ICTRI-2026

PROCEEDINGS

of the

3rd International Conference on Technological Research and Innovation 2026

'Empowering Agri-Entrepreneurs through Technology and Innovation: Startups, Digital Agriculture, and Rural Innovation Ecosystems.'

25TH MAY 2026

Organized by

Faculty of Technology, Eastern University, Sri Lanka

Abstracts of the Proceedings

of the

3rd International Conference on Technological Research and Innovation 2026

"Empowering Agri-Entrepreneurs through Technology and Innovation: Startups, Digital Agriculture, and Rural Innovation Ecosystems."

25th May 2026
Faculty of Technology
Eastern University, Sri Lanka

ABSTRACTS

Session Mode: Hybrid

Organized by: Faculty of Technology, Eastern University, Sri Lanka

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Website: http://www.esn.ac.lk/fte

ISBN/ISSN: ISBN 978-624-5731-62-6

Barcode: 9 786245 731626

Published by:

Faculty of Technology, Eastern University, Sri Lanka, Pallacholai, Kaluwankerny-30372

3rd International Conference on Technological Research and Innovation 2026

Faculty of Technology, Eastern University, Sri Lanka is organized to host its 2nd International Conference on Technological Research and Innovation with following thematic tracks, Biosystems Technology, Climate Energy and Environment and Innovative Technology for Entrepreneurship.

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Message from the Vice Chancellor

Prof. P. Peratheepan
Vice Chancellor
Eastern University, Sri Lanka

It is with great pleasure that I extend my warm greetings to all participants of the 3rd International Conference on Technological Research and Innovation (ICTRI-2026), organized by the Faculty of Technology, Eastern University, Sri Lanka.

The theme of this conference, "Empowering Agri-Entrepreneurs through Technology and Innovation: Startups, Digital Agriculture, and Rural Innovation Ecosystems," reflects the growing importance of integrating research, technology, and innovation to address contemporary societal and economic challenges. ICTRI-2026 provides a valuable platform for academics, researchers, industry experts, and students to exchange ideas, share experiences, and explore innovative solutions for sustainable development.

Research plays a vital role in advancing knowledge and transforming communities. Therefore, I encourage researchers to focus on innovative and impactful research that can be translated into practical applications, commercialization opportunities, startups, patents, industrial collaborations, and community development initiatives. Our collective efforts should ensure that research outcomes benefit farmers, rural entrepreneurs, industries, policymakers, and society at large.

The conference tracks, namely Sustainable Agriculture and Green Innovation, Entrepreneurship and Rural Innovation Ecosystem, Value Addition to Agri and Food Products, and Information Technology and Digital Agriculture, highlight critical areas that can contribute significantly to national and global development.

Eastern University, Sri Lanka remains committed to promoting research culture, innovation, entrepreneurship, and meaningful community engagement. We strongly believe that collaboration among academia, industry, government institutions, and communities is essential to achieving sustainable progress.

I extend my sincere appreciation to the Dean, Faculty of Technology, the organizing committee, resource persons, authors, and participants for their dedication and contribution towards making ICTRI-2026 a success.

I wish the conference every success and hope that the deliberations and outcomes of ICTRI-2026 will inspire future collaborations, innovations, and impactful research endeavors.

Thank you.

Message from the Chairperson

Dr. (Mrs.) D.M. Hunupolagama
Dean, Faculty of Technology
Eastern University, Sri Lanka

It is my distinct privilege and honor to send this message to the 3rd International Conference on Technological Research and Innovation (ICTRI-2026), proudly hosted by the Faculty of Technology, Eastern University, Sri Lanka. In this third iteration in a hybrid format, bridging both in-person and online participants, we look back with immense pride at the foundation laid by our previous two conferences. The inaugural conference successfully sparked vital academic dialogue, establishing a collaborative framework for researchers worldwide. Building on that momentum, the second conference pushed the boundaries further, bridging the gap between theoretical research and real-world industrial applications.

This year, ICTRI has grown not only in scale but in societal relevance. The overarching theme of this year's conference, "Empowering Agri-Entrepreneurs through Technology and Innovation: Startups, Digital Agriculture, and Rural Innovation Ecosystems" underscores a critical truth that the global challenges we face in food security, economic resilience, and sustainability require disruptive, technologically driven innovations. To address these challenges, the technical program of this third edition has been meticulously organized into four key tracks that reflect the pulse of modern agricultural and technological advancement:

- Track 1: Sustainable Agriculture and Green Innovation
- Track 2: Entrepreneurship and Rural Innovation Ecosystem
- Track 3: Value Addition to Agri and Food Products
- Track 4: Information Technology and Digital Agriculture

This conference serves as a vital nexus where academia, international experts including our distinguished keynote speakers, Prof. Murodjon Samadiy from Uzbekistan and Professor Gamini Senanayeka from Sri Lanka industry professionals, and young researchers intersect. The peer-reviewed papers compiled in these proceedings reflect months of rigorous inquiry, creativity, and a shared commitment to human progress.

I would like to extend my deepest gratitude to the organizing committee, the technical review panel, and our global community of reviewers for their tireless efforts in maintaining the highest standards of academic integrