indicate that most drinking water sources in District Kasur are unsafe for direct consumption without treatment. The study underscores the urgent need for systematic water quality monitoring, improved purification strategies, and collaborative management efforts to safeguard public health.

Keywords: Microbiological Contamination, *Klebsiella*, *Shigella*, *E. coli*, TDS

Knowledge, Attitudes and Perceptions Toward the Indian Flying Fox (*Pteropus medius*) and Other Bats in Punjab and Islamabad, Pakistan

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Bats provide essential ecosystem services; however, negative perceptions and hunting pressure threaten their populations in South Asia. This study assessed the knowledge, attitudes, perceptions

(KAP), human–bat interactions and utilization patterns regarding bats, particularly the Indian flying fox (*Pteropus medius*), across selected districts of Punjab and Islamabad, Pakistan, from July 2022 to May 2024. A structured questionnaire survey (n = 492) was conducted among local residents (n = 392), farmers (n = 50) and traditional practitioners (n = 50). Data were analyzed using descriptive statistics and chi-square tests ($p < 0.05$). Field observations confirmed the presence of *P. medius* and insectivorous bats including *Pipistrellus pipistrellus* and *Scotophilus kuhlii*. Although all respondents were familiar with bats, detailed taxonomic and ecological knowledge was limited. Misconceptions were common, including beliefs that bats suck blood and are major disease sources. Fear and negative attitudes were prevalent, with a substantial proportion expressing willingness to kill bats upon encounter. Perceptions of ecological importance were mixed; while some respondents recognized roles in pollination, pest control and seed dispersal, uncertainty remained high. Hunting and killing of bats were frequently reported, primarily for fruit protection, medicinal beliefs, pest control and fear of disease. Bat consumption was reported in certain areas, often linked to perceived medicinal benefits, particularly among traditional practitioners. Support for conservation measures varied significantly among respondent groups, though many expressed willingness to participate in awareness campaigns and community-based conservation initiatives. The findings highlight significant knowledge gaps, persistent myths and socio-cultural drivers influencing bat persecution in Pakistan. Targeted education programs, awareness campaigns and community engagement strategies are urgently needed to improve public understanding and promote evidence-based conservation of *P. medius* and other bat species in agro-urban landscapes.

Keywords: Indian flying fox, *Pteropus medius*, Bats, Conservation.

Antioxidant potential and Phytochemical Profiling of Monofloral Honey from Diverse Regions of Pakistan

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Present study investigates the phytochemical content of five types of monofloral honey from Pakistan: beri honey, eucalyptus honey, citrus honey, robinia honey, and sunflower honey. The aim is to identify active compounds with potential antibacterial and antioxidant properties through qualitative tests for coumarin, protein, carbohydrates, phenol, alkaloids, flavonoids, tannins, saponins, triterpenoids, quinones, and sterols. The results indicate that all five types of honey positively contain flavonoids, saponins, coumarin, protein, carbohydrates, phenol, triterpenoids, quinones, and sterols. These secondary metabolites confer significant antioxidant, antibacterial, anti-inflammatory, analgesic, wound-healing, anti-cancer, and free radical scavenging activities to the honey. This study highlights the therapeutic potential of these monofloral honeys, supporting their use in medical and health applications.

Keywords: Phytochemical profiling, antioxidant potential, Honey, coumarin, protein, carbohydrates, phenol, alkaloids, flavonoids

Development of Jamun (*Syzygium cumini* L) Tea for diabetic patients and its organoleptic evaluation, TPC, antioxidant activity

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Popular in Pakistan, jamun (*Syzygium cumini* L.) is a significant tropical and subtropical evergreen plant belonging to the Myrtaceae family. The presence of bioactive chemicals in every part of the plant is responsible for its well-known hypoglycemic, hepatoprotective, anti-allergic, hypolipidemic, anti-fungal, antiviral, anti-inflammatory, and antioxidant qualities. Along with other compounds like kamferol, canferol, methyl gallate, and nilocitin, the chemical composition of *S. cumini* seed showed the existence of phenolic compounds such gallic acid, tannic acid, betulinic acid, myricetin, ellagic acid, chlorogenic acid, and quercetin. Since they are a natural source of broad-spectrum natural sunscreens and oxidation inhibitors, phenolic compounds have drawn a lot of interest recently. Jamun seeds also have digestive, cooling, liver-stimulating, and blood-purifying properties. A glycoside found in jamun seeds called jamboline aids in keeping blood sugar levels within acceptable ranges. According to an Ayurvedic source, the average daily dosage for treating diabetes is 1-3 g of jamun seed powder. The aim of this study to development of antidiabetic tea from jamun seeds and to analyze the antioxidant activity and polyphenolic content. Folin reagent was used to measure the total phenolic content, and free radical scavenging activity (DPPH) was used to determine the antioxidant activity. Investigations of organolaptic into appearance, color, smell, taste, and general acceptability findings ranging from 6.5 to 8.9. The jamun seed tea extract has a total phenolic content of 274 ± 1.90 mg/g gallic acid equivalent (GAE). In the DPPH radical scavenging method, the jamun seed tea demonstrated antioxidant activity in the range of 38.50 ± 0.80 - $89.60 \pm 1.70\%$ at doses (20 - $100 \mu\text{g/ml}$). When compared to BHT, the antioxidant activity of the jamun seed tea was found to be greater with IC₅₀ values of $85.40 \pm 1.25 \mu\text{g/ml}$ (BHT) and $18.50 \pm 0.32 \mu\text{g/ml}$ (developed tea), the jamun seed tea extract. These findings suggested that jamun (*Syzygium cumini*) seed tea could be a useful natural antioxidant source for people with diabetes. To understand the intracellular pathways involved in the mechanism of the antioxidant action, more research is required in future.

Keywords: jamun seed tea, polyphenolic content, antioxidant activity, organolaptic evaluation

Environmental Data Analytics for Predictive Flood Modeling and Climate Resilience in Pakistan

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Flood hazards in Pakistan are intensifying under the influence of climate change, extreme precipitation, and river discharge variability, posing substantial environmental, economic, and societal risks. This study develops a data-driven framework for predictive flood modeling by integrating historical rainfall, river flow, soil moisture, and satellite-derived hydrological datasets. Machine learning and predictive analytics are employed to capture complex spatiotemporal flood patterns and generate high-resolution early-warning forecasts. A comprehensive risk assessment of exposed communities and critical infrastructure informs adaptive mitigation strategies. By combining environmental informatics with advanced data analytics, the framework provides actionable insights for disaster management, policy formulation, and climate resilience. The approach is designed to be scalable and transferable, offering a robust model for evidence-based flood preparedness and sustainable adaptation in Pakistan and other developing regions facing climate-induced hazards.

A Systematic Review of Phytochemical and Antioxidant Activities of *Monothea buxifolia*-Based Nanoparticles

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Background: *Monothea buxifolia*, locally known as Gurgurai, is a member of the Sapotaceae family found in some areas of Balochistan, Khyber Pakhtunkhwa, and Punjab provinces of Pakistan. *M. buxifolia* is a strong contender for antioxidant nanomedicine formulation due to its flavonoids, phenolics, alkaloids, tannins, saponins, and terpenoids.

Objectives: The present review evaluates the phytochemical composition and antioxidant potential of *M. buxifolia*-based nanoparticles (NPs).

Methodology: Published original research articles till February 2026 were searched on PubMed and Google Scholar using the keywords “*Monothea buxifolia* (*M. buxifolia*)”, “nanoparticles (NPs)”, “phytochemicals”, and “antioxidants”. Two authors independently extracted the data from the included studies, which were later synthesized qualitatively.

Results: The initial search yielded 229 articles; after screening, only six met the inclusion criteria.

Phytochemical screening by two studies consistently reported multiple bioactive constituents in leaf extract, including carbohydrates, flavonoids, saponins, phenols/tannins, and glycosides, subsequently utilized for the green synthesis of NPs, such as Ag, Au, Fe₂O₃, CuO, CdO, ZnO, and NiO. NPs exhibited variable phenolic-like and flavonoid-like properties, e.g., CuO-NPs synthesized at alkaline pH showed the highest phenolic and flavonoid contents, whereas Fe₂O₃-NPs at pH 9 showed negligible flavonoid levels. Antioxidant activity was assessed by using DPPH, ABTS, Total Antioxidant Capacity (TAC), Total Reducing Power (TRP), and ferric-reducing power assays. Strongest radical scavenging activity was reported for gold NPs, with DPPH inhibition reaching 86.31%, followed by silver NPs (~71%). In contrast, other metal and metal oxide NPs generally demonstrated moderate activity, with the highest DPPH scavenging observed for CuO-NPs at pH 9 (~53.4%) and the lowest for NiO-NPs (~25.8%). In the ABTS assay, ZnO-NPs exhibited the highest activity (~59.24% inhibition). For TAC and TRP assays, silver NPs demonstrated the strongest antioxidant capacity (TAC ≈ 33.7 μg AAE/mg) and reducing power (TRP ≈ 48.9 μg AAE/mg), while Fe₂O₃-NPs showed the lowest antioxidant performance. Additionally, ferric reducing power assays confirmed moderate reducing activity for AgNPs (0.485 ± 0.005).

Conclusion: Phytochemical screening identified multiple bioactive compounds in the plant leaf extract. CuO-NPs had the highest phenolic and flavonoid contents. Gold and silver NPs showed significant antioxidant potential, while most metal oxide NPs had moderate effects. Future studies should focus on characterizing and quantifying phytochemicals in *M. buxifolia* extracts in different solvents and their role in NPs synthesis and stabilization. Standardized antioxidant evaluations using multiple assays are necessary for reliable comparisons. Additionally, mechanistic investigations, bioavailability studies, and in vivo assessments will help elucidate the therapeutic potential and biomedical applications of *M. buxifolia*-derived phytochemicals and NPs.

Antibacterial and cytotoxic activity of *Monothea buxifolia*-based nanoparticles: A systematic review

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Background: *Monothea buxifolia*, a member of the Sapotaceae family, is a medicinal plant known for its pharmacological properties. Its extract has significant antibacterial activity due to flavonoids, alkaloids, and phenolic compounds. The fruit, known as Gurgurai, also exhibits notable antibacterial and cytotoxic effects.

Objectives: To systematically review all existing studies about antibacterial and cytotoxic activity of *M. buxifolia*-based nanoparticles (NPs).

Methods: Studies published till February 2026 on antibacterial and cytotoxic activities of *M. buxifolia*-based NPs were searched on PubMed, Google Scholar, and ScienceDirect using specific keywords such as “*Monothea buxifolia* (*M. buxifolia*)”, “nanoparticles (NPs)”, “biological activities”, “antibacterial”, “antimicrobial”, and “cytotoxic”.

Results: A total of 194 studies were initially identified, but only 5 studies were finally selected for the systematic review. All five studies assessed the antibacterial potential of NPs, whereas only two studies assessed their cytotoxic potential. These studies reported the green synthesis of seven metal and metal oxide NPs using aqueous extracts of *M. buxifolia*, including silver (AgNPs), zinc oxide (ZnO-NPs), iron oxide (Fe₂O₃-NPs), copper oxide (CuO-NPs), cadmium oxide (CdO-NPs), nickel oxide (NiO-NPs), and gold NPs (AuNPs). Antibacterial activity was evaluated against 14 Gram-positive and Gram-negative bacterial strains, most commonly *E. coli* and *S. aureus*, using disc diffusion assays, with several studies additionally reporting minimum inhibitory concentrations (MIC) and minimum bactericidal concentrations (MBC). Among the NPs, ZnO-NPs demonstrated the strongest antibacterial activity, producing the largest inhibition zones against *E. coli* (22 ± 1.3 mm) and *S. aureus* (20 ± 1.1 mm), and showing notable activity against *K. pneumoniae*, *S. pneumoniae*, and *S. typhi*. AgNPs and CuO-NPs also exhibited moderate antibacterial effects against selected strains. Cytotoxic activity, assessed in two studies using the brine shrimp lethality assay (*Artemia salina*), indicated concentration-dependent toxicity, with CdO-NPs showing the lowest LC₅₀ value (24.1 µg/ml), suggesting comparatively higher cytotoxic potential.

Conclusion: Green-synthesized NPs derived from *M. buxifolia* exhibit notable antibacterial activity against a broad range of Gram-positive and Gram-negative bacterial pathogens, with ZnO-NPs showing the most consistent and potent effects. Some NPs formulations also demonstrated measurable cytotoxic potential in brine shrimp assays, indicating possible biological activity that warrants further safety evaluation. However, the limited number of studies and variability in synthesis conditions and testing methods highlight the need for standardized and well-designed investigations to validate their therapeutic potential. Future research should optimize and standardize the green synthesis of *M. buxifolia*-mediated NPs to enhance reproducibility and efficacy. Comprehensive studies involving diverse bacterial pathogens and thorough toxicity assessments are needed to clarify their therapeutic potential and safety. Additionally, exploring NPs formulations, synergistic effects with antibiotics, and potential biomedical applications could promote these NPs as alternative antimicrobial agents.

Evaluation of methanolic extract of *Abutilon indicum* on *Pseudomonas* isolated from urinary tract and Skin infection

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The resistance of emerging microbial strains against existing drug has become challenge for the scientific world to eradicate or inhibit the disease or growth of these bugs. This study aims to investigate the evaluation of methanolic extract of abutilon indicum on *pseudomonas aeruginosa* isolated from wound and urinary tract infections. The leaves of Abutilon indicum were collected, identified by the botany department and subjected to Soxhlet apparatus for extraction with methanol and then evaporated. The active phytochemical compounds against the Pseudomonas were found by High Performance Liquid Chromatography. The bacterial samples were collected from tertiary care hospital, isolated, and identified by standard microbiological practices and biochemical tests. The inhibitory effect of extract and the antibiotics against the Pseudomonas were determined by antimicrobial sensitivity testing following CLSI guidelines. The MIC and MBC values of extract and drugs were determined using CLSI guidelines to evaluate the bacteriostatic and bactericidal effect. The biofilm assay under Tecan spark microtiter plate reader was performed to demonstrate the inhibition of planktonic and biofilms produced by Pseudomonas. The overall findings described the presence of bioactive compounds such as quercetin, kaempferol, p coumaric acid and beta sitosterol and the zones of inhibition were up to 24mm were measured. The bacteriostatic and bactericidal values of extract were up to 25mg/ml and 12.5mg/ml for the extract. The values for antibiotic solution were different such as 512µg/ml, 256 µg/ml, 128 µg/ml. The resistance pattern of antibiotic disc revealed the bacteria to be XDR with MIC and MBC values were up high. The biofilm inhibition was reported to inhibit 58% of the microbial cells in biofilm and planktonic form. These conclusions suggest that the methanolic extract of abutilon indicum was effective against Pseudomonas isolates with inhibitory and antibiofilm effect.

Keywords: AST, Soxhlet Apparatus, HPLC, Biofilm Inhibition Assay, Abutilon Indicum

Understanding Knowledge Of The Farmers About Climate Smart Food System Practices: An Empirical Review

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The integration of climate-smart farming techniques has increasingly become essential for the sustainability of food systems, especially in regions prone to climate variability, such as the arid areas of Punjab. Groundnut producers, who are largely dependent on climatic conditions for their crop production, are confronting several challenges related to soil degradation, water scarcity, erratic weather phenomena and limited knowledge about climate smart food system. To this backdrop, it was unclear about knowledge of the farmers about climate smart food system. Therefore, the present study was designed to understand the current situation. The data were collected from 384 farmers, inhabitant of Chakwal District, through a structured and pre-tested research instrument. The collected data were analyzed through SPSS software. The findings reveal that farmers' understanding about Climate Smart Food System (CSFS) practices was moderate, with many only partially aware of practices such as drought-tolerant varieties, conservation tillage, and efficient irrigation. The farmers showed higher knowledge of basic practices like crop rotation though limited understanding of advanced methods, including drought-tolerant varieties and integrated pest

management. Access to education, extension services, and timely climate information significantly affects their knowledge. While most of the farmers recognize the benefits of CSFS for productivity and profitability, gaps remained in technical knowledge, pest management, and disease control. Thus, it is suggested that groundnut farmers need to be equipped about climate smart food system through state of the art training programs. These findings may be useful for academia, researchers working on groundnut crop and its growers, policy makers and farmers.

Proliferation of Waterborne Diseases: A Comparative Analysis of drivers and Alleviation Strategies in Global and Pakistani Contexts

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Water contamination is emerging health crisis if not addressed properly. Climate change and inadequate infrastructure are major drivers of water contamination, leaving approximately 785 million people globally without access to potable water. This crisis aggravates in Pakistan where 70 % of population is vulnerable to natural hazard. Pakistan agriculture sector utilizes approximately 6 million tons of fertilizer and 50,000 tons of pesticides annually; during flood these chemicals discharged into local sewage system and river bodies. 2025 monsoon around 1000 water supply schemes are damaged make situation more alarming. Waterborne diseases cholera, diarrhea, Hepatitis A and E have significant influence on public health. In 2024 alone 560,000 cholera cases were reported worldwide. Mortality rate of children reaches to 444,000 due to diarrhea. In specific context of Pakistan waterborne diseases account for 30% of all diseases and total 40% of total mortality and about 270,000 children lose their lives annually. 53,000 child deaths are due to diarrhea. In Rawalpindi 80,000 reported cases of waterborne disease and 4000 registered hepatitis cases. Despite the complexity of these challenges, mitigation is achievable at the individual level. Water boiling remains one of the simplest and most effective methods for eliminating microbial contamination. In addition, chlorination provides an affordable disinfecting stored water, although its efficacy remains limited in removing dissolved heavy metals and salts. For more purification, low-cost multi-layer filtration systems; utilizing charcoal, sand, and a biological layer offer a sustainable method for significant pollutant reduction. However, the successful adoption of these techniques is hindered by a critical knowledge gap; studies indicate that limited health literacy is prevalent, with 65% to 75% of mothers lacking essential health literacy. Therefore, educational campaigns and awareness are necessary to reduce the incidence of waterborne diseases.

Synergistic Application of Rice Husk Biochar and Green-Synthesized Iron Oxide Nanoparticles for Enhancing Drought Tolerance in Wheat

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Wheat (*Triticum aestivum* L.) is a major cereal crop and a primary food source for millions of people worldwide. Its productivity is highly sensitive to abiotic stresses, particularly drought, which affects more than 50% of wheat-growing areas and significantly reduces both yield and grain quality. Climate

change-induced water scarcity has further exacerbated this challenge, highlighting the need for sustainable and environmentally friendly mitigation strategies. This study investigates the potential of rice husk-derived biochar and green-synthesized iron oxide nanoparticles (FeO-NPs) to improve soil physicochemical properties and enhance drought tolerance in wheat. Rice husk biochar will be produced through controlled pyrolysis at 450°C and 500°C with a heating rate of 20°C for 4 hours. Detailed characterization will include analysis of pH, particle size distribution, porosity, moisture content, surface morphology, thermal stability, and other relevant physicochemical properties to optimize its performance as a soil amendment. FeO-NPs will be synthesized using pomegranate peel extract as a natural reducing and stabilizing agent, ensuring an environmentally friendly synthesis process. The structural and functional properties of the nanoparticles will be evaluated using UV-Visible spectroscopy, Fourier Transform Infrared spectroscopy (FTIR), X-ray Diffraction (XRD), and Scanning Electron Microscopy (SEM). A controlled pot experiment under induced drought stress will assess individual and combined treatments: Biochar (BC), FeO-NPs, and BC + FeO-NPs. Plant responses will be evaluated through morphological, physiological, and biochemical parameters, including antioxidant enzyme activity and proline accumulation. The integrated application is expected to improve soil water retention, nutrient availability, oxidative stress regulation, and overall wheat performance under drought conditions. This combined approach represents a sustainable and climate-adaptive strategy for enhancing wheat productivity under water-limited environments.

Keywords: Rice husk biochar, Iron oxide nanoparticles, Wheat, Drought stress, Green Synthesis

Evaluating Yield–Water Productivity Trade-offs in Rice under Continuous Flooding and Alternate Wetting–Drying Regimes

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Decreasing water availability in essentially irrigated rice systems of Pakistan necessitates irrigation strategies that enhance water productivity without compromising yield. A field experiment was conducted at the On-Farm Water Management Farm, Okara to quantify yield responses and infer water productivity trade-offs under continuous flooding (CF), single drainage (SD), and alternate wetting and drying (AWD) at varying depths (9 cm, 12 cm, 15 cm, and 18 cm). Grain yield was significantly affected by irrigation regime. Continuous flooding produced the lowest yield (2661 kg ha⁻¹), while AWD significantly enhanced productivity. The highest grain yield was recorded under AWD at 12 cm (5463 kg ha⁻¹), representing a significant increase over CF. AWD at 9 cm (5106 kg ha⁻¹) yielded statistically comparable results, forming the superior performance group. Although AWD at 15 cm also improved yield relative to CF, our results suggested that the ‘safe AWD’ recommendation of 15 cm may cause yield penalty in medium soils with difficulty of puddling. The results demonstrate that moderate AWD thresholds (9 to 12 cm) optimize the balance between soil aeration and plant water availability, maximizing yield while enabling irrigation water savings. Given that AWD typically reduces irrigation input by 20–35%, these findings suggest substantial gains in water productivity without yield penalty when irrigation depth is carefully managed. Overall, the study confirms that properly calibrated AWD regimes provide a viable pathway for sustainable intensification of rice systems by minimizing the trade-off between water savings and grain yield. These findings are

particularly relevant for water-limited rice–wheat systems of Punjab and similar agro-ecologies facing increasing competition for irrigation resources.

Analysis of Biofilm-Forming Potential and Antibiotic Resistance in Bacterial Isolates from Hospital Wastewater in Kohat

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Hospital wastewater effluents represent a major environmental reservoir for the dissemination of pathogenic microorganisms and antimicrobial resistance (AMR) due to the presence of antibiotic residues, disinfectants, and resistant clinical strains. This research focuses on the isolation and phenotypic characterization of clinically significant bacteria, including *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Staphylococcus aureus*, from various hospital discharge points in Kohat. The study aimed to evaluate the multidrug resistance (MDR) patterns and biofilm-forming potential of these isolates, which are key factors in bacterial persistence and treatment failure. The methodology involved the collection of wastewater samples followed by serial dilutions and cultivation on selective media such as Eosin Methylene

Blue (EMB), MacConkey, Mannitol Salt Agar (MSA), and Ceramide agar. The isolates were identified through colony morphology, Gram staining, and a comprehensive battery of biochemical tests including Catalase, Oxidase, Triple Sugar Iron (TSI), Motility Indole Urease (MIU), and Citrate utilization tests. Antibiotic susceptibility was determined using the Kirby–Bauer disk diffusion method following CLSI guidelines. Furthermore, the biofilm-forming capability was assessed qualitatively via the Congo Red Agar (CRA) method and quantitatively using the Microtiter Plate (Crystal Violet) assay. Preliminary results indicated a high prevalence of MDR strains with varying degrees of biofilm production, highlighting the critical role of hospital waste in the environmental spread of resistance. These findings underscore the urgent necessity for improved wastewater treatment and management strategies to safeguard public health and mitigate the environmental burden of antimicrobial resistance.

Synthesis Of Magnetic Oxide Nanoparticles Using *Livistona Chinensis* For Adsorption Of Lead, Nickel And Copper From Wastewater

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Industrial activities released heavy metals such as lead (Pb), nickel (Ni), and copper (Cu) into water bodies, posing serious risks to human health and the environment. These pollutants were persistent and non-biodegradable, and exposure above WHO limits (Pb: 0.01, Ni: 0.07, Cu: 2.0 mg/L) caused neurological disorders, kidney damage, and carcinogenic effects. Conventional treatment methods were costly and produced secondary pollutants, necessitating a greener, more efficient alternative. This study proposed the green synthesis of Fe_3O_4 nanoparticles using *Livistona chinensis* extract, whose phytochemicals (phenolics, flavonoids, terpenoids) acted as natural reducing and stabilizing agents. Nanoparticles were prepared by co-precipitation of $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ and $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ at pH 10–11 and 35–40°C, then magnetically separated and dried. Structural and morphological properties were

confirmed by UV–Vis, FTIR, XRD, SEM, and EDX. Adsorption of Pb^{2+} , Ni^{2+} , and Cu^{2+} from synthetic wastewater was assessed through batch experiments by optimizing dosage (0.1–1.0 g), pH (4–7), and contact time (10–120 min). Residual metal concentrations were measured by AAS and removal efficiency calculated using standard equations. This was the first study to use *Livistona chinensis* for the simultaneous removal of all three metals and Fe_3O_4 synthesis, providing an economical, environmentally benign, and magnetically separable adsorbent for the treatment of industrial wastewater.

Keywords: Green synthesis, Iron oxide nanoparticles, *Livistona chinensis*, Heavy metal removal, Adsorption, Wastewater treatment, Lead, Nickel, Copper

Enhanced Pseudocapacitive and Supercapattery Performance of $\text{La}_2\text{O}_3/\text{rGO}$ Nanocomposite Electrodes: Electrochemical and impedance analysis

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La_2O_3 and $\text{rGO}/\text{La}_2\text{O}_3$ supercapacitor electrodes were fabricated through wet chemical approach. To enhance the electrochemical performance, GO was initially prepared using a modified Hummer's method, subsequently reduced to rGO , and then integrated with La_2O_3 . The structural properties were confirmed by X-ray diffraction, which revealed crystalline La_2O_3 with broad diffraction peaks and also successful incorporation of rGO in composite. Scanning electron microscopy demonstrated a morphological transition from granular La_2O_3 particles to a more uniform, layered structure, confirming integration of rGO . Elemental composition and purity were further validated by EDX spectroscopy. Electrochemical performance was systematically evaluated using cyclic voltammetry (CV), Galvano static charge-discharge (GCD), linear sweep voltammetry (LSV), and electrochemical impedance spectroscopy (EIS). The $\text{La}_2\text{O}_3/\text{rGO}$ composite exhibited higher current response, distinct redox peaks, and enhanced pseudocapacitive and supercapattery type behavior compared to pure La_2O_3 . The specific capacitance increased to 207 F/g (CV) and 88 F/g (GCD), alongside improvements in power and energy density. Electrochemical impedance spectroscopy revealed a lower charge transfer resistance (0.54 Ω) and reduced internal resistance. Furthermore, the composite maintained superior conductivity and charge transfer characteristics during cycling, unlike pure La_2O_3 , which showed no semicircle in the Nyquist plot. These findings highlight the potential of $\text{La}_2\text{O}_3/\text{rGO}$ composites as promising electrode materials for high-performance supercapacitor application.

Keywords: Composite, Supercapacitors, Cyclic voltammetry, Galvanostatic Charge and Discharge, Ragone Plot

The Impact of Climate Change on Marine Biodiversity and Antibiotic Discovery: A Pharmacoeconomic Scoping Review.

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The aquatic –ecosystem faces various challenges from climate change emerging through ocean warming, acidification, deoxygenation, and habitat degradation. This situation is alarming for the diversity and stability of marine life that supports global ecological health and pharmaceutical innovation. The aquatic-ecosystem host various organisms like sponges, algae, bryozoans, and symbiotic microbes that are producing unique natural products and bio-active compounds having therapeutic potential. A significant role has been played by these marine natural products in the development of clinically essential medicines and provide a vital area of research in future antibiotic development. However, in marine life a rise in sea surface temperatures (marine heatwaves), rapid salinity or acidification and anthropogenic stressors are predicted to result in significant species loss, daunting both ecological functions and the chemical diversity required for innovative therapeutic discovery. In lost pharmaceutical value especially for anticancer and potentially antibacterial agents, amount to hundreds of billions to over a trillion dollars in terms of economic loss. From a pharmaco-economic perspective, this decline translates into increased long-term healthcare costs and a reduced capacity to address the growing challenge of antimicrobial resistance. This scoping review synthesizes current evidence on the impact of climate change on marine biodiversity, the implications for antibiotic discovery, and the associated economic consequences. Integrating sustainable drug discovery approaches with ecological conservation strategies, such as marine protected areas, blue biotechnology, and responsible bioprospecting, can enhance climate resilience while preserving critical health and economic benefits derived from marine natural products. Understanding these interconnected dynamics is essential for informed policy-making and investment decisions aimed at safeguarding marine biodiversity and future pharmaceutical resources.

Keywords: Marine Biodiversity, Antibiotic, Pharmaco-economics

Phyto-Mediated Green Synthesis Of Nickel Oxide Nanoparticles Using *Nicotiana glauca* And Their Antimicrobial And Antioxidant Activities

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Green synthesis of nanoparticles using plant extracts is an eco-friendly and cost-effective alternative to conventional methods. *Nicotiana glauca*, rich in bioactive phytochemicals, can act as a natural reducing and stabilizing agent. Nickel oxide nanoparticles (NiO-NPs) are known for their important antimicrobial and antioxidant properties. This study focuses on the green synthesis of NiO-NPs using *Nicotiana glauca* and evaluation of their biological activities. Leaf extract of *Nicotiana glauca* was used to synthesize NiO-NPs from a nickel salt solution. The nanoparticles were characterized using UV–Vis, FTIR, XRD, and SEM techniques. Antimicrobial activity was assessed by agar well diffusion, while antioxidant activity was evaluated using the DPPH assay. The successful synthesis of NiO nanoparticles was confirmed by characteristic absorption peaks in UV–Vis spectra and distinct crystalline patterns in XRD analysis. SEM results revealed predominantly spherical nanoparticles with nanoscale dimensions. The synthesized NiO-NPs exhibited significant antimicrobial activity, producing measurable zones of inhibition against tested bacterial strains. Additionally, the nanoparticles demonstrated strong, concentration-dependent antioxidant activity in the DPPH assay, indicating effective free radical scavenging potential. The study demonstrates that *Nicotiana glauca* is an efficient and eco-friendly source for the green synthesis of nickel oxide nanoparticles.

The synthesized NiO-NPs showed promising antimicrobial and antioxidant activities, likely due to the synergistic interaction between nanoparticle properties and plant-derived phytochemicals. These findings highlight the potential applications of green-synthesized NiO-NPs in biomedical, pharmaceutical, and environmental fields.

Keywords: Green synthesis, Nickel oxide nanoparticles (NiO-NPs), *Nicotiana glauca*.

Yolo-Based Image Detection Of Macronutrient Deficiency In Maize (Zea Mays L) Plants

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The timely identification of nutrient deficiencies is critical to enhancing crop production and assisting in sustainable agriculture activities. The proposed research paper presents a deep learning-based macronutrient deficiency detection system in maize (*Zea mays* L.) using YOLO (You Only Look Once) object detection models. Experimental induction of nitrogen N and phosphorus P deficiencies under controlled conditions, along with control and negative control treatment were conducted to develop a reliable and scientifically validated image datasets. Images of leaves were taken and annotated in three categories healthy (control), nitrogen deficiency and phosphorus deficiency. To ascertain the correctness of visual symptoms, SEM- EDX was used to perform elemental analysis. The developed dataset was then used to train and evaluate three YOLO variants, YOLOv11n (nano), YOLOv11m (medium), and YOLOv11l (large), using standard performance metrics. YOLOv11n achieved a mean average performance (mAP@0.5) of approximately 91.43% and mAP@0.5-0.95 of 83.10%, with precision of 90.93% and recall of 85.68%. YOLOv11m achieved a mAP@0.5 of approximately of 91.9% and mAP@0.5-0.95 of 81.74%, with precision of 91.38% and recall of 85.6%. YOLOv11l demonstrated comparable performance, with mAP@0.5 of approximately 91.55% and mAP@0.5-0.95 with 82.86%, with precision of 88.08% and recall of 86.37%. These results indicate that all models attained a high level of detection, with minor differences depending on evaluation criteria. A trade-off between model complexity, accuracy and computational efficiency was observed, where YOLOv11n having faster inference, YOLOv11m provides higher detection accuracy while YOLOv11l delivers stable and consistent results. The proposed method demonstrates that YOLO-based models are a promising tool for the early detection of nutrients deficiencies in maize which can contribute to improved crop management and yield optimization.

Keywords: Maize (*Zea mays* L), Nutrient Deficiency Detection, YOLOv11, Deep Learning in Agriculture, Object Detection.

Characterization, antibacterial and antioxidant activities of essential oil extracted from Orange peels waste

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Phytochemicals specifically fragrant oils are an excellent source of bioactive compounds, which account for their wide range of applications, including antimicrobial, antioxidant, antifungal, and

anti-inflammatory activities. The present study aimed to extract essential oil from *Citrus sinensis* peels using hydro distillation where the peels were collected from the local market. The chemical characterization of e. oil was done by GC-MS while the biological evaluation was done by performing antibacterial and antioxidant activities. The yield of essential oil obtained was 0.44% (v/w). The GC-MS analysis showed the presence of D-Limonen as major component of the essential oil. The results indicated significant biological activities against bacterial strains and DPPH free radical. Overall, the findings suggest that *Citrus sinensis* peel oil has potential for the development of safe antioxidant and antibacterial agents for applications in the food and pharmaceutical industries.

Keywords: *Citrus sinensis*, peels, essential oil, GC-MS, biological activities

Advanced Nanomaterials For Water Purification And Environmental Remediation: Progress, Mechanisms, And Future Prospects

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Rapid urbanization, agriculture, and industrialization have all contributed to water contamination, which is now a major global environmental and public health hazard. Ecosystems and human health are seriously endangered when contaminants including heavy metals, synthetic colors, pharmaceutical residues, pesticides, and pathogenic microbes are present in water systems. These varied and persistent pollutants are frequently difficult for conventional water treatment technologies to effectively remove, especially at low concentrations. Nanotechnology has become a viable and cutting-edge method for improving environmental cleanup and water purification procedures in recent years. High surface area increased catalytic activity, and tunable surface functionalities are some of the unique physicochemical characteristics of nanomaterials that greatly enhance their interaction with contaminants and boost removal effectiveness. The recent developments in the creation and use of different nanomaterials, such as metal and metal oxide nanoparticles, carbon-based nanostructures like graphene and carbon nanotubes, magnetic nanoparticles, and nanocomposite materials for water purification, are all thoroughly covered in this review. To demonstrate their efficacy in removing a variety of contaminants from water systems, the main mechanisms involved in pollutant removal such as adsorption, photocatalytic degradation, redox reactions, membrane-assisted separation, and antimicrobial activity are thoroughly evaluated. Additionally, the benefits of nanomaterial-based treatment technologies are examined in relation to traditional purification techniques, including their high efficiency, quick reaction kinetics, enhanced selectivity, and potential for regeneration and reuse. Notwithstanding these encouraging advancements, there are still a number of obstacles to overcome, such as worries about the toxicity of nanoparticles, environmental stability, economic viability, and widespread use. Therefore, more study is required to create sustainable, economical, and ecologically safe nanomaterial-based solutions for environmental remediation and water purification. All things considered, the development of nanotechnology holds great promise for resolving the world's water pollution issues and enhancing the effectiveness of upcoming water treatment technologies.

Biochar for Climate Mitigation: Chemical Stability, Soil Interaction and Sequestration Potential

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Chemical change mitigation requires a scalable carbon sequestration mechanism for chemical stability, along with environmental functionality. Biochar, a sustainable carbon-rich material produced through oxygen-limited pyrolysis of biomass, emerges as a promising strategy for carbon sequestration. This study mentions recent advances in biochar chemistry and the soil interaction to evaluate its climate mitigation potential. Increased thermal exposure during pyrolysis (300-700°C) reduces O/C and H/C ratios, giving progressive carbonization and forming condensed aromatic structures with amplified recalcitrance. The feedstock composition influences sequestration potential. Furthermore, biochar amendment can reduce soil N₂O emission up to ~50%, prolonging its impact. However, biochar's efficiency depends on soil type, mineralogy, microbial activity, pH, and environmental conditions. Although it increases carbon resistance time, soil organic carbon remains a flexible reserve to oxidation, redistribution, and ecological interactions. Overall, biochar is not a universal solution but a strategy whose effectiveness depends on feedstock composition, thermal conditions, and site-specific soil. Strategic integration of biochar could impart value to long-term carbon management.

Preparation and Characterization of Chitosan-g-Poly(acrylic acid)/Rice Husk Ash Based Superabsorbent Hydrogel Composite

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The advancement of environmental friendly and sustainable superabsorbent materials has drawn intriguing attention due to the environmental constraints linked with petroleum based polymers. In this study, a biobased hydrogel composite was formed via graft copolymerization of acrylic acid onto chitosan backbone in the presence of rice husk ash (RHA), an abundant agricultural waste material. The hydrogel composite was synthesized through free radical polymerization using potassium persulfate as an initiator and N,N'-methylene bisacrylamide as a cross-linker in aqueous media. The incorporation of rice husk acted as an inorganic filler to improve swelling and structural properties of the hydrogel network. Furthermore, the prepared hydrogels were characterized by employing advanced analytical techniques like Fourier Transform Infrared Spectroscopy (FTIR), X-ray Diffraction (XRD), and Scanning Electron Microscopy (SEM) to validate successful grafting and to analyze effective structural and morphological features of the hydrogel. Additionally, swelling behaviour was conducted under multiple conditions including varying pH, cross-linker concentrations, initiator content and saline solutions. Results depicted that the addition of rice husk ash substantially enhanced the water absorption capability because of the porous structure and additional hydrophilic interaction sites within the polymer matrix. The optimized hydrogel composite exhibited a high-water uptake capacity of approximately 255g water per gram of absorbent highlighting excellent superabsorbent efficiency. Also, the hydrogel displayed pH-responsive swelling behaviour, with maximum swelling observed in slightly alkaline conditions, demonstrating its potential as a stimuli responsive material. The findings suggest that integrating natural polymers with agricultural waste materials offers an effective strategy for generating environmental friendly green and sustainable along with biodegradable and high performance hydrogel composites. Therefore, such materials

have promising applications in soil moisture management in agriculture, adsorption of toxic pollutants in wastewater treatment and stimuli responsive drug delivery systems in biomedical engineering.

Multifunctional Metallic (Ag and Au) Graphene Nanocomposites and their Photocatalytic Applications

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The demand for nanoparticles has been increasing rapidly due to their wide range of applications in various commercial fields, especially in nanopharmaceutical industries for the treatment of different diseases. Human life is continuously threatened by infections as well as by the high concentration of hazardous industrial wastes present in water, which is a serious concern. In this study, multifunctional metallic (Ag and Au) graphene nanocomposites (Ag/Au)_{1-x}(GNPs)_x were synthesized using an ex-situ approach with different compositions of graphene nanoplatelets, including 25% (x = 0.25), 50% (x = 0.50), and 75% (x = 0.75). The synthesized nanocomposites were further characterized and confirmed using several analytical techniques such as UV-Vis (Ultraviolet-Visible), XRD, SEM, FT-IR (Fourier-transform infrared), EDX, and Raman spectroscopy analysis. The average particle size of the prepared nanocomposites was found to be in the range of 24 nm to 32 nm. Moreover, the synthesized nanocomposites were investigated for multiple biological and chemical activities. Their antibacterial activity was tested against different bacterial strains and showed significant antibacterial potential, while antifungal activity was evaluated against a toxic fungal strain and also demonstrated notable antifungal potential. The cytotoxicity of the targeted nanocomposites was assessed against U87 brain cancer cell lines and showed a dose-dependent response. In addition, the photocatalytic activity of the metallic graphene nanocomposites with different ratios was studied for the degradation of the toxic dyes Congo red and Methylene blue, and the synthesized nanocomposites exhibited remarkable dye degradation ability. Based on these findings, it can be concluded that metallic nanoparticles containing carbon derivatives (graphene) possess strong anticancer, antibacterial, antifungal, and photocatalytic activities. In conclusion, the synthesized nanocomposites demonstrated significant in vitro biological potential, and further in vivo studies are recommended in the future to explore their role in other biomedical applications.

Green Chemistry: A Sustainable Approach for Environmental Protection

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Green chemistry is changing the way we approach chemical processes and their environmental impact. Traditional chemical methods often use hazardous materials and produce toxic waste, which can harm both human health and the environment. Green chemistry focuses on designing chemicals and processes that are safer, cleaner, and more efficient, while still supporting scientific and industrial progress. Recent studies highlight the benefits of using renewable materials, eco-friendly solvents, and energy-saving reactions. Techniques such as catalytic reactions, solvent-free synthesis, and biodegradable materials have proven effective in reducing waste, enhancing safety, and even

saving costs. These improvements show that environmental care can go hand-in-hand with innovation. Applying green chemistry principles also helps address major global challenges such as climate change, water pollution, and resource depletion. By incorporating these practices into research, industry, and education, scientists can develop solutions that are practical, sustainable, and environmentally responsible. In short, green chemistry is more than a scientific approach—it is a path toward a cleaner, safer, and sustainable future. Collaboration between researchers and industry is crucial to ensure that eco-friendly chemical practices become the norm. Therefore, the advancement and application of green chemistry principles are fundamental for developing sustainable technologies that minimize environmental impact, enhance resource efficiency, and support global environmental protection.

Deep Eutectic Solvents: A Review of Fundamentals and Applications

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The transition from traditional solvents to green solvents represents a pivotal paradigm shift in sustainable chemistry, addressing the growing concerns over toxicity, environmental persistence, and occupational hazards associated with conventional organic solvents. Traditional solvents such as benzene, toluene, chloroform, and dichloromethane have long been essential in chemical synthesis, pharmaceutical manufacturing, and industrial processes due to their superior solvating properties. However, these VOCs pose significant risks to both human health and ecosystems through their toxicity, flammability, and contribution to air pollution and ozone depletion. Green Chemistry principles have driven the search for safer alternatives that reduce hazardous impacts throughout a chemical's life cycle. Among the most promising green solvents are bio-based solvents derived from renewable feedstocks, supercritical fluids, ionic liquids, and deep eutectic solvents (DESs). These alternatives offer distinct advantages including biodegradability, low toxicity, reduced VOC emissions, and compatibility with energy-efficient processes. Deep eutectic solvents, formed by combining hydrogen bond donors and acceptors such as choline chloride with urea or carboxylic acids, have garnered particular attention due to their tunable properties, simple synthesis, low cost, and remarkable ability to dissolve a wide range of compounds including metal oxides, pharmaceuticals, and biopolymers. The application of deep eutectic solvents in extraction processes has demonstrated extraction efficiencies comparable to or better than conventional organic solvents for phenolic compounds, flavonoids, and other bioactive substances from natural sources. Furthermore, green solvents align with multiple United Nations Sustainable Development Goals, particularly those addressing good health and well-being, clean water and sanitation, and responsible consumption and production. Despite these advances, challenges remain regarding viscosity, recyclability, and comprehensive toxicity assessments to ensure that these alternatives genuinely reduce environmental footprints. The study concludes that deep eutectic solvents represent a viable and sustainable alternative to conventional solvents for extraction and separation processes, with their physicochemical properties being tunable through appropriate selection of hydrogen bond donor and acceptor pairs for specific applications.

Cellulose acetate based hybrids: fascinating material as a potential adsorbent for Congo red removal

Daima Arooj kazmi

Pollutant removal from wastewater stays a critical global challenge with conventional methods often suffering from limitations such as sludge disposal issues, high costs, and low efficiency. Adsorption, a well-established separation technique, has emerged as a promising, efficient, and economic method for water decontamination, particularly due to the regenerable nature of adsorbents. This review focuses on the synthesis and characterization of novel cellulose acetate (CA)-based hybrid materials and evaluates their performance as potential adsorbents for Congo red (CR) which is a prominent industrial dye, characterized as a red crystalline powder. It is an elongated, flat molecule providing bilateral symmetry and 3 bonding sites, which include sulfonic acids and amines. This pH-sensitive acidic dye carries negative charges on its surface because of the dissociation of its polar sulfonic groups, making its removal from industrial effluents a critical problem. The objective is to analyze the effectiveness of these eco-friendly, low-cost, and biodegradable materials, highlighting their unique advantages in environmental applications. Key topics explored include the facile and greener synthesis approach for incorporating various metal moieties (Al^{3+} , Ti^{4+} , Zr^{4+} , and Si^{4+}) into CA to enhance its chemical and thermal stability, as well as its adsorptive properties. Characterization techniques such as ^1H NMR, XRD, FTIR, TGA/DTA, EDX-SEM, and BET analysis confirm the successful formation of these hybrids, revealing increased pore extent, surface area, and distinct morphological features compared to raw cellulose acetate. This research article gives details about the adsorption mechanism, demonstrating that the hybrids exhibit higher adsorptive capacities over a huge pH range (1-7), following Ho's pseudo-second-order kinetics and fitting well with the Langmuir isotherm model. Physisorption and cooperative adsorption phenomena are identified as dominant mechanisms, particularly in synthesized hybrids. The synthesis approach involves mixing CA with metal precursors (e.g., aluminum isopropoxide, TEOS/APTMS, titanium but-oxide, zirconium chloride) in a solution of acetone and glacial acetic acid, followed by dropping the mixture into distilled water to form fiber. The enhanced performance of these CA-based hybrids, especially CA-Al and CA-Si, is attributed to their increased surface area, improved textural properties, and the positive surface charge observed below pH 8, which enables the adsorption of anionic dyes like Congo red. This comprehensive analysis the strong potential of CA-based hybrids as commercially-feasible, low-budget and effective alternative materials for efficient dye removal from industrial effluents, contributing substantially to sustainable waste water treatment solutions.

Simple Sunlight Method Using C60 Fullerenes to Clean Textile Wastewater

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Textiles industry wastewater containing synthetic dyes cause a serious threat in Pakistan, particularly near Faisalabad and Karachi industrial zones. Traditional methods are costly and produce toxic sludge as a side product. Buckminsterfullerene (C_{60}), discovered in 1985, has multiples application in daily life. one of these is uses as photocatalyst that harness abundant sunlight to minimize to toxicity of organic dyes by conversion into harmless CO_2 and water. This research demonstrates a facile synthesis of C_{60} – TiO_2 nanocomposites via ultrasonication –assisted impregnation (1- 5% C_{60}

loading). The black photo catalyst was characterized by UV-Vis spectroscopy (bandgap reduced from 3.2 eV to 2.7 eV) and confirmed by characteristic C60 peaks at 330 nm. Photocatalytic performance was evaluated against Rhodamine B (10 mg/L, pH 7) under natural sunlight. The optimized 3 wt.% C60-TiO₂ achieved 95% dye decolorization within 120 minutes-3.2 times faster than pristine TiO₂ (30% removal)-demonstrating superior charge separation. Radical scavenging experiments identified OH as the dominant reactive species. The catalyst maintained 92% efficiency after five consecutive cycles, indicating excellent photo stability. This low-cost, sunlight-driven technology addresses Pakistan's pressing need for sustainable wastewater treatment. Scalability using commercial TiO₂ paint pigment makes industrial adoption feasible. Future research will test local reactive azo dyes and optimize continuous flow reactors.

Keywords: fullerene C60, photocatalysis, textile wastewater, dye degradation, nanocomposites, environmental remediation.

The "Nobel Era" of Reticular Chemistry: Scaling Metal-Organic Frameworks Towards a Sustainable Future

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In the wake of the 2025 Nobel Prize in Chemistry, the field of reticular chemistry and metal-organic frameworks (MOFs) has entered a new period with the emphasis shifting from the discovery of materials to their industrial application. Metal-organic frameworks are highly porous materials composed of metal nodes and organic ligands linked by coordinative bonds. The high surface area and tunable pore structure and the existence of chemically active sites have made them highly attractive materials with applications in carbon capture, hydrogen storage, catalysis, separation technology, and water harvesting. Therefore, they are considered to have great potential in resolving some of the energy and environmental challenges facing the world. In the "Nobel Era" beyond 2025, there is an increasing stress on scaling the synthesis and accelerating the discovery of materials with potential applications. The development of sustainable routes to the synthesis of MOFs and their scalability is refining with time. The immense design space available with MOFs, with more than hundreds of thousands of known structures, is creating challenges in the discovery of materials with optimal performance for specific applications. Recent developments in artificial intelligence and machine learning have therefore emerged as powerful tools to hasten MOF discovery. Generative models such as MOFGPT, a transformer-based framework for inverse MOF design, enable the generation of novel framework structures with targeted properties. MOFGPT combines a GPT-based generative model with property prediction and reinforcement learning modules to guide the creation of synthetically feasible and functionally optimized MOFs. This approach allows exploration of vast chemical spaces while preserving structural validity and diversity, overcoming limitations associated with traditional computational screening methods such as density functional theory and molecular simulations. Beyond MOFGPT, broader advances in generative artificial intelligence including diffusion models, variational autoencoders, and agent-based AI systems are restructuring the paradigm of reticular chemistry. These systems integrate high-throughput simulations, materials databases, and automated experimental workflows to produce and assess thousands of candidate frameworks for energy and environmental applications. Such AI-driven pipelines have demonstrated the ability to propose and experimentally synthesize earlier unknown MOFs, highlighting the

potential of autonomous materials discovery platforms. This review explores the evolution of reticular chemistry in the Nobel era, emphasizing advances in scalable MOF synthesis, the incorporation of artificial intelligence in materials design, and the development of generative models such as MOFGPT. By analyzing recent growth in both experimental and computational approaches, the review highlights future opportunities for rendering MOF research from laboratory-scale discovery to industrial implementation for sustainable technologies.

Investigation Of Local Hemp Fiber Characteristics For Technical Textile Applications

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The textile industry, recognized as one of the world's most environmentally impactful sectors, is increasingly shifting toward sustainable and biodegradable raw materials due to growing ecological concerns and the depletion of natural resources. In this context, natural bast fibers such as hemp and jute have gained considerable attention as eco-friendly alternatives to conventional cotton and synthetic fibers, which require intensive water, energy, and chemical consumption. Hemp (*Cannabis sativa*), known for its drought resistance, rapid growth cycle, and high carbon sequestration capacity, together with jute, often referred to as the "golden fiber" because of its rich cellulosic composition, offers significant potential for sustainable technical textile applications. This study investigates the transformation of these sustainable natural fibers into advanced technical textile structures through fiber characterization, surface modification, dyeing optimization, and composite reinforcement applications. Initially, the effects of bleaching and dyeing treatments using different dyestuffs and mordants were examined to improve the compatibility and usability of hemp and jute fibers within textile structures. The influence of these treatments on fiber morphology, chemical structure, and mechanical behavior was analyzed using tensile strength testing, scanning electron microscopy (SEM), and Fourier-transform infrared spectroscopy (FTIR). In addition, color fastness, rubbing resistance, and bleeding properties were evaluated to determine the industrial applicability of the fibers in sustainable textile production. Beyond conventional textile applications, the study further explores the utilization of domestically produced industrial hemp fibers in protective technical textiles and lightweight composite systems. Hemp fibers were incorporated into epoxy-based composite structures either individually or in hybrid layered configurations together with aramid (Kevlar) fabrics. Composite panels were manufactured using established reinforcement techniques to evaluate the role of natural fibers in sustainable protective materials. The developed structures were subjected to comprehensive mechanical and ballistic characterization. Fiber-matrix interfacial adhesion, structural integrity, and energy absorption behavior were experimentally investigated, while ballistic performance was evaluated according to the NIJ 0101.06 standard. The ballistic responses of hemp-based, Kevlar-based, and hybrid hemp/Kevlar composites were comparatively analyzed to assess their effectiveness in lightweight body armor applications. The results demonstrate that sustainable bast fibers can successfully progress from raw fiber form to functional technical textile products with enhanced environmental and mechanical performance. In particular, hemp-based hybrid composite structures exhibited promising potential for energy dissipation and lightweight protective applications. This research therefore contributes to the development of next-sustainable technical textiles by integrating eco-friendly fiber resources with advanced composite and protective textile technologies.

Keywords: Hemp fiber, Local Hemp, Technical Textiles, Composite, Sustainability.

Surface phonon polaritons graphene embedded between hexagonal boron nitride layers for THz applications

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In this research, surface phonon polaritons (SPhPs) embedded between hexagonal boron nitride layers (hBN) layers will be theoretically analyzed for terahertz (THz) applications. The hybrid graphene–hBN heterostructure enables strong field of confinement due to the coupling between graphene plasmons and hBN optical phonons. Kubo formalism will be used for the physical modelling of graphene conductivity. Dispersion characteristics of the supported modes will be analyzed. The effects of graphene chemical potential, relaxation time, and hBN thickness on the effective mode index, propagation length, and confinement will be studied in the THz frequency range. These results provide promising platform for tunable THz photonic and plasmonic devices, including sensors, modulators, and integrated on-chip components.

Modelling of electromagnetic surface waves in plasma slab waveguide surrounded by temperature sensitive material

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This work will present the theoretical modelling of electromagnetic surface waves in a plasma slab waveguide surrounded by temperature-sensitive material. The electromagnetic field components of proposed materials will be derived by applying Maxwell's equations and boundary conditions at the plasma–InSb interfaces will be applied to obtain the characteristics equation. The dielectric response of plasma will be described using the Drude model, while the temperature-dependent permittivity of InSb will be incorporated through its intrinsic carrier concentration variation. Numerical analysis will demonstrate that the propagation characteristics, including effective mode index, attenuation constant, and phase velocity, will strongly depend on plasma frequency, slab thickness, and temperature of the surrounding InSb medium. Computed numerical results will indicate that plasma–InSb waveguides may provide an efficient platform for temperature-controlled THz devices, with potential applications in sensing, modulation, and reconfigurable plasmonic waveguide systems.

Behaviour of plasmon mode in black phosphorus wrapped cylindrical waveguide filled with chiroferrite medium

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This work will investigate the behavior of plasmon modes in a black phosphorus wrapped cylindrical waveguide filled with a chiroferrite medium. The dispersion characteristics of the proposed structure will be derived using differential form of Maxwell's equations in cylindrical coordinates and appropriate boundary conditions will be applied to obtain the dispersion relation. The anisotropic conductivity of black phosphorus will be incorporated to account for its in-plane direction-dependent optical response, while the chiroferrite medium will be modelled using bi-anisotropic constitutive relations. Numerical analysis will be carried out to examine the influence of structural and material parameters, including cylinder radius, chirality parameter, and ferrite permeability, on the effective mode index, attenuation constant, and phase velocity. It will be shown that the coupling between plasmonic confinement in black phosphorus and magneto-chiral effects in the core medium will enable tunable dispersion and asymmetric mode propagation in the terahertz regime. The proposed structure will support highly confined and controllable plasmon modes, making it a potential candidate for polarization-sensitive and nonreciprocal THz waveguide applications.

**Numerical analysis of transverse magnetic mode lithium fluoride filled sandwiched between
chiroplasma medium**

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This work will present the numerical analysis of electromagnetic modes in lithium fluoride (LiF) wrapped cylindrical waveguide surrounded by chiroplasma medium. The dispersion characteristics of the proposed configuration will be derived by solving Maxwell's equations in cylindrical coordinates and appropriate boundary conditions at the LiF–chiroplasma interface will be employed to analyze the characteristics equation. The frequency-dependent permittivity of lithium fluoride will be incorporated to describe its dielectric response, while the surrounding chiroplasma medium will be modelled using bi-isotropic constitutive relations including plasma and chirality parameters. Numerical simulations will be performed to investigate the effects of cylinder radius, plasma frequency, and chirality parameter on the effective mode index, attenuation constant, and modal confinement. It will be shown that the presence of chirality in the surrounding medium will significantly modify the dispersion behavior and may induce asymmetric mode propagation. The structure will support tunable and confined electromagnetic modes in the terahertz frequency regime which may enable chiral sensing, polarization-selective guiding, and reconfigurable THz waveguide applications.

**Dual-Action Nanotherapeutics for Glioblastoma: Gold Nanocage- mediated Delivery of Silymarin
Improves Tumor Targeting and Neurobehavioral Outcomes**

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Glioblastoma multiforme (GBM) is the primary malignant brain neoplasm, characterized by rapid proliferation, therapy resistance, and poor prognosis. Treatment efficacy is compromised by the

restrictive blood–brain barrier (BBB) and the systemic toxicity associated with conventional chemotherapy. GBM patients frequently develop neuropsychiatric symptoms, including depression and anxiety, primarily by tumor-induced neuroinflammation and neuronal damage. Surgical resection is the safest conventional treatment followed by chemotherapy by temozolomide (TMZ). TMZ provides modest survival benefits and may exacerbate neuropsychiatric symptoms. Therefore, developing novel therapeutics targeting tumor progression as well as neurological symptoms remains a major clinical challenge. Current study investigated the therapeutic potential of the phytochemical Silymarin in gold nanocages (AuNCs) as a targeted drug delivery method for GBM. AuNCs were synthesized via galvanic replacement of silver nanocubes and co-loaded with TMZ and silymarin. Physicochemical characterization was done by using UV–Vis spectroscopy, FTIR, XRD, and SEM. These nanocages were found to be highly efficient (drug loading efficiency $\geq 78\%$) with sustained release over 48 hours. In vitro assays using U87-MG glioblastoma and HEK-293 cells demonstrated enhanced selective cytotoxicity toward cancer cells. In vivo evaluation using an orthotopic GBM mouse model revealed behavioral struggles including anxiety, anhedonia, and reduced sociability. Treatment with Silymarin significantly improved behavioral outcomes and preserve hippocampal structural integrity (as shown by histological analysis) comparable to TMZ that has worsen neuropsychiatric symptoms. Bio distribution analysis revealed off-target accumulation of TMZ in vital organs, while silymarin shown minimal retention. These findings conclude Silymarin as a promising dual-function therapeutic with anticancer and neuroprotective properties. AuNC-based nanocarriers represent enhance targeted drug delivery system overcoming BBB resistance in GBM treatment, offering a potential translational pathway for improved clinical outcomes.

Spatial Analysis Of Tree Functional Traits In Response To Climate Variables In Margalla Hills, Islamabad

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Anthropogenic climate change is fundamentally changing forest ecosystems around the globe, and requires a mechanistic understanding of how tree functional trait supports resilience and adaptation. This research is the analysis of the spatial heterogeneity of the pivotal functional traits based on climatic and elevation gradient in Margalla Hills National Park (MHNP) which is a known biodiversity hotspot. With the help of a trait-based, spatially-explicit approach, correlations among tree structural traits (height and diameter at breast height (DBH)) and leaf functional traits (Specific Leaf Area (SLA) and Leaf Dry Matter Content (LDMC)) were estimated with respect to environmental variables and long-term climatic changes. A total of 12 plots comprising 144 trees were sampled across the hiking trails (2-5) in order of altitude (low, mid, high). The results of the analysis showed that there were strong altitude-structuring effects in tree structural characteristics: means of height had a strong positive correlation ($r = 0.90$, $p < 0.001$);

means of DBH had a very strong positive correlation ($r = 0.95$, $p < 0.001$) with increasing altitude. Conversely, Kruskal-Wallis tests showed that there were no statistically significant differences between different elevation classes with respect to SLA ($H = 0.29$) or LDMC ($H = 0.33$). Regression analyses on the other hand showed that there was a moderate negative correlation between mean SLA and elevation ($r = -0.61$, $p = 0.037$; $R^2 = 0.53$) and positive but non-significant trend to mean LDMC ($r = 0.56$, $p = 0.06$; $R^2 = 0.47$). These results indicate a shift to more conservative

resource-use strategies, who are typified by the low SLA and high LDMC, at elevated altitudes, which is in line with stress-tolerance to the more demanding environment. Above all, spatial mapping revealed that the functional traits have a localized cluster and they are not evenly distributed. Analysis of long-term climatic trend during 1995-2024 showed that there were no statistically significant directional changes in annual temperature, precipitation or relative humidity. However, the trends in temperature anomaly showed that the recent warming events occurred after 2010, and precipitation had a high level of inter-annual variability. Normalized Difference Vegetation Index (NDVI) had moderate positive relationships with mean temperature (r 0.376) and relative humidity (r 0.333), although it had a weak negative relationship with precipitation (r 0.069). The study adds new data to the adaptability of montane forest in the context of species, where structural features are shown to respond to the elevational gradient with a strong response, and leaf functional features can be shown to be more subtle and spatially detailed. The results support the urgency of incorporating a trait-based ecology with sophisticated spatial analysis tools in predicting forest susceptibility and resiliency.

Development Of Bio-Based Charcoal Filters From *Ailanthus Altissima* For Water Purification In Hill Communities

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The invasive tree *Ailanthus altissima* poses a significant threat to native biodiversity in Pakistan's hill communities, while access to safe drinking water remains a critical challenge in these regions. This study aimed to valorize this invasive species by developing biochar-based water filters and evaluating their suitability for drinking water purification. Biochar was produced from leaves, twigs and their mixture through slow pyrolysis at 350°C for 2 hours, followed by KOH activation. Comprehensive characterization including proximate analysis, Scanning Electron Microscopy (SEM) and Fourier Transform Infrared Spectroscopy (FTIR) revealed distinct feedstock-dependent properties. Leaves biochar exhibited the highest volatile matter (59.79%) and ash content (18.93%) with abundant oxygen-containing functional groups (O-H, C=O, C-O) and rough, heterogeneous surface morphology (pores 0.5 - 2 μ m). Twigs biochar showed the highest fixed carbon (34.22%), lowest ash (7.20%) and well-organized porous structures with uniform pores (1 - 5 μ m). Mix biochar displayed intermediate properties with interconnected pore networks (1 - 3 μ m). Filtration experiments demonstrated that leaves biochar achieved superior microbial removal (91.1%), significantly outperforming twigs (53.3%) and mix biochar (11.1%) (p < 0.001). All filters successfully improved pH from slightly acidic (6.20) to within WHO range (7.42 - 7.78) and showed practical flow rates (30 - 50 mL/min). However, substantial metal leaching occurred across all biochar types: iron increased from 32.72 ppm in raw water to 99.83 ppm (mix), 76.04 ppm (leaves) and 51.83 ppm (twigs), exceeding WHO guidelines by 170 - 330 times. Chromium and manganese also showed significant leaching. Correlation analysis revealed strong negative relationship between ash content and flow rate (r = -0.992) and moderate positive correlation between ash content and microbial removal (r = 0.579). A user-friendly gravity-fed filter system was developed at approximately 1000 PKR, but despite thorough washing, it produced water with pale yellow color, objectionable odor and only 25 - 40% microbial removal, failing to meet drinking water standards. This research concludes that *Ailanthus altissima* biochar demonstrates excellent potential for microbial decontamination (up to 91.1%) but is unsuitable for

direct drinking water application without pre-treatment due to significant metal leaching and release of dissolved organic carbon. The extent of suitability is feedstock-dependent: leaves biochar excels at microbial removal while twigs biochar offers greater structural stability with moderate leaching. Essential pre-treatment strategies including acid washing and higher pyrolysis temperatures (500 - 600°C) are mandatory before these biochars can be safely employed for drinking water purification. This study successfully demonstrates valorization of an invasive species into functional filtration media while clearly identifying critical limitations requiring intervention, thereby transforming an ecological problem into a valuable resource with defined pathways for improvement.

Evaluating The Effect Of Urban Forests For Pollution Control And Climate Mitigation

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Heavy metal pollution can be effectively monitored using urban plants as bioindicators. The accumulation of specific heavy metals in leaf samples taken from three different plant species in two urban parks was assessed in the current study. To investigate spatial variation in metal concentrations, a total of eighteen samples were taken from the edge, middle, and core zones. To compare the zones, the data were statistically analyzed and expressed as mean $\pm$ standard deviation. The results showed no significant differences ($p > 0.05$) among the zones under study, despite minor variations in metal concentrations. The study emphasizes the potential of plants as environmental quality indicators and offers baseline data on heavy metal accumulation in urban vegetation.

Root-Knot Nematode the Hidden and Mysterious Plant Pathogen

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Root-knot nematodes (*Meloidogyne* spp.) are among the most destructive plant-parasitic nematodes, causing significant yield losses in tomato and other crops worldwide. *Meloidogyne enterolobii* is of particular concern due to its aggressive nature, wide host range, and resistance breaking ability. This study evaluated the efficacy of selected non-fumigant chemical nematicides (Fluensulfone, Fluazaindolizine, Fluopyram, and Oxamyl) and bionematicides (lignin-alkali at two concentrations and Majestene) for the management of *M. enterolobii* in greenhouse-grown tomato. Tomato plants were inoculated with 29,400 eggs per pot, followed by nematicide drench applications. Parameters measured included root galling index, nematode reproduction factor, egg density, and plant growth traits. Results indicated that Fluensulfone significantly reduced galling, egg density, and reproduction factor, while Fluopyram improved shoot growth and Oxamyl enhanced root growth. Among bionematicides, the high-concentration lignin-alkali treatment effectively suppressed nematode infestation and promoted plant growth. These findings highlight the potential of integrating chemical and biological nematicides into an integrated nematode management (INM) framework, offering sustainable alternatives for tomato production in the absence of fumigants.

Keywords: Meloidogyne enterolobii, tomato, root-knot nematode, nematicides, bionematicides, integrated nematode management (INM), plant-parasitic nematodes.

Climate Resilient And Sustainable Food Production By The Use Of Microbial Fermentation

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Every now and then food insecurity is a burning issue across the globe and the driving factors behind it is climate change which tremendously effect global food production systems by decreasing crop yields, spiking environmental stress, and threatening nutritional security. Therefore the development of resilient food systems potent enough to meet growing population food demands is required, by bringing sustainable and innovative approaches to life. Among the bio-innovation solutions Microbial fermentation has emerged as a promising solution that can substantially minimize environmental impacts thus contributing to sustainable food production. Raw agricultural materials can be transformed into nutrient-rich and shelf-stable food products through the use of microorganisms that include bacteria, yeast, and fungi. Through fermentation not only the nutritional quality and digestibility of foods can be enhanced but it can result in increased production of bioactive compounds, vitamins, and natural preservatives. Reliance on energy intensive food processing methods can be reduced by utilizing fermentation technologies and getting best out of locally available agricultural resources which in return can minimize wastes and can aid to global sustainability goals. In addition to it fermentation based food systems support circular bioeconomy principles through the conversion of low value substrates into high value nutritional products. Recent advancements include the use of biotechnology and microbial science that have potential for developing novel functional foods and alternative protein sources. Adopting microbial fermentation technologies can act as a sustainable and climate resilient solution for improving food security and nutritional quality. The problem of climate change can be tackled through the integration of traditional fermentation knowledge with modern biotechnological innovations that play a critical role in building a sustainable and resilient food system.

Keywords: Microbial fermentation, Sustainable food production, Climate resilience, Circular bioeconomy, Functional foods.

Impact Of Climate Change On Food Security And Nutritional Quality

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Climate change is one of the most serious threats to food security and human nutrition. Food security is not just a matter of deal, but it is cornerstone of health and well-being for individuals and communities. Food security deal with the four pillars of food; that is its availability, access utilization and stability to every individual present in a community. Change in climate severely damages not just the quantity of food but also it lowers the quality. High levels of CO₂ reduces the level of micronutrients such as zinc, calcium iron and protein in staple foods such as rice, wheat and maize. Different environmental factors such as change in extreme weather, ecosystem effects and environmental degradation effects agricultural and food processing levels which lead to altered food choices through changes in prices and availability, and low-carbon diet choice. This condition results

in high incidence of infectious and non- infectious diseases. With change in climate condition, the production of food will be placed in altered ecosystems, which altered agricultural condition. Condition can be further alleviated by food industry by applying the procedure of processing, preserving, packaging and manufacturing. Organization such as Food and Agriculture Organization (FAO) and World Health Organization (WHO) are playing essential roles in transforming the policies. They provide policy guidance, technical support, funding, research and emergency assistance to strengthen global and national food systems.

Keywords:Food security, Micronutrients, Environmental factor, Ecosystem,Processing, Preserving, Packaging, Manufacturing.

From Compliance to Assurance: A Digital Governance Model for Halal Food Service Systems

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The accelerating expansion of the halal food industry demands more advanced governance mechanisms to ensure integrity, safety, and accountability across food service operations. Conventional halal management systems largely rely on manual supervision, periodic audits, and paper based certification processes, which are reactive in nature and vulnerable to human error, delayed detection, and traceability gaps. This study proposes a structured conceptual model, the Smart Halal Assurance Framework (SHAF) which integrates digital transformation technologies with Poka-Yoke (error prevention) principles to transition halal food service management from reactive compliance to proactive risk prevention. The framework is built upon four interlinked pillars: (1) Digital Monitoring Infrastructure, (2) Automated Error Proofing Controls, (3) Real Time Traceability and Verification, and (4) Predictive Compliance Analytics. Under this model, IoT enabled sensors continuously monitor critical control points, while embedded Poka-Yoke mechanisms prevent cross contamination and unauthorized process deviations. Blockchain supported certification enhances supply chain transparency, and AI driven analytics predict compliance risks before violations occur. The introduction of a “Halal Digital Twin” enables simulation based monitoring of operational vulnerabilities, strengthening audit readiness and governance resilience. The proposed framework demonstrates that integrating preventive engineering principles with intelligent digital systems can significantly reduce compliance risks, enhance traceability integrity, and improve consumer confidence. However, challenges including capital investment requirements, cybersecurity concerns, digital skill shortages, and regulatory harmonization must be addressed for scalable implementation. The Smart Halal Assurance Framework offers a strategic pathway for transforming halal food service management into a technology enabled, risk preventive governance system aligned with global standards of transparency and sustainability.

Keywords:Halal assurance framework, digital governance, Poka-Yoke, predictive compliance, halal traceability, smart food systems

Ethnobotanical study of medicinal plants practiced by local communities of Turbat, Balochistan.

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Since the beginning of time, people have used many medicinal plants as traditional remedies to cure various human health problems. So far, very few studies have been conducted to properly document and promote traditional ethnomedicinal knowledge. Therefore, this study aimed to document traditional knowledge regarding the utilization of medicinal plants for various illnesses in Turbat, Balochistan, and to develop an ethnomedicinal account of the species diversity in the area. The data were collected using a semi-structured method with a list of questionnaires. The information was categorized, including botanical names, local names, families, dosage, mode of preparation, and specific plant parts used by the local population. In the current study, 115 informants were selected, among them 42 were male and 73 were female. A total of 53 plant species belonging to 30 families were identified, with the maximum number of species recorded from the fabaceae family. According to the informant consensus factor (ICF), the highest number of plant species were used against toothache, cough and flu, heart problems, diabetes, and gastric issues. The highest relative frequency citation (RFC) values were recorded for *Zataria multiflora*, *Otostegia persica*, *Citrullus colocynthis*, *Cocculus pendulus*, and *Myrtus communis*. This study will help to establish a catalog of medicinal plants used in traditional treatments and will support for conservation, and rational use of these plants as alternative remedies.

Keywords: Medicinal plants, Turbat

Traditional knowledge Synergistic Effect of 6-benzylaminopurine and Activated Charcoal on in vitro Plant Growth and Biomass Accumulation in *Ocimum basilicum* L.

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Sweet basil (*Ocimum basilicum* L.) is one of the most important aromatic and medicinal herbs that is extensively grown in order to be used in culinary, pharmaceutical and nutraceutical. Due to the growing demand and therapeutic importance, it is critical to advance the efficient strategies of in vitro cell propagation to maximize the growth and biomass yield under controlled conditions. Plant growth regulators and culture additives play an important role in morphogenesis and biomass accumulation along with enhanced synthesis of nutraceuticals in the tissue culture systems. The current experiment examined the synergies between 6-benzylaminopurine (BAP) and activated charcoal on the in vitro growth and biomass production of sweet basil. Three concentrations of BAP were tested: 0.5 mg/L, 1.5 mg/L and an integrated treatment of 0.5 mg/L BAP and 4.5 g/L of activated charcoal. Explant of sweet basil were sterilized and placed nodal section on the media of different concentrations. The growth parameters such as number of internodes, plant length, the number of leaves, fresh and dry weight were measured to measure the efficacy of treatments. The findings were indicative of great difference between treatments. The medium with 0.5 mg/L BAP proved most effective with the highest count of internodes and leaves, maximum shoot elongation, and fresh biomass. The interactive effect was also positive at reduced cytokinin concentration as the combined treatment of 0.5 mg/L BAP + 4.5 g/L activated charcoal also stimulated better growth and biomass accumulation than 1.5 mg/L BAP. These results indicate that 0.5 mg/L BAP provides the best in vitro growth of *O. basilicum* and the further inclusion of activated charcoal at the same concentration can potentially increase the growth relative to higher concentrations of cytokinins. The research offers

useful information towards the optimization of micropropagation protocols and production of biomass in sweet basil. Using the in vitro system of propagating the medicinal plants to efficient levels offers a long-term and climate-inducible method of producing biomass of economically significant herbs like *Ocimum basilicum*.

Keywords: *Ocimum basilicum*, BAP, Activated Charcoal, Morphology, Tissue Culture

Biogenic Synthesis of Nickel Oxide Nanoparticles using *Melia Azedarach* for Detection of Antibiotics, Antioxidant and Antibacterial Activities

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The development of eco-friendly nanomaterials has gained significant attention due to their potential applications in environmental and biomedical fields. In the present study, nickel oxide nanoparticles (NiO NPs) will be synthesized through a green and sustainable approach using the aqueous bark extract of *Melia azedarach*. Plant-mediated synthesis offers advantages such as low cost, environmental compatibility, and reduced toxicity compared with conventional chemical methods. The synthesized nanoparticles will be characterized using various analytical techniques including UV–Visible spectroscopy, Fourier Transform Infrared Spectroscopy (FT-IR), X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), and Energy Dispersive X-ray Spectroscopy (EDX) to determine their structural, morphological, and compositional properties. The prepared NiO nanoparticles will be further explored for their potential applications in environmental and biological systems. Specifically, the nanoparticles will be applied for the colorimetric detection of antibiotics such as azithromycin in water through observable color change and spectrophotometric analysis. In addition, the antioxidant activity of the synthesized nanoparticles will be evaluated using the DPPH free radical scavenging assay, while antibacterial activity will be investigated against selected Gram-positive and Gram-negative bacterial strains using the well diffusion method. The study aims to develop a simple, cost-effective, and environmentally friendly method for the synthesis of nickel oxide nanoparticles and to explore their multifunctional applications in antibiotic detection and biological activities. The findings of this research may contribute to the development of efficient nanomaterials for environmental monitoring and biomedical applications.

Fabrication of Climate-Responsive Fe-Doped CuS Nano-Hydrogel Beads for Controlled Nutrient Release in Sustainable Agriculture

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One of the primary constraints to sustainable agricultural productivity is climate change and heat stress and the inconsistency of water supplies. Traditional fertilizers have low nutrient use efficiency because of the rapid leaching, volatilization, and lack of synchronization with plant nutrient demand particularly in high temperature conditions and water-deficit conditions. These drawbacks do not only cause a loss of crop yield but also soil erosion and contamination of the environment. Thus, there is a great necessity of coming up with intelligent and climate responsive nutrient delivery

mechanisms that are efficient and minimise the losses. The latest developments in nanotechnology focus on environmentally-friendly and sustainable production processes. The conventional methods of fabricating nanoparticles require the use of poisonous chemicals and energy that produces harmful wastes. Green synthesis provides a less expensive cleaner. Plant extracts are source of polyphenols, flavonoids, alkaloids, and organic acids that help in controlled nanoparticles formation because they control size, morphology, and surface properties. Iron (Fe) doping is an effective method by which the structural features and the electronic properties of copper sulphide (CuS) nanoparticles are changed to enhance their properties. In this experiment, the Fe-doped CuS nanoparticles were prepared through green techniques and it was encapsulated in sodium alginate/chitosan hydrogel beads with the help of ionic crosslinking of CaCl_2 ions. The hydrogel matrix is used to increase the level of moisture and Fe doping is used to increase the level of micronutrient availability and stress responsiveness. The beads were loaded with urea to release gradually into the root-zone. Nanoscale crystallinity was detected by characterization by XRD, UV-Vis, and SEM. This nano- hydrogel system is climate responsive and efficient in nutrient capture, soil moisture retention, and sustainable crop production. Overall, this represent a sustainable and innovative nano-enabled strategy to address emerging agricultural challenges and promote climate-smart farming practices for future food security.

Keywords: Fe-doped CuS nanoparticles, Sustainable agricultural, Leaching, Hydrogel beads, Climate responsive

Molecular Docking and Pharmacokinetic Profiling of Solanaceous Bioactive Compounds Against Major Cancer Targets

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Cancer remains a complex and life-threatening condition, contributing significantly to global mortality despite progress in conventional treatments such as chemotherapy, radiotherapy, and immunotherapy. These methods often face challenges like drug resistance, toxicity, and relapse, creating a need for safer and more effective alternatives. Plant-derived bioactive compounds have gained attention for their therapeutic potential due to their low toxicity and diverse pharmacological actions. This study investigates the anticancer potential of two medicinally valuable Solanaceous plants *Cestrum aurantiacum* L. and *Solanum elaeagnifolium* L. through in silico methods. *Cestrum aurantiacum* is recognized for its antimicrobial and anti-inflammatory constituents, while *Solanum elaeagnifolium*, commonly known as silverleaf nightshade, has traditional uses in treating pain and inflammation and exhibits pharmacological relevance. Four bioactive compounds beta-amyrin, lupeol, Tris(2,4-di-tert-butyl)phosphite, and 2-Pentadecanone, 6,10,14-trimethyl were isolated from these species and assessed through molecular docking against protein targets from nine major cancer types: blood, bone, liver, lung, thyroid, breast, oral, stomach, and kidney cancers. The docking results revealed that beta-amyrin,

lupeol, and Tris(2,4-di-tert-butyl)phosphite showed strong binding affinities to several cancer-related proteins, while 2-Pentadecanone, 6,10,14-trimethyl demonstrated relatively weak binding. Pharmacokinetic evaluation (ADME analysis) indicated excellent properties for 2- Pentadecanone, 6, 10, 14-trimethyl, moderate properties for beta-amyrin and lupeol, and poor results for Tris (2, 4-di-

tert-butyl) phosphite. Drug-likeness assessment using Lipinski's Rule of Five and other filters confirmed favorable drug-like characteristics for beta-amyrin, lupeol, and 2-Pentadecanone 6,10,14-trimethyl, whereas Tris(2,4-di-tert-butyl)phosphite failed to meet key criteria. Overall, the results suggest that beta-amyrin and lupeol hold significant promise for further preclinical investigation due to their strong binding, moderate pharmacokinetics, and drug-like properties. Although 2-Pentadecanone, 6,10,14-trimethyl has excellent ADME and drug-likeness, its low binding affinity limits its current therapeutic potential. Tris(2,4-di-tert-butyl)phosphite, while effective in binding, lacks essential pharmacokinetic and drug-likeness attributes. This study highlights the importance of integrating computational methods to identify plant-derived anticancer agents and supports the continued exploration of Solanaceous species in cancer drug discovery.

KeyWords: Cancer, *Cestrum aurantiacum* L., *Solanum elaeagnifolium* L., Beta-amyrin, Lupeol, Tris(2,4-di-tert-butyl)phosphite, 2-Pentadecanone, 6,10,14-trimethyl

Evaluation and Development of mRNA vaccine for Glioblastoma

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Objectives:

1. Computational design and prediction of a multi-epitope mRNA construct targeting neo-antigens specific to glioblastoma
2. Formulation and characterization of Metal Organic Nanoparticles for effective delivery of mRNA vaccines targeting brain cancer cells.
3. In vitro Screening of the anticancer effectiveness of the multi-epitope mRNA vaccine against glioblastoma.

Methodology: This study aims to design and evaluate a novel mRNA-based vaccine targeting glioblastoma-specific and tumor-associated antigens, using Metal–Organic Nanoparticles (MONs) as an efficient delivery platform. During in silico phase, potential glioblastoma antigens were identified using integrated bioinformatics tools, followed by prediction of antigenic epitopes using immunoinformatics tools. Selected epitopes were determined for immunogenicity, antigenicity, allergenicity and toxicity. The optimized mRNA construct was designed. Molecular docking and dynamics simulations were performed to evaluate the binding affinity and stability of predicted epitopes with HLA alleles. MON will be synthesized for the efficient delivery of mRNA and characterized for size and encapsulation efficiency. In vitro and in vivo experiments will focus on testing the formulated vaccine in U87 and U251 glioma cell lines to assess antigen expression, dendritic cell maturation, and cytotoxic T lymphocyte activation.

Expected Outcomes: It is expected that the proposed mRNA vaccine will effectively encode and express chosen glioblastoma-associated antigens, resulting in robust immune activation upon experimental testing. The Metal–Organic Nanoparticle (MON) formulation is expected to stabilize the mRNA, facilitate cellular uptake, and ensure efficient antigen presentation by dendritic cells. As a result, an enhanced cytotoxic T lymphocyte (CTL) response against glioblastoma cells (U87 and U251) is expected, inhibiting tumor proliferation and inducing targeted immune-mediated cell death.

Keywords: Glioblastoma, mRNA vaccine, Metal–Organic Nanoparticles (MONs), Immunoinformatics

Cancer immunotherapy Evaluation of the Antimicrobial activity of the *Cotoneaster nummularius* fruit extract against selected bacterial strains.

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The expanding occurrence of antimicrobial resistance amongst disease causing bacteria has made a sudden need for the discovery of novel and effective antimicrobial agents, particularly from natural sources. This research was aimed to evaluate the antimicrobial potential of *Cotoneaster nummularius* fruit extract against selected bacterial species. The fruit was made using a suitable solvent extraction procedure and tested against gram-positive bacteria (*Staphylococcus aureus*, *Streptococcus pyogenes*) and gram-negative bacteria (*Pseudomonas aeruginosa*, *Klebsiella pneumonia*). The antimicrobial activity was evaluated using standard microbiological techniques such as agar well diffusion method and determination of minimum inhibitory concentration through microdilution methods. The results showed that the *Cotoneaster nummularius* fruit extract have significant inhibitory effects against all bacterial strains. The extract showed high activity against gram-positive bacteria and activity against gram negative bacteria was also significant. The findings suggest that *cotoneaster nummularius* fruit extract contains bioactive compounds which exhibit potent antimicrobial activities and it can be used as an alternative to treat bacterial infections.

Keywords: *Cotoneaster nummularius*, Antimicrobial resistance, plant extract, MIC, Agar well diffusion, phytochemicals, Bacterial pathogens.

Encapsulation Of Limonene In Whey Protein-Based Matrices For The Development Of Limonene-Infused Dairy Products

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Limonene has natural bioactive properties known for numerous health benefits however, it has low water solubility, high volatility and pungent odor which limits its direct application in food industry. The aim of this study is to increase functionality, stability, control release of limonene in dairy matrices through encapsulation technique using protein-based matrices such as Whey Protein. There is limited research on behavior and functionality of protein based encapsulated limonene during processing conditions in dairy system. Therefore, there is a strong need to develop natural, stable, and sensory-acceptable food-grade formulations as alternatives to synthetic additives. Limonene encapsulated powder is developed by whey protein using emulsion method carried out by Lyophilization, access its stability properties, incorporate in dairy product access its physicochemical properties, microbial safety and sensory acceptability The study follows two phase experimental design, first phase involves formation of encapsulated powder using Whey Protein and different wall materials while, second phase involves incorporation of encapsulated limonene in milk. This research addresses the limitation that use of free limonene is not effective so effective delivery system is required to improve functionality of dairy products.

Keywords: Encapsulated Limonene, Emulsion method, Functional Dairy Products, Lyophilization, Whey Protein.

Effect Of Different Additives On Quality Of Flavored Yogurt

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Yogurt fortified with natural additives has attracted research interest because it is expected to improve nutritional and consumer acceptability and meets consumer requirements of functional and clean-label dairy products. Flavored yogurt being a widely accepted food due to its flavoring and nutritional properties but often contains artificial preservatives and stabilizers that have raised health concerns. In this study, three natural plant-based additives Hibiscus sabdariffa, Foeniculum vulgare, and Moringa oleifera are selected for their antioxidants, antimicrobials, and useful properties. Despite previous studies that have focused on specific components and effects of dairy matrices, there is very little research that has attempted to compare and integrate individual and combined effects of these specific natural additives on flavored yogurt. This study aims to fill a research gap by evaluating individual and combined concentrations of the plant extracts on physicochemical, microbial, nutritional and sensory properties of yogurt. A totally randomized design (CRD) using eight treatment groups will be conducted and each of these groups will be evaluated on days 0, 7, 14 and 21 of storage. Standard methods will be followed in analytical procedures, and finally the statistically method will be used to analyze the data. The study is expected to produce new insights in terms of how to develop and produce yogurts with value-added and clean-label formulations that are applicable at both the industrial and consumer level. This study bridges the gap between nutritional science and food innovation by validating the role of plant-based natural additives in increasing yogurt quality.

Water Chestnut (*Trapa Bispinosa*) As An Emerging Functional Food: Nutritional And Health Benefits

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Water chestnut (*Trapa bispinosa*) which is an underutilized aquatic perennial herb that was eaten in South and Southeast Asia has gained a lot of scientific interest as it has a good nutritional content and may be beneficial to help prevent various illnesses. Nutritional studies show that water chestnut fruits contain high amounts of carbohydrates, dietary fiber, essential minerals including potassium, phosphorus, and magnesium, and vitamins, which implies its use in the maintenance of balanced diets and intake of micronutrients. Recent comparative analyses have identified that the levels of phenolic and flavonoid compounds in indigenous varieties are significant, and that levels are correlated with high in vitro antioxidant activities assessed using standard assays, and therefore have the potential to reduce oxidative stress associated with the pathogenesis of chronic disease. Furthermore, water chestnut starch has functional properties that are useful in food application e.g. thickening and water retention and has been successfully integrated in probiotic dairy food product and gluten free formulation which is a sign of its versatility as a food functional ingredient. Traditional medicine Phytochemical research also justifies traditional medicinal applications, in which bioactive compounds have been shown to have anti-inflammatory, antimicrobial, and enzyme-inhibitory

effects that can have a health-promoting effect on metabolism. Nutrient density, bioactivity, and application potential convergence makes water chestnut a promising functional food that has the potential to address the nutritional shortage, promote digestive and cardiovascular health, and help to diversify food. This review summarises existing data on the nutritional profile, phytochemical properties, and nutritional health of water chestnut highlighting its increasing importance in the functional food research and development.

Climate-Resilient Cereal-Based Innovation: Development And Nutritional Evaluation Of Rice– Sorghum Gluten-Free Noodles

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The increasing prevalence of gluten intolerance, coupled with climate-induced challenges to global food systems, necessitates the development of sustainable and nutritionally enhanced food products. Climate-resilient indigenous cereals, such as sorghum (*Sorghum bicolor*), offer significant potential because of their drought tolerance, adaptability, and superior nutritional composition. However, their use in value-added gluten-free products remains limited. This study aimed to develop gluten-free noodles using rice (*Oryza sativa*) and sorghum composite flour and evaluate their nutritional, physicochemical, and sensory characteristics. Composite flour blends were prepared in varying proportions to optimize their functional and cooking properties. The developed noodle samples were analyzed for proximate composition, including moisture, crude protein, crude fat, ash, carbohydrate, and dietary fiber content, using standard AOAC methods. Antioxidant activity will also be determined to assess the functional enhancement. Cooking quality parameters, such as cooking loss, water absorption capacity, and texture profile analysis, will be evaluated. Sensory attributes, including color, aroma, texture, taste, and overall acceptability, will be assessed using a nine-point hedonic scale to identify the most acceptable formulation. The nutritional profile of the optimized product will be compared with that of conventional rice-based noodles to determine the extent of improvement. Sorghum incorporation will significantly enhance the protein, fiber, and mineral contents and antioxidant potential while maintaining acceptable sensory properties. This study is expected to provide scientific evidence supporting the utilization of climate-resilient cereals in gluten-free product development, thereby contributing to sustainable food systems, nutritional security, and climate-responsive food innovation.

Keywords: Gluten-free noodles; Climate resilience; Composite flour; Sustainable nutrition; Antioxidant

Climate-Resilient Indigenous Crops: A Sustainable Approach To Improving The Nutritional Quality Of Infant Weaning Food

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Infant malnutrition continues to be a serious public health issue in Pakistan, where about 40% of children under the age of five are suffering from stunting and 17.7% are from wasting due to inadequate nutrition during the weaning stage. Although commercially available weaning foods are nutritionally balanced but they are often unaffordable for low-income households, and they rely on such ingredients that are susceptible to climate-induced supply chain disruptions. In contrast, indigenous crops are nutritionally rich, climate-resilient, and locally available such as, wheat (*Triticum aestivum*), sorghum (*Sorghum bicolor*) and mung bean (*Vigna radiata*), yet remain underutilized in infant food products. This study aims to develop a low-cost, nutritionally balanced weaning food by utilizing these locally sourced indigenous crops and evaluate its potential to improve infant dietary practices. Composite blends of weaning food will be prepared using different proportion of sorghum, mung bean and wheat flour. When the weaning food will be developed it will be analyzed for proximate composition such as moisture, fat, fiber, protein, carbohydrate, and ash content according to the standard AOAC methods, and for sensory attributes such as taste, color, aroma, texture and overall acceptability using a 9-point hedonic scale in order to identify the most nutritionally balanced formulation. The nutritional profile of the selected weaning food will be compared with Codex Alimentarius standards for complementary foods. It is anticipated that the formulated weaning food will provide enough nutrient and energy content to support infant growth. Sensory evaluation is expected to identify the formulation with acceptable palatability, indicating its potential to be accepted at household level. This research will provide a scientific basis for the development of an affordable and sustainable weaning food by utilizing locally sourced indigenous, climate-resilient crops.

Keywords: Weaning food, Indigenous crops, Climate-resilient, Malnutrition, Pakistan

Anti-Inflammatory Properties of Turmeric (Curcuma longa) in CVD Patients Saba Ansar

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Cardiovascular diseases rates are still rising on global scale and in Pakistan. These conditions arise when normal structure or function of heart and blood vessels is affected. Chronic inflammation is the key driver of CVDs, treatment exists but they have side effects and expensive. Now there is growing interest in herbal therapies and nutraceuticals as an adjunct therapy. Among them, turmeric is widely known for its inflammation reducing effects. Several studies on active compounds of turmeric exists but limited by bioavailability. Limited studies exist on turmeric in CVD patients. Therefore, this study fills the gap by conducting randomized trial to assess the turmeric's anti-inflammatory effect in CVD patients. The research will have two experiment. In first experiment, the physiochemical and phytochemical potential of turmeric obtained from three different sources will be analyzed and then turmeric with premium quality will be used for clinical trial. In second experiment, randomized trial for 12 weeks will be undertaken. Participants will be randomly allocated into control group (DASH diet +Placebo) and two treatment groups (DASH diet +turmeric supplement). The data of anthropometric and biochemical parameters will be collected at 0 day ,45 days and 90 day and statistically analyzed using one way ANOVA and two factor CRD. It will be expected turmeric will have reduced inflammation and improved CVD outcomes.

Clinical Applications Of Bergamot (Citrus Bergamia) Against Cardiovascular Diseases

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Cardiovascular diseases are still the topmost reason of mortality rate at global level. In Pakistan, the rate of CVDs is elevated due to some risk factors that can modify for instance diabetes, dyslipidemia, high blood pressure, obesity, and inactive lifestyle. Present pharmaceutical therapies, which include statins and antihypertensives, indeed effective but are often restricted by side effects such as liver improper function, myopathy, and statin intolerance. This has elevated interest in safe substitutes and complementary therapies, particularly nutraceuticals; food-based substances with therapeutic potential. Citrus fruits, especially bergamot (Citrus bergamia), aboriginal to Calabria, Italy, is rich in flavonoids (neohesperidin, naringin, brutieridin, and melitidin) known for lipid-lowering, antioxidant, and anti-inflammatory properties. Clinical studies have revealed that polyphenolic fraction of bergamot remarkably reduces LDL-C, triglycerides, and inflammatory markers. However, most research focuses on commercial BPF extracts, with limited evidence and investigation on the potential of peel, pulp, and seed fractions. This purpose of this study is to evaluate the phytochemical composition of bergamot fractions & to assess their clinical effectiveness in improving lipid profiles and inflammatory biomarkers in CVD patients in Pakistan. A 12- week randomized trial will be conducted with three groups: Control (DASH diet + placebo), T1 (DASH diet + bergamot 500 mg/day), and T2 (DASH diet + bergamot 1000 mg/day). Outcomes will be measured through anthropometric measures, biochemical parameters, and dietary adherence will be ensured. It is expected that Bergamot supplementation, along with dietary counselling, will notably reduce CVD risk factors, offering a safe, cost-effective, and holistic approach to traditional management strategies.

The Impact Of Administration Of Olive Oil In Diabetic Patients

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Type 2 Diabetes Mellitus (T2DM) is a metabolic illness marked by impaired regulation of blood glucose due to poor insulin production or ineffective insulin utilization. Persistently elevated blood sugar levels are a hallmark of this condition. In Pakistan, the T2DM is escalating at an alarming rate, exerting pressure on healthcare infrastructure and posing challenges for sustained pharmaceutical interventions, particularly among economically disadvantaged populations. This study aims to examine the how Olive oil effects on metabolic and biochemical markers such as FBG, HbA1c, lipid parameters like HDL, LDL, triglycerides, insulin sensitivity assessed via HOMA-IR, and antioxidant status. OO, known for its rich content of monounsaturated fatty acids and polyphenolic compounds, is explored here as a potential therapeutic agent. A 90-day randomized controlled trial will be conduct to involving individuals diagnosed with T2DM. The participants will be given a standard dose of OO to take on a daily basis with clinical examination before and after the intervention period. Analysis will be done using the SPSS software through statistical methods, which include correlation analysis, mean comparison, and testing of significance. The standard protocols will used to validate

the nutritional composition of the oil. Research objectives include exploring the use of OOs as a dietary supplement in the management of diabetes; also, to increase the ability to promote culturally appropriate, economically viable, and nutritionally relevant approach to improve glycemic control and overall population health outcomes.

Oyster Mushrooms (*Pleurotus Ostreatus*): Nutritional Value, Bioactive Compounds, And Health Benefits

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One of the most well-known nutritionally enriched edible fungi having a high functional and therapeutic value is oyster mushrooms (*Pleurotus ostreatus*). This is a critical review of scientific evidence on their nutritional constituents, bioactive compounds, health-promoting effects, safety issues and methods of preservation. *P. ostreatus* is a good alternative source of protein that has high-quality protein (1742 g/100 g dry weight), essential amino acids, dietary fiber and low lipid content. It contains also plenty of vitamins (especially B-complex, C, and D 2), as well as such essential minerals as potassium, iron, magnesium, and zinc. Other than nutritious value, oyster mushroom has significant amounts of bioactive compounds such as β -glucans, phenolic compounds, terpenoids, lectins, ergothioneine, lovastatin, polysaccharides which are used in antioxidant activity, antimicrobial, anticancer, antidiabetic, anti-inflammatory, and hypocholesterolemic properties. The review also addresses food safety concerns such as microbial contamination, buildup of heavy metal, presence of pesticides residues and postharvest issues such as its high moisture content and perishability. Techniques of preservation (modified atmosphere packaging, edible coatings, refrigeration, irradiation, drying) are considered in improving shelf life and quality. *P. ostreatus* is a sustainable and eco-friendly food source because of the capacity to develop on agricultural waste substrates. Its growing use in functional foods and in nutraceutical development emphasizes its possible use in facilitating the health and food security of the population. Nonetheless, additional clinical studies are needed to legitimize therapeutic arguments and streamline large scale production systems.

Keywords: *Pleurotus ostreatus*, oyster mushroom, nutritional value, bioactive, antioxidant, functional food, nutraceuticals, food safety, shelf-life, food systems sustainability.

Storage Stability Assessment Of Apple (*Malus Domestica L.*) In Response To Different Edible Coatings

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Postharvest losses of apple (*Malus domestica L.*) in Pakistan exceed 30%, primarily due to inadequate cold-chain infrastructure and limited adoption of sustainable preservation technologies. This study comparatively evaluated natural biopolymer-based edible coatings for enhancing the storage stability of commercially important cultivar (Golden Delicious). Samples of the apple were collected from sunny bank muree at mature stage and coatings were applied. Protein-based (2% gelatin enriched with 10-30% Aloe vera gel), Carbohydrate-lipid bilayer (2% chitosan combined with 1-5% carnauba wax), and Fomesa wax (100%) coatings were applied by dip treatment and fruits were

stored at room temperature with 75% relative humidity. Quality attributes were monitored fortnightly, including weight loss, firmness, color parameters (L^* , a^* , b^*), total soluble solids, titratable acidity, ethylene estimation, respiration rate, ascorbic acid, total phenolics, flavonoids and radical scavenging activity. Statistical analysis was conducted using one-way ANOVA and a two-factor factorial design in a completely randomized arrangement ($p < 0.05$). All coatings significantly improved storage performance compared to uncoated controls. Gelatin-Aloe vera treatment reduced softening by approximately 30%, delayed enzymatic browning. The chitosan-carnauba wax effectively minimized respiration rate and weight loss, thereby preserving firmness and soluble solids. Fomesa wax demonstrated enhanced antimicrobial efficacy and retained the weight, firmness and color of the apple without compromising sensory attributes. Coated fruits also retained higher phenolic content and antioxidant activity throughout storage. These findings demonstrate that edible biopolymer coatings provide a cost-effective, environmentally sustainable strategy to reduce postharvest deterioration while maintaining physicochemical and nutraceutical quality of Pakistan's apple cultivars, offering practical potential for large-scale application in resource-limited supply chains.

Keywords: Edible coatings, Postharvest storage, Biopolymer film, Sustainability

Green Synthesis Of Carbon Dots From Xanthium Strumarium Leaves For Metal Ion Sensing And Antimicrobial Applications

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Carbon dots (CDs) are carbon-based nanomaterials that have gained much attention because of their good optical properties, low toxicity, chemical stability, and biocompatibility. In this study, carbon dots were synthesized using Xanthium strumarium leaves through a green and eco-friendly hydrothermal method. Plant-based synthesis was selected to avoid toxic chemicals and reduce environmental impact. The prepared carbon dots were characterized using UV-Visible spectroscopy, X-ray diffraction (XRD), scanning electron microscopy (SEM), and Fourier transform infrared (FTIR) spectroscopy to study their optical properties, structure, surface morphology, and functional groups. The antibacterial activity of the synthesized carbon dots was evaluated by the agar well diffusion method against two Gram-positive bacteria (*Bacillus subtilis* and *Bacillus velezensis*) and two Gram-negative bacteria (*Pseudomonas brenneri* and *Pseudomonas aeruginosa*). Gentamicin was used as a standard antibiotic for comparison. The results showed that the carbon dots exhibited effective antibacterial activity against both Gram-positive and Gram-negative bacterial strains. Moreover, the metal ion sensing ability of the carbon dots was studied by observing their fluorescence response in the presence of different metal ions such as Pb^{2+} , Cu^{2+} , Fe^{3+} , and Hg^{2+} . The carbon dots showed selective fluorescence changes toward specific metal ions, indicating their potential use as fluorescent sensors. Overall, this study demonstrates a simple, green, and cost-effective approach for the synthesis of multifunctional carbon dots with applications in antibacterial activity and metal ion sensing.

Keywords: biocompatibility, antibacterial, carbon dots, strumarium

Green Synthesis of Co-doped ZnO Nanoparticles using Jasminum Officinale Leaf Extract for Photocatalytic Degradation of Crystal Violet

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The growing demand for environmentally sustainable materials has encouraged the development of green synthesis methods for metal oxide nanoparticles. Conventional chemical synthesis techniques often involve toxic chemicals and complex procedures that may cause environmental and health concerns. In contrast, plant-mediated synthesis offers a simple, cost-effective, and environmentally friendly alternative for nanoparticle production. In the present study, cobalt-doped zinc oxide (Co-doped ZnO) nanoparticles were synthesized through a green synthesis approach using the leaf extract of *Jasminum officinale*. The synthesized nanoparticles were further evaluated for their potential application in the photocatalytic degradation of Crystal Violet dye, which is widely used in textile and printing industries and is considered a harmful pollutant when released into aquatic environments. Fresh leaves of *Jasminum officinale* were collected, thoroughly washed to remove impurities, and processed to obtain an aqueous leaf extract. This extract acted as a natural reducing and stabilizing agent during nanoparticle synthesis. Zinc acetate was used as the precursor for ZnO formation, while cobalt nitrate was added in calculated amounts to achieve different doping concentrations. Using a green co-precipitation method under controlled reaction conditions, Co-doped ZnO nanoparticles containing 1%, 3%, and 5% cobalt were successfully synthesized. The phytochemical constituents present in the plant extract played a significant role in facilitating nanoparticle formation and stabilizing the resulting particles. The prepared samples were characterized using several analytical techniques to investigate their structural, morphological, elemental, and optical properties. Fourier Transform Infrared (FT-IR) spectroscopy was used to identify functional groups and to confirm the presence of Zn–O bonding in the synthesized nanoparticles. X-ray diffraction (XRD) analysis was carried out to determine the crystalline structure and phase purity of the samples, while the average crystallite size was estimated using standard calculations. Scanning Electron Microscopy (SEM) was employed to observe surface morphology and particle distribution, whereas Energy Dispersive X-ray (EDX) analysis confirmed the elemental composition and verified the successful incorporation of cobalt into the ZnO structure. In addition, UV–Visible spectroscopy was used to evaluate the optical absorption behavior of the nanoparticles and to examine the influence of cobalt doping on the band gap and light absorption properties of ZnO. The photocatalytic activity of the synthesized nanoparticles was investigated through the degradation of Crystal Violet dye under visible light conditions. The reduction in dye concentration was monitored at regular time intervals using UV–Visible spectrophotometry. The results indicated that cobalt doping significantly influenced the photocatalytic performance of ZnO nanoparticles. Among the synthesized samples, the 3% Co-doped ZnO nanoparticles exhibited the most effective degradation performance compared to pure ZnO and other doping concentrations. This enhanced photocatalytic activity may be attributed to improved light absorption and more efficient charge separation resulting from cobalt incorporation into the ZnO lattice. Overall, the study demonstrates that green synthesized Co-doped ZnO nanoparticles using *Jasminum officinale* leaf extract can serve as an efficient and environmentally friendly photocatalyst for the removal of dye pollutants from aqueous systems and may contribute to sustainable wastewater treatment technologies.

Phyto-Mediated Green Synthesis Of Nickel Oxide Nanoparticles Using *Nicotiana glauca* And Their Antimicrobial And Antioxidant Activities

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Green synthesis of nanoparticles using plant extracts is an eco-friendly and cost-effective alternative to conventional methods. *Nicotiana glauca*, rich in bioactive phytochemicals, can act as a natural reducing and stabilizing agent. Nickel oxide nanoparticles (NiO-NPs) are known for their important antimicrobial and antioxidant properties. This study focuses on the green synthesis of NiO-NPs using *Nicotiana glauca* and evaluation of their biological activities. Leaf extract of *Nicotiana glauca* was used to synthesize NiO-NPs from a nickel salt solution. The nanoparticles were characterized using UV–Vis, FTIR, XRD, and SEM techniques. Antimicrobial activity was assessed by agar well diffusion, while antioxidant activity was evaluated using the DPPH assay. The successful synthesis of NiO nanoparticles was confirmed by characteristic absorption peaks in UV–Vis spectra and distinct crystalline patterns in XRD analysis. SEM results revealed predominantly spherical nanoparticles with nanoscale dimensions. The synthesized NiO-NPs exhibited significant antimicrobial activity, producing measurable zones of inhibition against tested bacterial strains. Additionally, the nanoparticles demonstrated strong, concentration-dependent antioxidant activity in the DPPH assay, indicating effective free radical scavenging potential. The study demonstrates that *Nicotiana glauca* is an efficient and eco-friendly source for the green synthesis of nickel oxide nanoparticles. The synthesized NiO-NPs showed promising antimicrobial and antioxidant activities, likely due to the synergistic interaction between nanoparticle properties and plant-derived phytochemicals. These findings highlight the potential applications of green-synthesized NiO-NPs in biomedical, pharmaceutical, and environmental fields.

Keywords: Green synthesis, Nickel oxide nanoparticles (NiO-NPs), *Nicotiana glauca*.

Harnessing novel Rhizobacteria and Botanicals for Eco-Friendly Management of *Meloidogyne incognita* in Tomato

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Among various factors affecting tomato productivity and quality, root-knot nematodes cause substantial damage. Chemical nematicides pose health and environmental risks, necessitating alternative biological control strategies. The present study evaluated the effects of rhizobacteria and plant extracts on *Meloidogyne incognita* management in tomatoes. In the first phase, aqueous extracts of *Azadirachta indica*, *Moringa oleifera*, and *Cannabis sativa*, along with six rhizobacterial strains, were tested for nematocidal activity. The stock solutions of *A. indica*, *M. oleifera*, and *C. sativa* showed the highest egg hatch inhibition (99.23%, 95.54%, and 99.30%) and juvenile mortality (95%, 93%, and 94.64%) after 6 and 48 hours, respectively. Among rhizobacteria, *Bacillus australimaris* LWD73 was most effective (45.9% egg hatch inhibition, 44.32% juvenile mortality). Compatibility tests confirmed synergy of *M. oleifera* with rhizobacteria for further experiments. In the second phase, the combined application of *M. oleifera* and *B. australimaris* LWD73 significantly improved plant growth and suppressed *M. incognita*, resulting in the highest plant height (96.94 cm) and root length (30.48 cm). *B. australimaris* alone yielded the highest shoot

biomass, while *M. oleifera* alone enhanced root weight. Infection parameters, including root galling (2.67) and juvenile count (680/60cc soil), were lowest in the combined treatment. The third phase involved FTIR and GC-MS analyses, which identified nematicidal compounds in plant extracts, such as flavonoids, phenols, and n- Hexadecanoic acid, while rhizobacterial volatile organic compounds like 2-Nonanone and Dimethyl trisulfide exhibited nematicidal potential. In the fourth phase, *B. australimaris* LWD73 and *B. thuringiensis* WAG41 induced systemic resistance in tomatoes by enhancing ROS- scavenging enzymes (CAT, POD, SOD, PPO, PAL). The study highlights the potential of *M. oleifera*-*rhizobacteria* integration as an eco-friendly strategy against *M. incognita*.

Botanical Gardens and Plant Biodiversity: Pathways toward Sustainability and Climate Resilience

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Plant biodiversity forms the ecological foundation for ecosystem stability, climate regulation, food security, medicinal resources, and sustainable livelihoods. However, rapid urbanization, habitat fragmentation, climate change, invasive species, and unsustainable exploitation of natural resources are accelerating the loss of plant diversity worldwide. In this context, botanical gardens have emerged as vital institutions for biodiversity conservation, scientific research, environmental education, ecological restoration, and climate resilience. This presentation highlights the multifaceted role of botanical gardens as living repositories of genetic resources and centers for ex situ conservation of rare, endemic, threatened, and economically important plant species. Botanical gardens not only support taxonomic and ecological research but also contribute significantly to public awareness, sustainable urban development, and capacity building in plant sciences. Through seed banks, tissue culture technologies, climate-adaptive landscaping, and restoration ecology programs, botanical gardens provide innovative pathways for conserving biodiversity under changing climatic conditions. Special emphasis will be placed on the role of botanical gardens in promoting nature-based solutions, sustainable resource management, ethnobotanical knowledge preservation, and climate-smart conservation strategies. The presentation will further discuss the importance of integrating botanical gardens into national biodiversity action plans, climate adaptation frameworks, and sustainable development goals (SDGs). The lecture underscores that strengthening botanical gardens through scientific collaboration, policy support, digital documentation, and community participation is essential for safeguarding plant diversity and enhancing ecological resilience in climate-vulnerable regions such as Pakistan. Botanical gardens represent not merely centers of plant display, but dynamic institutions that bridge science, sustainability, conservation, and societal well-being for future generations.

Keywords: Botanical gardens, Plant biodiversity, Climate resilience, Sustainable development, Ecosystem restoration, Ex situ conservation, Environmental sustainability.

Application of Advanced Technologies for Biosecurity: Role of Botanicals

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Biosecurity has emerged as a critical global priority in response to increasing threats posed by emerging pathogens, antimicrobial resistance, invasive species, environmental degradation, food insecurity, and climate change. Conventional approaches alone are often insufficient to address

these complex biological risks, thereby necessitating the integration of advanced technologies and sustainable bio-based interventions. In this context, botanicals and plant-derived bioactive compounds are gaining increasing scientific attention due to their eco-friendly, biodegradable, and multifunctional properties. This presentation explores the role of advanced technologies in enhancing the application of botanicals for modern biosecurity systems across agriculture, healthcare, environmental protection, and food safety sectors. The lecture highlights recent developments in nanotechnology, biotechnology, phytochemistry, molecular diagnostics, precision agriculture, biosensors, artificial intelligence, and genomic tools that are transforming the identification, extraction, formulation, and delivery of plant-based bioactive compounds. The presentation further discusses the importance of indigenous knowledge systems, biodiversity conservation, and ethnobotanical resources in developing innovative biosecurity strategies, particularly in climate-vulnerable and biodiversity-rich regions such as Pakistan. Challenges related to standardization, quality control, regulatory frameworks, commercialization, and large-scale implementation of botanical technologies will also be addressed.

Keywords: Biosecurity, botanicals, advanced technologies, medicinal plants, nanotechnology, phytochemicals, sustainable disease management, biotechnology, climate resilience, environmental sustainability.

Encapsulation Of Limonene In Whey Protein-Based Matrices For The Development Of Limonene-Infused Dairy Products

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Limonene has natural bioactive properties known for numerous health benefits however, it has low water solubility, high volatility and pungent odor which limits its direct application in food industry. The aim of this study is to increase functionality, stability, control release of limonene in dairy matrices through encapsulation technique using protein-based matrices such as Whey Protein. There is limited research on behavior and functionality of protein based encapsulated limonene during processing conditions in dairy system. Therefore, there is a strong need to develop natural, stable, and sensory-acceptable food-grade formulations as alternatives to synthetic additives. Limonene encapsulated powder is developed by whey protein using emulsion method carried out by Lyophilization, access its stability properties, incorporate in dairy product access its physicochemical properties, microbial safety and sensory acceptability The study follows two phase experimental design, first phase involves formation of encapsulated powder using Whey Protein and different wall materials while, second phase involves incorporation of encapsulated limonene in milk. This research addresses the limitation that use of free limonene is not effective so effective delivery system is required to improve functionality of dairy products.

Keywords: Encapsulated Limonene, Emulsion method, Functional Dairy Products, Lyophilization, Whey Protein.

Effect Of Different Additives On Quality Of Flavored Yogurt

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Yogurt fortified with natural additives has attracted research interest because it is expected to improve nutritional and consumer acceptability and meets consumer requirements of functional and clean-label dairy products. Flavored yogurt being a widely accepted food due to its flavoring and nutritional properties but often contains artificial preservatives and stabilizers that have raised health concerns. In this study, three natural plant-based additives Hibiscus sabdariffa, Foeniculum vulgare, and Moringa oleifera are selected for their antioxidants, antimicrobials, and useful properties. Despite previous studies that have focused on specific components and effects of dairy matrices, there is very little research that has attempted to compare and integrate individual and combined effects of these specific natural additives on flavored yogurt. This study aims to fill a research gap by evaluating individual and combined concentrations of the plant extracts on physicochemical, microbial, nutritional and sensory properties of yogurt. A totally randomized design (CRD) using eight treatment groups will be conducted and each of these groups will be evaluated on days 0, 7, 14 and 21 of storage. Standard methods will be followed in analytical procedures, and finally the statistically method will be used to analyze the data. The study is expected to produce new insights in terms of how to develop and produce yogurts with value-added and clean-label formulations that are applicable at both the industrial and consumer level. This study bridges the gap between nutritional science and food innovation by validating the role of plant-based natural additives in increasing yogurt quality.

Water Chestnut (*Trapa Bispinosa*) As An Emerging Functional Food: Nutritional And Health Benefits

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Water chestnut (*Trapa bispinosa*) which is an underutilized aquatic perennial herb that was eaten in South and Southeast Asia has gained a lot of scientific interest as it has a good nutritional content and may be beneficial to help prevent various illnesses. Nutritional studies show that water chestnut fruits contain high amounts of carbohydrates, dietary fiber, essential minerals including potassium, phosphorus, and magnesium, and vitamins, which implies its use in the maintenance of balanced diets and intake of micronutrients. Recent comparative analyses have identified that the levels of phenolic and flavonoid compounds in indigenous varieties are significant, and that levels are correlated with high in vitro antioxidant activities assessed using standard assays, and therefore have the potential to reduce oxidative stress associated with the pathogenesis of chronic disease. Furthermore, water chestnut starch has functional properties that are useful in food application e.g. thickening and water retention and has been successfully integrated in probiotic dairy food product and gluten free formulation which is a sign of its versatility as a food functional ingredient. Traditional medicine Phytochemical research also justifies traditional medicinal applications, in which bioactive compounds have been shown to have anti-inflammatory, antimicrobial, and enzyme-inhibitory effects that can have a health-promoting effect on metabolism. Nutrient density, bioactivity, and application potential convergence makes water chestnut a promising functional food that has the potential to address the nutritional shortage, promote digestive and cardiovascular health, and help to diversify food. This review summarises existing data on the nutritional profile, phytochemical

properties, and nutritional health of water chestnut highlighting its increasing importance in the functional food research and development.

Climate-Resilient Cereal-Based Innovation: Development And Nutritional Evaluation Of Rice–Sorghum Gluten-Free Noodles

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The increasing prevalence of gluten intolerance, coupled with climate-induced challenges to global food systems, necessitates the development of sustainable and nutritionally enhanced food products. Climate-resilient indigenous cereals, such as sorghum (*Sorghum bicolor*), offer significant potential because of their drought tolerance, adaptability, and superior nutritional composition. However, their use in value-added gluten-free products remains limited. This study aimed to develop gluten-free noodles using rice (*Oryza sativa*) and sorghum composite flour and evaluate their nutritional, physicochemical, and sensory characteristics. Composite flour blends were prepared in varying proportions to optimize their functional and cooking properties. The developed noodle samples were analyzed for proximate composition, including moisture, crude protein, crude fat, ash, carbohydrate, and dietary fiber content, using standard AOAC methods. Antioxidant activity will also be determined to assess the functional enhancement. Cooking quality parameters, such as cooking loss, water absorption capacity, and texture profile analysis, will be evaluated. Sensory attributes, including color, aroma, texture, taste, and overall acceptability, will be assessed using a nine-point hedonic scale to identify the most acceptable formulation. The nutritional profile of the optimized product will be compared with that of conventional rice-based noodles to determine the extent of improvement. Sorghum incorporation will significantly enhance the protein, fiber, and mineral contents and antioxidant potential while maintaining acceptable sensory properties. This study is expected to provide scientific evidence supporting the utilization of climate-resilient cereals in gluten-free product development, thereby contributing to sustainable food systems, nutritional security, and climate-responsive food innovation.

Keywords: Gluten-free noodles, Climate resilience, Composite flour, Sustainable nutrition, Antioxidant

Climate-Resilient Indigenous Crops: A Sustainable Approach To Improving The Nutritional Quality Of Infant Weaning Food

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Infant malnutrition continues to be a serious public health issue in Pakistan, where about 40% of children under the age of five are suffering from stunting and 17.7% are from wasting due to inadequate nutrition during the weaning stage. Although commercially available weaning foods are nutritionally balanced but they are often unaffordable for low-income households, and they rely on such ingredients that are susceptible to climate-induced supply chain disruptions. In contrast,

indigenous crops are nutritionally rich, climate-resilient, and locally available such as, wheat (*Triticum aestivum*), sorghum (*Sorghum bicolor*) and mung bean (*Vigna radiata*), yet remain underutilized in infant food products. This study aims to develop a low-cost, nutritionally balanced weaning food by utilizing these locally sourced indigenous crops and evaluate its potential to improve infant dietary practices. Composite blends of weaning food will be prepared using different proportion of sorghum, mung bean and wheat flour. When the weaning food will be developed it will be analyzed for proximate composition such as moisture, fat, fiber, protein, carbohydrate, and ash content according to the standard AOAC methods, and for sensory attributes such as taste, color, aroma, texture and overall acceptability using a 9-point hedonic scale in order to identify the most nutritionally balanced formulation. The nutritional profile of the selected weaning food will be compared with Codex Alimentarius standards for complementary foods. It is anticipated that the formulated weaning food will provide enough nutrient and energy content to support infant growth. Sensory evaluation is expected to identify the formulation with acceptable palatability, indicating its potential to be accepted at household level. This research will provide a scientific basis for the development of an affordable and sustainable weaning food by utilizing locally sourced indigenous, climate-resilient crops.

Keywords: Weaning food; Indigenous crops; Climate-resilient; Malnutrition; Pakistan

Anti-Inflammatory Properties of Turmeric (*Curcuma longa*) in CVD Patients

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Cardiovascular diseases rates are still rising on global scale and in Pakistan. These conditions arise when normal structure or function of heart and blood vessels is affected. Chronic inflammation is the key driver of CVDs, treatment exists but they have side effects and expensive. Now there is growing interest in herbal therapies and nutraceuticals as an adjunct therapy. Among them, turmeric is widely known for its inflammation reducing effects. Several studies on active compounds of turmeric exists but limited by bioavailability. Limited studies exist on turmeric in CVD patients. Therefore, this study fills the gap by conducting randomized trial to assess the turmeric's anti-inflammatory effect in CVD patients. The research will have two experiment. In first experiment, the physiochemical and phytochemical potential of turmeric obtained from three different sources will be analyzed and then turmeric with premium quality will be used for clinical trial. In second experiment, randomized trial for 12 weeks will be undertaken. Participants will be randomly allocated into control group (DASH diet +Placebo) and two treatment groups (DASH diet +turmeric supplement). The data of anthropometric and biochemical parameters will be collected at 0 day ,45 days and 90 day and statistically analyzed using one way ANOVA and two factor CRD. It will be expected turmeric will have reduced inflammation and improved CVD outcomes.

Clinical Applications Of Bergamot (Citrus Bergamia) Against Cardiovascular Diseases

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Cardiovascular diseases are still the topmost reason of mortality rate at global level. In Pakistan, the rate of CVDs is elevated due to some risk factors that can modify for instance diabetes, dyslipidemia,

high blood pressure, obesity, and inactive lifestyle. Present pharmaceutical therapies, which include statins and antihypertensives, indeed effective but are often restricted by side effects such as liver improper function, myopathy, and statin intolerance. This has elevated interest in safe substitutes and complementary therapies, particularly nutraceuticals; food-based substances with therapeutic potential. Citrus fruits, especially bergamot (*Citrus bergamia*), aboriginal to Calabria, Italy, is rich in flavonoids (neoeriocitrin, naringin, brutieridin, and melitidin) known for lipid-lowering, antioxidant, and anti-inflammatory properties. Clinical studies have revealed that polyphenolic fraction of bergamot remarkably reduces LDL-C, triglycerides, and inflammatory markers. However, most research focuses on commercial BPF extracts, with limited evidence and investigation on the potential of peel, pulp, and seed fractions. This purpose of this study is to evaluate the phytochemical composition of bergamot fractions & to assess their clinical effectiveness in improving lipid profiles and inflammatory biomarkers in CVD patients in Pakistan. A 12-week randomized trial will be conducted with three groups: Control (DASH diet + placebo), T1 (DASH diet + bergamot 500 mg/day), and T2 (DASH diet + bergamot 1000 mg/day). Outcomes will be measured through anthropometric measures, biochemical parameters, and dietary adherence will be ensured. It is expected that Bergamot supplementation, along with dietary counselling, will notably reduce CVD risk factors, offering a safe, cost-effective, and holistic approach to traditional management strategies.

The Impact Of Administration Of Olive Oil In Diabetic Patients

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Type 2 Diabetes Mellitus (T2DM) is a metabolic illness marked by impaired regulation of blood glucose due to poor insulin production or ineffective insulin utilization. Persistently elevated blood sugar levels are a hallmark of this condition. In Pakistan, the T2DM is escalating at an alarming rate, exerting pressure on healthcare infrastructure and posing challenges for sustained pharmaceutical interventions, particularly among economically disadvantaged populations. This study aims to examine the how Olive oil effects on metabolic and biochemical markers such as FBG, HbA1c, lipid parameters like HDL, LDL, triglycerides, insulin sensitivity assessed via HOMA-IR, and antioxidant status. OO, known for its rich content of monounsaturated fatty acids and polyphenolic compounds, is explored here as a potential therapeutic agent. A 90-day randomized controlled trial will be conduct to involving individuals diagnosed with T2DM. The participants will be given a standard dose of OO to take on a daily basis with clinical examination before and after the intervention period. Analysis will be done using the SPSS software through statistical methods, which include correlation analysis, mean comparison, and testing of significance. The standard protocols will used to validate the nutritional composition of the oil. Research objectives include exploring the use of OOs as a dietary supplement in the management of diabetes; also, to increase the ability to promote culturally appropriate, economically viable, and nutritionally relevant approach to improve glycemic control and overall population health outcomes

Oyster Mushrooms (*Pleurot.Us Ostreatus*): Nutritional Value, Bioactive Compounds, And Health Benefits

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One of the most well-known nutritionally enriched edible fungi having a high functional and therapeutic value is oyster mushrooms (*Pleurotus ostreatus*). This is a critical review of scientific evidence on their nutritional constituents, bioactive compounds, health-promoting effects, safety issues and methods of preservation. *P. ostreatus* is a good alternative source of protein that has high-quality protein (1742 g/100 g dry weight), essential amino acids, dietary fiber and low lipid content. It contains also plenty of vitamins (especially B-complex, C, and D 2), as well as such essential minerals as potassium, iron, magnesium, and zinc. Other than nutritious value, oyster mushroom has significant amounts of bioactive compounds such as β -glucans, phenolic compounds, terpenoids, lectins, ergothioneine, lovastatin, polysaccharides which are used in antioxidant activity, antimicrobial, anticancer, antidiabetic, anti-inflammatory, and hypocholesterolemic properties. The review also addresses food safety concerns such as microbial contamination, buildup of heavy metal, presence of pesticides residues and postharvest issues such as its high moisture content and perishability. Techniques of preservation (modified atmosphere packaging, edible coatings, refrigeration, irradiation, drying) are considered in improving shelf life and quality. *P. ostreatus* is a sustainable and eco-friendly food source because of the capacity to develop on agricultural waste substrates. Its growing use in functional foods and in nutraceutical development emphasizes its possible use in facilitating the health and food security of the population. Nonetheless, additional clinical studies are needed to legitimize therapeutic arguments and streamline large scale production systems.

Keywords: *Pleurotus ostreatus*; oyster mushroom; nutritional value; bioactive; antioxidant; functional food; nutraceuticals; food safety; shelf-life; food systems sustainability.

Storage Stability Assessment Of Apple (*Malus Domestica* L.) In Response To Different Edible Coatings

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Postharvest losses of apple (*Malus domestica* L.) in Pakistan exceed 30%, primarily due to inadequate cold-chain infrastructure and limited adoption of sustainable preservation technologies. This study comparatively evaluated natural biopolymer- based edible coatings for enhancing the storage stability of commercially important cultivar (Golden Delicious). Samples of the apple were collected from sunny bank muree at mature stage and coatings were applied. Protein-based (2% gelatin enriched with 10-30% Aloe vera gel), Carbohydrate–lipid bilayer (2% chitosan combined with 1–5% carnauba wax), and Fomesa wax (100%) coatings were applied by dip treatment and fruits were stored at room temperature with > 75% relative humidity. Quality attributes were monitored fortnightly, including weight loss, firmness, color parameters (L^* , a^* , b^*), total soluble solids, titratable acidity, ethylene estimation, respiration rate, ascorbic acid, total phenolics, flavonoids and radical scavenging activity. Statistical analysis was conducted using one-way ANOVA and a two-factor factorial design in a completely randomized arrangement ($p < 0.05$). All coatings significantly improved storage performance compared to uncoated controls. Gelatin-Aloe vera treatment reduced softening by approximately 30%, delayed enzymatic browning. The chitosan-carnauba wax

effectively minimized respiration rate and weight loss, thereby preserving firmness and soluble solids. Fomesa wax demonstrated enhanced antimicrobial efficacy and retain the weight, firmness and color of the apple without compromising sensory attributes. Coated fruits also retained higher phenolic content and antioxidant activity throughout storage. These findings demonstrate that edible biopolymer coatings provide a cost-effective, environmentally sustainable strategy to reduce postharvest deterioration while maintaining physicochemical and nutraceutical quality of Pakistan's apple cultivars, offering practical potential for large-scale application in resource-limited supply chains.

Keywords: Edible coatings, Postharvest storage, Biopolymer film, Sustainability

Gut Microbiota and Nutrition: Understanding the Diet–Microbiome Connection

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The human gut microbiome is a complex ecosystem housing trillions of microorganisms within the gastrointestinal tract and it plays a significant role in human health and the development of diseases. Advanced genomic sequencing techniques have allowed for an in-depth exploration of the gut microbiome, shedding light on its composition and functions. Of particular interest is the role of diet in shaping the gut microbiome, influencing its diversity, population size, and metabolic functions. Precision nutrition, a personalized approach based on genetic, metabolic and lifestyle factors, has shown promise in directly impacting the composition of the gut microbiome. The human microbiome has emerged as the key moderator between diet and host physiology. It is increasingly recognized that the microbiome influences brain function and behavior and is associated with a wide range of diseases including cancer, cardiometabolic diseases, allergies, and obesity. The etiology of many diseases remains incompletely understood; however, nutrients, microbial metabolites, and gut microbes are increasingly considered key contributors, although the exact underlying mechanisms are still unclear. The composition of the gut microbiota changes across the lifespan and is associated with multiple health parameters, highlighting the importance of diet in shaping microbial balance and host health. This reflects the complex interaction between the gut microbiota and the human host, which is strongly influenced by diet and plays a key role in dietary modulation of health outcomes.

KeyWords: Gut microbiota, Diet precision nutrition, Microbial diversity, Metabolic health, Microbial metabolites, Gut-Brain axis, Cardiometabolic diseases, Dysbiosis, Human Health

Development Of Functional Foods Using Local Pakistani Ingredients For Better Nutrition

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Functional foods play a vital role in improving health and preventing chronic diseases by providing benefits beyond basic nutrition. In developing countries like Pakistan, the use of locally available, cost-effective, and nutrient-dense ingredients offers a sustainable approach to combat malnutrition

and lifestyle-related disorders. This study focuses on the development of functional food products using indigenous Pakistani ingredients such as whole grains, legumes, seeds, herbs, and fruits. Ingredients like barley, millet, chickpeas, flaxseeds, moringa, and traditional herbs possess significant bioactive compounds including dietary fiber, antioxidants, omega-3 fatty acids, and phytochemicals. These components contribute to improved gut health, enhanced immunity, and reduced risk of non-communicable diseases such as diabetes, cardiovascular diseases, and obesity. The research emphasizes formulation techniques, nutritional evaluation, and potential health benefits of these functional foods. Furthermore, it highlights the importance of promoting culturally acceptable and economically feasible dietary solutions to improve public health outcomes. In conclusion, the development of functional foods using local Pakistani ingredients presents an innovative, sustainable, and practical strategy to address nutritional deficiencies and enhance overall health at both community and national levels.

Keywords: Functional foods, Pakistani ingredients, Nutrition, Bioactive compounds, Sustainable diet

Single cell proteins as powerhouse in alternative protein revolution for future of human nutrition and Food Security

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In present ages, the major cause of malnourishment and hidden hunger is population explosion, drastically increasing trend of urbanization and low resources of proteins. Other traditional protein sources such as Chicken, Beef, Mutton, Pork, Fish and crustaceans are in scarce and these somehow lead to ecological issues such as global warming and land usage problems. Following this situation, Single Cell Proteins are derived as novel and feasible alternative to other primary and overconsumed proteinaceous foods. Single Cell Proteins are synthesized from microorganisms such as bacteria, algae, fungi and yeasts that grow by consumption of different types of substrates. These substrates are usually cheaper and easily accessible what may include any food or agricultural residues or waste material. The microorganisms involved in SCP production have a fast growth rate and require specialized or monitored conditions. They produce an optimal ratio of proteins to other components which means that these are capable of providing nourishment to both humans and animals.

This paper narrates the evolutionary synthesis of SCPs from its recognition to current developments. This as whole presents sources, methods of synthesis, food of microorganisms, and techniques employed to get better produce along with the nutritional aspects are discussed.

In short, the only innovative and rewarding proteinaceous source to overcome ongoing protein gaps eventually securing the food minimizing expenses, enhancing satisfaction and acceptability placing it on top positions for a sustainable food system.

Keywords: Alternative protein, single cell protein, mycoprotein, sustainability, food security, microbial protein

Reimagining Food Product Development through Biomimicry, Functional Fortification and the Post-Harvest Paradox: A review Paper on Edible intelligence

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The global food industry holds at a paradoxical juncture – it supplies more than enough calories to nourish every living human but systematically fails to sustain it. For many decades, food product development has been conducted in a atomistic paradigm: extract a nutrient fortify a conveyer, market a claim. This paper completely overturns that archetype. It argues that the next frontier in food innovation happens not merely in the lab walls but rather where biomimicry, intelligent post-harvest engineering, and metabolic foresight meet to create food's communicative property, which turns every meal into a biological dialogue instead of passive sustenance. If the dialogue is broken, the calories are useless. Drawing an emergent research in food system design this abstract persuades that nature is the most sophisticated food technologist in existence. We just add vitamins to processed goods. First we should use biomimicry to copy nature's proven survival strategies, post-harvest physiology to turn waste into "smart data". Furthermore, biomimicked functional food development will offer radical template for physical appearance, controlled bioavailability, and ambient stability without synthetic intervention. Synchronously, as an untapped data traceability rather than logistical failures losses of post-harvest, which are counts for nearly one third of world food production are reframed here_ metabolic signals from fresh yields communicating abiotic stress, respiration, and cellular degradation that, if decoded sagaciously, could essentially reshape preservation and packaging design. Moreover this paper interrogates the flawed linearity of current nutraceuticals food developments, where fortification is applied without regard for delivery ecosystem, food synergies or consumer metabolic diversity.. The future of food product development demands a shift from ingredient-centric to systemcentric thinking -designing food architectures that respond to the human body, moving beyond sustenance. The conclusion proposed here are not matter of theoretical conjecture; they are an urgent evidence-grounded call for interdisciplinary convergence__ where food scientists, ecologists, data engineers, and nutritionists co-author the next chapter of what it means to eat intelligently on a stressed planet.

KEYWORDS: Biomimicry, Functional food development, Post - harvest physiology, Bioavailability, Food system design, Sustainable innovation

Climate Resilient And Sustainable Food Production By The Use Of Microbial Fermentation

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Every now and then food insecurity is a burning issue across the globe and the driving factors behind it is climate change which tremendously effect global food production systems by decreasing crop yields, spiking environmental stress, and threatening nutritional security. Therefore the development of resilient food systems potent enough to meet growing population food demands is required, by bringing sustainable and innovative approaches to life. Among the bio-innovation solutions Microbial fermentation has emerged as a promising solution that can substantially minimize environmental impacts thus contributing to sustainable food production. Raw agricultural materials can be transformed into nutrient-rich and shelf-stable food products through the use of microorganisms that include bacteria, yeast, and fungi. Through fermentation not only the

nutritional quality and digestibility of foods can be enhanced but it can result in increased production of bioactive compounds, vitamins, and natural preservatives. Reliance on energy intensive food processing methods can be reduced by utilizing fermentation technologies and getting best out of locally available agricultural resources which in return can minimize wastes and can aid to global sustainability goals. In addition to it fermentation based food systems support circular bioeconomy principles through the conversion of low value substrates into high value nutritional products. Recent advancements include the use of biotechnology and microbial science that have potential for developing novel functional foods and alternative protein sources. Adopting microbial fermentation technologies can act as a sustainable and climate resilient solution for improving food security and nutritional quality. The problem of climate change can be tackled through the integration of traditional fermentation knowledge with modern biotechnological innovations that play a critical role in building a sustainable and resilient food system.

Keywords: Microbial fermentation, Sustainable food production, Climate resilience, Circular bioeconomy, Functional foods.

Impact Of Climate Change On Food Security And Nutritional Quality

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Climate change is one of the most serious threats to food security and human nutrition. Food security is not just a matter of deal, but it is cornerstone of health and well-being for individuals and communities. Food security deal with the four pillars of food; that is its availability, access utilization and stability to every individual present in a community. Change in climate severely damages not just the quantity of food but also it lowers the quality. High levels of CO₂ reduces the level of micronutrients such as zinc, calcium iron and protein in staple foods such as rice, wheat and maize. Different environmental factors such as change in extreme weather, ecosystem effects and environmental degradation effects agricultural and food processing levels which lead to altered food choices through changes in prices and availability, and low-carbon diet choice. This condition results in high incidence of infectious and non-infectious diseases. With change in climate condition, the production of food will be placed in altered ecosystems, which altered agricultural condition. Condition can be further alleviated by food industry by applying the procedure of processing, preserving, packaging and manufacturing. Organization such as Food and Agriculture Organization (FAO) and World Health Organization (WHO) are playing essential roles in transforming the policies. They provide policy guidance, technical support, funding, research and emergency assistance to strengthen global and national food systems.

KEYWORDS: Food security, Micronutrients, Environmental factor, Ecosystem, Processing, Preserving, Packaging, Manufacturing.

Food systems play a central role in sustaining human life by supporting food security, nutritional well-being, livelihoods, and economic growth. However, increasing population demands, climate variability, environmental deterioration, and inefficient use of natural resources have exerted substantial stress on traditional food production and distribution systems. Climatic factors such as rising global temperatures, declining freshwater availability, soil quality degradation, and the increasing occurrence of extreme weather conditions are severely constraining agricultural output and food supply. These growing pressures emphasize the urgent necessity to redesign current food systems into more sustainable, adaptive, and resilient frameworks. This abstract addresses the concept of transforming food systems, focusing on the transition from conventional methods toward climate-resilient and sustainability-oriented strategies. Major components of this transformation include the promotion of environmentally responsible agricultural practices, incorporation of biological innovations, advancement in food processing and storage technologies, reinforcement of supply chain efficiency, and the reduction of post-harvest losses and food waste. The application of emerging technologies such as biotechnology, precision farming, and eco-friendly processing solutions can enhance productivity while reducing environmental footprints. Additionally, restructured food systems contribute significantly to improving diet quality, safeguarding food safety, and increasing access to nutritious and affordable food options. The success of food system transformation largely depends on strong policy frameworks, institutional capacity building, and the collaborative involvement of key stakeholders, including producers, scientists, industry professionals, policymakers, and consumers. An inclusive and systems-based approach is essential to ensure coherence with the Sustainable Development Goals (SDGs). Ultimately, transforming food systems is a vital strategy for strengthening climate resilience, securing long-term food availability, and fostering sustainable development in an increasingly complex global landscape.

KeyWords: Food system transformation; Climate-smart agriculture; Sustainable food systems; Climate change adaptation; Food security; Sustainable development

Association Between Ultra-Processed Food Intake and Metabolic Risk Factors Among University Students: A Review of Emerging Evidence

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Background: The shift in young adults' eating habits has emerged as a significant global public health issue. Due to academic pressure, erratic schedules, limited financial resources, convenience-driven food choices, and greater exposure to heavily promoted processed food products, university students are especially susceptible to bad eating habits. According to the NOVA food classification system, ultra-processed foods (UPFs) are industrially produced formulations that contain little to no whole food ingredients and are frequently enhanced with additives like artificial flavorings, colorants, emulsifiers, preservatives, and excessive amounts of refined sugars, sodium, and unhealthy fats. Poor nutritional quality and several detrimental metabolic consequences have been connected to the rising UPF consumption among university populations. These foods contribute to excessive

calorie intake and disruptions in metabolic balance because they are high in calories but low in nutrients. According to recent research, even in younger people, regular UPF intake may raise the risk of obesity, insulin resistance, dyslipidemia, hypertension, systemic inflammation, and other early indicators of metabolic syndrome.

Objective: With an emphasis on obesity, insulin resistance, dyslipidemia, and early markers of metabolic syndrome, this review assesses the relationship between university students' consumption of ultra-processed foods and metabolic risk factors.

Methods: Using databases including PubMed, Google Scholar, and ScienceDirect, a narrative assessment of peer-reviewed literature published between 2021 and 2026 was carried out. Included were studies that looked at eating habits and metabolic health effects in populations of university age.

Outcomes: High UPF intake is significantly positively correlated with increased body mass index, abdominal obesity, poor glucose metabolism, raised lipid levels, and decreased overall nutritional quality, according to the reviewed data. Sedentary behavior, irregular eating habits, and elevated metabolic risk have all been repeatedly associated with frequent consumption of fast food, sugar-sweetened beverages, packaged snacks, and rapid meals. Academic stress and inadequate nutritional knowledge were also found to be relevant causes.

In conclusion: University students' metabolic risk is greatly increased by their overindulgence in ultra-processed foods. To lower the burden of non-communicable diseases in the future, awareness-based interventions, healthier campus food settings, and early nutrition education are crucial. Encouraging better eating habits in early adulthood may enhance long-term metabolic health outcomes.

Keywords: Ultra-processed foods, metabolic syndrome, university students, obesity, dietary behavior, nutrition transition

Green Processing Of Oat Dietary Fiber: A Bio-Innovation For Sustainable And Climate-Smart Food Systems

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Oats (*Avena sativa* L.) are a climate-resilient cereal crop known for their high dietary fiber content, notably β -glucan, which helps with glycemic control, cholesterol management, and gut health. However, traditional processing methods can degrade dietary fiber's structural integrity and functional quality, which limits its use in advanced food compositions. This study explores a green processing technique for extracting, characterizing, and stabilizing oat dietary fiber with the objective of developing a functional ingredient suited for sustainable and climate-smart food systems. Oat biomass is processed utilizing enzyme assisted and low aqueous extraction procedures that aim to limit chemical use while keeping the original structure of dietary fiber components. The extracted material is subsequently assessed for its physicochemical and functional features, such as composition, hydration behavior, and possible application in food systems. The fiber is further developed into a functional powdered ingredient using carrier assisted formulation processes to improve handling properties and storage stability. The study follows a two phase experimental approach, with the first phase focusing on the green extraction and characterization of oat dietary

fiber and the second phase developing and stabilizing the formulation into an application ready form. This method preserves the functional and nutritional value of the extracted fiber while emphasizing eco-friendly processing. The findings show a viable and scalable approach for transforming oats into high value functional ingredients, as well as the potential of green processing technologies to encourage sustainable nutrition and climate-smart food system growth. Overall, the study enables to support bio-based solutions for better food security and nutritious product development.

Keywords: Oats; Dietary fiber; Structural characterization; FTIR; SEM; Particle size; Functional foods.

Physicochemical And Nutraceutical Evaluation Of Apple (*Malus Domestica*) Cultivars

Zonia Ahmed

Fresh fruits play a vital role in rich source of essential nutrients and bioactive compounds that contribute to health. Apples (*Malus domestica*), belonging to the Rosaceae family, hold a prominent position in global fruit production. Apples (*Malus domestica*) are prized for their many bioactive ingredients and high nutritional content. This research highlights the possible health advantages of different apple cultivars by examining their physicochemical traits, nutraceutical qualities. It examines their bioactive ingredients, such as flavonoids, triterpenoids, and phenolic compounds, as well as their nutritional profile, which includes vitamins, minerals, and dietary fiber. A critical analysis is conducted of recent developments in omics-based technologies, apple cultivar genetic improvement, and the creation of value-added apple-based goods. Murree and its surrounding areas are well known for apple cultivation; however, the true potential of locally grown apple cultivars remains largely untapped. Moreover, due to their climacteric nature, apples are highly susceptible to postharvest losses, leading to significant economic setbacks. Addressing these challenges, the present study is designed to comprehensively explore the physicochemical and nutraceutical characterization of various apple cultivars such as Red Delicious, Golden Delicious, Gala Must, Royal Gala, Jona Gold, Summer Red, Sky Spur, Red Chief, Nugget, Star King Delicious, and Mondial Gala. The Richard cultivar had the highest flavonoid dominance, but the Montuan, Golden Delicious, and Cretesc cultivars had the highest phenolic acid levels. Richard and Montuan cultivars had higher levels of ursolic acid, which ranged from 55 to 436 mg/g apple extract, and oleanolic acid, which ranged from 11 to 83 mg/g apple extract. Principal component analysis (PCA) and hierarchical cluster analysis (HCA) could be used to differentiate between apple cultivars based on the amount of polyphenolic and triterpene acids present.

Keywords: Apple, *Malus Domestica*, Physicochemical properties, Nutraceutical evaluation, Bioactive compounds, Antioxidants

An Advanced Face Aging And Recognition System For Missing Persons Identification Using Diffusion Models And Vision Transformers

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The identification of missing persons is a critical humanitarian challenge requiring rapid, accurate, and scalable solutions. A major obstacle is the temporal appearance gap between archival photographs and a person's current appearance after years of aging, hardship, or displacement. This research develops an ethically grounded face aging and recognition framework combining identity-

preserving aging synthesis with CNN- and transformer-based recognition. The framework was implemented using four benchmark datasets, namely CACD, FG-NET, AgeDB, and MORPH Album 2, with 222,420 images initially loaded and a filtered practical dataset of 10,062 images selected for training and evaluation. A ResNet-50 baseline achieved 80.76% classification accuracy and TAR@FAR=0.001 of 0.9074, while the Swin Transformer achieved 54.48% accuracy under the same filtered-data setting. Although the transformer model did not outperform the CNN baseline, aging synthesis increased the average maximum cosine similarity from 0.5904 to 0.6932, indicating improved feature alignment between aged and probe representations. The Identity-Preserving Diffusion Model achieved strong biometric preservation with identity similarity of 0.9988 and Age MAE of 9.70 years. The updated practical implementation further introduced a Residual Aging Generator, which achieved identity similarity of 0.9949 and reduced Age MAE to 2.64 years, and a physical aging engine whose evaluation showed increasing pixel difference and decreasing SSIM/PSNR as target age increased. Fairness analysis revealed performance disparities across age groups, gender groups, and dataset sources, emphasizing the need for balanced data and continuous bias monitoring. The proposed framework is therefore positioned as an assistive, human-in-the-loop tool rather than a fully automated identification system.

Ethnobotanical Survey Of Village Tarki Khel, District Karak And Phytocheical Evaluvation Of Onosa Arenaria

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Background: The semi-arid region of Karak District possesses diverse medicinal flora that plays an important role in the traditional healthcare system of local communities. Among these plants, *Onosma arenaria* is traditionally used for various ailments, yet its phytochemical composition and antioxidant potential remain insufficiently explored. This study aimed to document ethnobotanical knowledge and evaluate the phytochemical constituents and antioxidant activity of *O. arenaria* collected from Village Tarki Khel, District Karak.

Methodology: An ethnobotanical survey was conducted through field visits and interviews with local informants in Village Tarki Khel. A total of 58 plant species belonging to 34 families were documented for their traditional medicinal uses, particularly for gastrointestinal, respiratory, dermatological, and febrile disorders. Fresh leaves of *O. arenaria* were collected, taxonomically identified, and voucher specimens were deposited in the herbarium of Kohat University of Science and Technology. Methanolic leaf extract was prepared using the maceration method and analyzed for phytochemical constituents and GC–MS profiling at the University of Peshawar. Vitamin C content was determined using the DCPIP method, while antioxidant activity was evaluated using the DPPH free radical scavenging assay.

Results: Phytochemical screening confirmed the presence of flavonoids, phenolics, alkaloids, tannins, glycosides, and saponins, indicating a rich bioactive profile. Vitamin C estimation showed an ascorbic acid content of 7.84 ± 0.42 mg/g dry weight. Antioxidant analysis demonstrated strong free radical scavenging activity, with a maximum inhibition of 71.36% at 1000 µg/mL and an IC₅₀ value of 412 µg/mL, reflecting moderate antioxidant potency.

Conclusions: The study provides the first ethnobotanical and phytochemical evidence of *O. arenaria* from the Karak region. The findings highlight its potential as a natural antioxidant source, supporting

its ethnomedicinal importance and encouraging further pharmacological and bioactive compound investigations

Keywords: *Onosma arenaria*, Ethnobotany, Phytochemical screening, Antioxidant activity

Ethnobotanical Survey Of *Nari Panos* (District Karak) And Evaluation Of Saponifications Characteristics Of *Anabasis Setifera*

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Background: The semi-arid district of Karak in Khyber Pakhtunkhwa, Pakistan possesses a rich xerophytic flora that contributes significantly to the livelihood and traditional healthcare practices of local communities. Among the indigenous plants, *Anabasis setifera* is traditionally used as a natural cleansing agent. The present study aimed to document the ethnobotanical knowledge of Naripanos (District Karak) and to evaluate the phytochemical, antimicrobial, and antioxidant potential of *A. setifera* for herbal soap formulation.

Methodology: An ethnobotanical survey was conducted through field visits and interviews with local inhabitants to document plant species used for medicinal, fodder, and domestic purposes. Aerial parts of *A. setifera* were collected, shade-dried, powdered, and extracted using methanol followed by solvent fractionation. Preliminary phytochemical screening was performed to identify major bioactive constituents. A glycerine-based herbal soap was formulated using varying concentrations of plant extracts and evaluated for organoleptic and physicochemical parameters, including color, odor, texture, pH, foam height, foam stability, moisture content, alcohol-insoluble matter, and total fatty matter. Antimicrobial activity was assessed against selected microbial strains, while antioxidant potential was determined using the DPPH assay.

Results: The survey documented several plant species utilized by local communities. Phytochemical screening revealed the presence of saponins, flavonoids, phenolics, and alkaloids in the extracts. The formulated herbal soap exhibited a brown color, pleasant odor, smooth texture, and skin-compatible pH. Physicochemical evaluation indicated satisfactory foam properties, acceptable moisture content, low alcohol-insoluble matter, and moderate total fatty matter. Antimicrobial tests showed measurable inhibition zones against selected microorganisms, and antioxidant analysis demonstrated notable concentration-dependent free radical scavenging activity.

Conclusions: The findings validate the traditional use of *Anabasis setifera* as a natural cleansing agent and highlight its potential as a sustainable bioresource for herbal soap development and eco-friendly cosmetic applications. Further studies on toxicity, formulation optimization, and large-scale antimicrobial evaluation are recommended.

Keywords: *Anabasis setifera*, Ethnobotany, Herbal soap formulation, Phytochemical screening

Ethnobotanical Study Of Village Kemanri Banda District Karak And Phytochemical, Antifungal And Insecticidal Activities Of *Ajuga Integrifolia*

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Background: Ethnobotanical knowledge plays an important role in identifying medicinal plants with potential therapeutic and pharmacological properties. District Karak, Khyber Pakhtunkhwa, Pakistan, possesses rich floral diversity; however, many medicinal plants used by local communities lack proper scientific validation. Among these, *Ajuga integrifolia* is traditionally used to treat fever, stomach disorders, hypertension, and inflammatory conditions. Therefore, the present study aimed to document the ethnobotanical knowledge of Village Kemanri Banda and to evaluate the phytochemical, antifungal, and insecticidal potential of *A. integrifolia*.

Methodology: An ethnobotanical survey was conducted through seasonal field visits using standard data collection methods, including interviews and questionnaires with local informants. A total of 45 medicinal plant species belonging to 28 families were documented from the study area. Methanolic extract of *A. integrifolia* was prepared and subjected to preliminary phytochemical screening to identify major secondary metabolites. Gas Chromatography–Mass Spectrometry (GC–MS) analysis was performed to detect specific bioactive constituents. Antifungal activity was evaluated at different concentrations of the extract (7.5–15 mg/mL), while insecticidal activity was assessed through mortality bioassays at varying concentrations.

Results: Phytochemical screening revealed the presence of alkaloids, flavonoids, tannins, saponins, glycosides, terpenoids, and phenolic compounds. GC–MS analysis confirmed several bioactive constituents associated with antimicrobial and insecticidal properties. Antifungal assays showed concentration-dependent inhibition of fungal growth, with the highest inhibition (70%) observed at 15 mg/mL, while the standard drug (DOX) showed 85% inhibition. Insecticidal assays demonstrated 75% mortality at 15 mg/mL after 48 hours, whereas lower concentrations showed reduced mortality.

Conclusion: The study confirmed that *A. integrifolia* possesses significant phytochemical richness and notable antifungal and insecticidal activities, supporting its traditional medicinal uses and suggesting its potential as a natural source of eco-friendly bioactive agents.

Keywords: Ethnobotany, *Ajuga integrifolia*, Phytochemical analysis, Antifungal and insecticidal Activity

Evaluation Of The Nlrp3 Inflammasome Inhibitory Potential Of Aloe Vera Gel Extract In Stz-Induced Type 1 Diabetic Balb/C Mice

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Type 1 Diabetes Mellitus (T1DM) is an intricate autoimmune metabolic disorder characterized by the selective destruction of pancreatic beta-cells, leading to an absolute insulin deficiency and a pervasive systemic inflammatory milieu. Central to the disease molecular progression is the NLRP3 inflammasome, a multiprotein complex whose aberrant activation orchestrates the maturation of pro-inflammatory cytokines, thereby exacerbating both pancreatic injury and secondary neuro-inflammatory complications. This study evaluates the therapeutic efficacy of a locally sourced Aloe vera gel extract in a Streptozotocin (STZ)-induced T1DM model. Male BALB/c mice were induced with a single intraperitoneal dose of STZ (90 mg/kg), and the diabetic state was confirmed via a persistent fasting blood glucose level exceeding 150 mg/dL. Physiological data indicated that oral intervention with Aloe vera extract (200 mg/kg/day) effectively stabilized post-prandial glucose levels and supported resilient body weight gain over a 14-day intervention period. Conversely, the Metformin-treated group (200 mg/kg/day) exhibited potent glucose reduction but suffered from significant

cachectic mass loss, requiring treatment cessation at day 8. Intraperitoneal Glucose Tolerance Test (IPGTT) results at day 14 confirmed superior metabolic homeostasis in the Aloe vera cohort. Phytochemical fingerprinting via GC-MS (ATR-4462) identified 3,5-Dihydroxy-6-methyl-2,3-dihydro-4H-pyran-4-one (31.49%) and L-(+)-Lactic acid (29.73%) as primary bioactives. Current investigations are focused on quantifying the protein expression of the TLR4/NF- κ B/NLRP3 signaling axis via Western blotting, alongside the spectrophotometric assessment of oxidative stress biomarkers (SOD, CAT, and MDA) in pancreatic and brain tissues. These findings highlight the potential of standardized botanical extracts as more stable therapeutic alternatives to synthetic agents in modulating the neuro-pancreatic axis during autoimmune metabolic stress.

Keywords: Aloe vera, NLRP3 Inflammasome, Type 1 Diabetes, Neuro-inflammation, GC-MS Profiling, Metabolic Homeostasis.

In Silico Drug Design and Molecular Modeling-Based Identification of Novel Inhibitors Targeting HIF-1 α to Overcome Radiation Therapy Resistance in Solid Tumor

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Radiation therapy (RT) remains one of the most widely employed treatment modalities for solid tumors; however, therapeutic resistance driven by intratumoral hypoxia constitutes a formidable clinical barrier. Hypoxia-inducible factor-1 α (HIF-1 α), a master transcriptional regulator activated under low-oxygen conditions, orchestrates a cascade of pro-survival programs including angiogenesis, metabolic reprogramming, DNA repair enhancement, and anti-apoptotic signaling, collectively rendering tumor cells refractory to ionizing radiation. Consequently, HIF-1 α has emerged as a compelling and validated molecular target for sensitizing solid tumors to radiotherapy. The advent of computer-aided drug design (CADD) and molecular modeling has revolutionized the drug discovery pipeline, enabling rapid, cost-effective identification of novel chemical entities against validated oncology targets. This review comprehensively discusses: (i) the structural biology and regulatory mechanisms of HIF-1 α ; (ii) molecular mechanisms by which HIF-1 α promotes radioresistance; (iii) key druggable binding sites on HIF-1 α and associated proteins; (iv) state-of-the-art in silico methodologies including homology modeling, molecular docking, virtual screening, quantitative structure-activity relationships (QSAR), machine learning-based screening, and molecular dynamics (MD) simulations; and (v) ADMET profiling frameworks for lead optimization. We also survey current HIF-1 α inhibitor candidates from preclinical and clinical investigations, highlight challenges, and propose a rational in silico workflow for the discovery of next-generation radiosensitizing inhibitors. Together, this review serves as a roadmap for medicinal chemists and computational biologists aiming to harness the power of molecular modeling in the fight against radiation-resistant solid tumors.

Evaluation of the Antimicrobial activity of the *Cotoneaster nummularius* fruit extract against selected bacterial strains.

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The expanding occurrence of antimicrobial resistance amongst disease causing bacteria has made a sudden need for the discovery of novel and effective antimicrobial agents, particularly from natural

sources. This research was aimed to evaluate the antimicrobial potential of *Cotoneaster nummularius* fruit extract against selected bacterial species. The fruit was made using a suitable solvent extraction procedure and tested against gram-positive bacteria (*Staphylococcus aureus*, *Streptococcus pyogenes*) and gram-negative bacteria (*Pseudomonas aeruginosa*, *Klebsiella pneumonia*). The antimicrobial activity was evaluated using standard microbiological techniques such as agar well diffusion method and determination of minimum inhibitory concentration through microdilution methods. The results showed that the *Cotoneaster nummularius* fruit extract have significant inhibitory effects against all bacterial strains. The extract showed high activity against gram-positive bacteria and activity against gram negative bacteria was also significant. The findings suggest that *cotoneaster nummularius* fruit extract contains bioactive compounds which exhibit potent antimicrobial activities and it can be used as an alternative to treat bacterial infections.

Keywords: *Cotoneaster nummularius*, Antimicrobial resistance, plant extract, MIC, Agar well diffusion, phytochemicals, Bacterial pathogens.

Development Of A Molecular Diagnostic Assay For The Detection Of Crimean-Congo Hemorrhagic Fever Virus

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Objective: Pakistan, being a resource-limited country heavily impacted by climate change, faces an increased risk of emerging viral infections. Crimean-Congo Hemorrhagic Fever Virus (CCHFV) poses a serious public health threat due to its high fatality rate and the lack of rapid, affordable diagnostic methods. Current molecular assays such as RT-PCR are expensive and require advanced laboratory infrastructure. This study aims to develop a rapid and cost-effective point-of-care molecular diagnostic assay for the detection of CCHFV that can be implemented in resource-limited settings.

Methods: The proposed diagnostic assay combines Reverse Transcription Loop-Mediated Isothermal Amplification (RT-LAMP) technique with gold nanoparticle (AuNP)-based colorimetric detection. Specific RT-LAMP primers will be designed against a conserved region of the CCHFV genome. Nucleic acid amplification will be carried out using a commercially available LAMP kit and the resulting LAMP products will be mixed with citrate-stabilized gold nanoparticles to produce a visually interpretable colorimetric signal. In CCHFV positive samples, the amplified DNA binds to the nanoparticles, providing stability and preventing their aggregation, therefore maintaining red color of the solution. CCHFV negative samples, lacking target DNA, will fail to stabilize the nanoparticles, resulting in aggregation and a greyish-purple color change.

Expected Outcomes: The developed RT-LAMP–AuNP assay is expected to provide a simple, rapid, and highly specific method for detecting CCHFV without the need for sophisticated instruments. The colorimetric detection will allow direct visual interpretation, facilitating point-of-care diagnosis and large-scale screening in endemic areas.

This assays will facilitate early and economical disease diagnosis, and effective disease management in Pakistan. Additionally, this approach will support the surveillance of CCHFV across humans, animals, and the environment, contributing to a more integrated understanding of disease dynamics

Keywords: Crimean-Congo Hemorrhagic Fever Virus (CCHFV), Nanotechnology, Molecular diagnostics, Infectious disease, Point-of-care testing

Computational Discovery of Single and Multi-Target HIV-1 Inhibitors Derived from Natural Products

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The Search for novel anti-HIV medications continuous to drive the exploration of diverse chemical space. Current study employs an integrated *in silico* approach to screen plant-derived compounds for their potential to inhibit both single and multi-target inhibition of five crucial HIV-1 proteins: gp120, gp41, Integrase, Reverse transcriptase (RT), and Protease. Lipinski RO5 was employed to identify drug like compounds, resulting in 412 compounds. Ten top-scoring ligands were prioritized for each of the five HIV-1 targets based on negative free energy, binding interactions and pose stability. This analysis suggests high potential hits: 30 compounds exhibit target specific interactions, with docking score ranging from approximately -10.2 to -7.0 kcal/mol. Notably, 14 common compounds demonstrated broad inhibitory potential across multiple proteins, displaying docking scores ranges from -9.0 to -8.5 kcal/mol. MD simulations analysis was performed to assess binding stability and protein conformational dynamics for each HIV-1 protein. The MD trajectories indicated stable protein ligand complexes, with restrained RMSD/RMSF and consistent radius of gyration (Rg) across representative complexes. First principal's calculations were carried out to calculate HOMO, LUMO and HOMO–LUMO gaps for each selected compound which shows consistent results with docking findings. These finalized compounds were then selected for testing in-vitro inhibitory potential, specifically against HIV-1 protease enzyme.

Investigating The Health Risk Of Contaminated Water Bodies In Rural Settings: A One Health Approach

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Contaminated water poses a significant public health and environmental challenge in rural and mountainous regions where communities rely on natural and piped sources. This study examines microbiological contamination and associated health risks in Murree, Pakistan, focusing on the localities of Azizabad and Karnah. Adopting a One Health approach, the research links water quality across different sources with potential implications for human health. Water samples from springs, pipelines, and bore sources are being collected over a three-month period (April–June), with sampling conducted twice monthly. Preliminary analysis of five spring water samples using the Most Probable Number (MPN) method revealed substantial microbial contamination, indicating potential health risks for communities using untreated water for various purposes. Further investigations will include physico-chemical characterization, heavy metal analysis, and microbial isolation through plate count techniques. Bacterial isolates will be identified using morphological and biochemical

methods. Comparative evaluation of different water sources will explore variations in water quality and reasons behind community preferences for certain sources. The study aims to provide actionable insights into the safety of water sources in Murree, supporting evidence-based recommendations for improving water quality and mitigating health risks. By integrating environmental monitoring with public health perspectives, the research highlights the importance of a One Health framework in addressing water-related health challenges.

Beyond the Barrier: Biodegradable Microneedles as a Precision Chemotherapy Delivery Platform for Glioblastoma

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Glioblastoma remains one of the largest challenges in the field of oncology with a median survival of merely **12-15 months** despite the use of aggressive multimodal treatment. The blood-brain barrier is a fatal to systemic chemotherapy as it results in severe systemic toxicity and inadequate drug levels in the tumour site. This is a failure in delivery and not merely a failure in treatment. We present an innovative biodegradable polymeric microneedle system to deliver chemotherapeutic agents to the tumour site in a local and sustainable way and that too without involving the blood-brain barrier. Physicochemical characterisation with morphological analysis, mechanical testing and in vitro release profiling will be done upon the manufacture of the microneedles and fine tuning of the mechanical strength and drug encapsulation efficiency. The therapeutic efficacy will be determined using the aggressive **GBM cell lines** which are **U251** and **U87** by measuring cytotoxicity, apoptosis, and anti-migratory activity against the free drug. Ex vivo penetration will be used to validate tissue insertion effectiveness and controlled release behaviour. Compared with conventional chemotherapy, this platform is expected to have a high cytotoxic efficacy, prolonged systemic drug release, and reduced systemic toxicity by many folds. This microneedle technology is an innovative technology with a potential of making a real difference in the survival of glioblastoma patients by combining polymer science with neuro-oncolog.

Organic soil inputs sustained C and N metabolism of Peanut under Nitrogen and water co-limitation

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Drought and nitrogen (N) limitation are major constraints to peanut (*Arachis hypogaea* L.) productivity, profoundly influencing plant metabolism and growth. This study investigated the interactive effects of drought stress and reduced nitrogen supply on peanut physiology and metabolism, and the mitigating potential of organic amendments. Plants were subjected to individual and combined drought and N-limiting conditions, with or without organic amendments, and evaluated for physiological performance and metabolic regulation. Despite severe stress treatments, organically amended plants experienced only mild water deficit, indicating improved soil

water retention and stress buffering capacity. Metabolomic profiling revealed distinct reprogramming of carbon (C) and nitrogen (N) metabolism in response to stress and amendment treatments. Enhanced accumulation of osmoprotectants, amino acids, and organic acids suggested an adaptive shift in metabolic fluxes toward maintaining C–N balance and energy homeostasis. Organic amendments improved N assimilation and secondary metabolite synthesis, reflecting an integrated defense mechanism against combined abiotic stresses. Overall, the results demonstrate that organic amendments not only alleviate drought and nitrogen limitations but also stabilize metabolic networks that sustain physiological resilience in peanut plants. This study provides novel insights into the metabolic plasticity of peanut under resource stress and highlights the potential of organic amendments as sustainable management tools for improving crop performance under fluctuating environmental conditions.

Evaluation and Development of mRNA vaccine for Glioblastoma

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Objectives: Computational design and prediction of a multi-epitope mRNA construct targeting neo-antigens specific to glioblastoma Formulation and characterization of Metal Organic Nanoparticles for effective delivery of mRNA vaccines targeting brain cancer cells.

In vitro Screening of the anticancer effectiveness of the multi-epitope mRNA vaccine against glioblastoma.

Methodology: This study aims to design and evaluate a novel mRNA-based vaccine targeting glioblastoma-specific and tumor-associated antigens, using Metal–Organic Nanoparticles (MONs) as an efficient delivery platform. During *in silico* phase, potential glioblastoma antigens were identified using integrated bioinformatics tools, followed by prediction of antigenic epitopes using immunoinformatics tools. Selected epitopes were determined for immunogenicity, antigenicity, allergenicity and toxicity. The optimized mRNA construct was designed. Molecular docking and dynamics simulations were performed to evaluate the binding affinity and stability of predicted epitopes with HLA alleles. MON will be synthesized for the efficient delivery of mRNA and characterized for size and encapsulation efficiency. *In vitro* and *in vivo* experiments will focus on testing the formulated vaccine in U87 and U251 glioma cell lines to assess antigen expression, dendritic cell maturation, and cytotoxic T lymphocyte activation. Expected Outcomes: It is expected that the proposed mRNA vaccine will effectively encode and express chosen glioblastoma-associated antigens, resulting in robust immune activation upon experimental testing. The Metal–Organic Nanoparticle (MON) formulation is expected to stabilize the mRNA, facilitate cellular uptake, and ensure efficient antigen presentation by dendritic cells. As a result, an enhanced cytotoxic T lymphocyte (CTL) response against glioblastoma cells (U87 and U251) is expected, inhibiting tumor proliferation and inducing targeted immune-mediated cell death.

KeyWords: Glioblastoma, mRNA vaccine, Metal–Organic Nanoparticles (MONs), Immunoinformatics, Cancer immunotherapy

Development of a Plant-Based Edible Vaccine Against HIV: A Multiepitope Approach

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The human immunodeficiency virus (HIV) continues to be a major global public health concern, and there is an urgent need for safe, accessible, and cost-effective immunization methods. Traditional vaccine platforms pose significant challenges in resource-limited situations, including their reliance on cold storage, high production cost, and the need for injection-based administration. Plant-based edible vaccines provide a better alternative by producing thermostable, orally delivered, and cost-effective antigens using transgenic crops. The current study offers a rational design, in silico validation, and experimental development of a multiepitope plant-expressed subunit vaccine candidate against HIV using tobacco as the expression host. Immunoinformatic tools, based on percentile rank thresholds, antigenicity scores, toxicity and allergenicity, are employed to identify and shortlisting the high-affinity cytotoxic T lymphocyte (CTL/MHC-I), helper T lymphocyte (HTL/MHC-II), and B-cell epitopes from conserved HIV antigenic regions. The selected epitopes are combined using chosen peptide liners into a multi-epitope construct while maintaining their immunogenic structure. To increase its immunogenicity, the Cholera Toxin B component (CTB) is added to the design as a mucosal adjuvant. The three-dimensional structure of the vaccine protein has been predicted using 3D structure prediction tools, which was further refined and assessed for the quality through C-score, TM-score, RMSD, and ERRAT analysis. Molecular docking involving key immunological receptors aims to reveal the binding affinity and interaction profiles of the target candidate. Before being inserted into a binary vector system, the confirmed coding sequence was subjected to plant specific codon optimization tailored. *Nicotiana benthamiana* plants will be used to transform through Agrobacterium mediated plant transformation. PCR will be employed to assess possible transgenic lines, while western blotting will verify recombinant protein expression. Antibody detection assays are designed to assess the humoral immune response triggered by an injection and will be used to determine the immunological effectiveness of the plant-expressed vaccine candidate. This study shows a comprehensive and integrated process that connects computational vaccine design, structural bioinformatics, molecular cloning, plant biotechnology, and immunological validation. The proposed candidate can serve as a scalable, needle-free, and field-deployable HIV vaccine platform, significantly increasing global efforts to offer accessible immunization against HIV.

Keywords: HIV vaccine; multiepitope design; plant-based vaccine; edible vaccine; immunoinformatics; Agrobacterium-mediated transformation; *Nicotiana benthamiana*; CTB adjuvant; molecular cloning

Hemolytic Activity Of Epidermal Mucus Of Catfish (*Clarias Batrachus*) And Rohu (*Labeo Rohita*) On Mammalian Rbcs

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Epidermal mucus in teleost fish serves as a critical interface of innate immunity, containing bioactive molecules that can disrupt microbial membranes. Despite its recognized importance, qualitative comparison of membrane-disruptive activity across economically and ecologically relevant freshwater species remains limited. This study evaluates and compares the hemolytic potential of epidermal mucus of *Clarias batrachus* and *Labeo rohita*, two widely cultured South Asian species, using mammalian erythrocytes as a proxy model for membrane lysis. Mucus samples were obtained from three individuals per species and processed to obtain cell-free supernatant. Hemolytic activity was quantified by incubating the sample with a 2% goat erythrocyte suspension and measuring the release of hemoglobin at 540 nm. Assays were conducted in triplicate, with distilled water and saline serving as positive and negative controls, respectively. Both species exhibited substantial hemolytic activity, with *C. Batrachus* showing higher mean hemolysis (51.3% OD-540 = 1.06) compared to *L. rohita* (47.8% OD-540 = 1.01). Statistical analysis indicates a significant difference between groups ($p < 0.001$). While the magnitude of this difference is modest, it suggests species-specific variation in mucus-associated membrane-disruptive capacity. Given the limited biological replication and absence of biochemical normalization, these findings should be considered preliminary. However, the observed activity supports the hypothesis that fish epidermal mucus contains functionally relevant membrane-active components that may differ across taxa. Future work incorporating protein standardization, dose-response assays, and molecular characterization will be necessary to resolve the mechanistic basis and biological significance of these differences.

Keywords: hemolytic activity, epidermal mucus, catfish, Rohu, innate immunity, erythrocytes.

Prevalence And Contributing Factors Of Polycystic Ovary Syndrome (Pcos) Among Reproductive - Aged Females In Dera

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Polycystic ovarian syndrome is one of the most common endocrine disorders that occurs among females of reproductive age and is associated with significant reproductive, metabolic, and psychological complications. The most common symptoms in women with polycystic ovarian syndrome are irregular or no menstrual period, heavy period, hirsutism, hair loss, difficulty in conception, acne, and other skin-related problems. My study aimed to determine the prevalence of polycystic ovarian syndrome among reproductive-aged females of D. I. Khan. It was a cross-sectional, survey-based study. Data were collected from the District Headquarters Hospital of D.I. Khan. A sample size of 100 women was used, and data collection was conducted from October to April. Information regarding socio-demographic characteristics, menstrual history, clinical symptoms, lifestyle patterns, dietary habits, physical activity, family history, and treatment status was obtained. The data was interpreted to find the prevalence of PCOs and symptoms of PCOs. Out of 100 females 31% females have hirsutism, 49 % females suffer from acne, alopecia hair loss 57% females, 63% females have obesity, 29% females have irregular menstruation, 100% females aware of PCOs, the study conclude that PCOs is prevalent among reproductive aged females of D.I. Khan and lifestyle sleep pattern and dietary factors are the main cause of PCOS. Early diagnosis, health education, and lifestyle modification programs are recommended to reduce long-term complications and improve the disease.

Keywords: Polycystic ovarian syndrome, prevalence, contributing factors, D.I. Khan, life factor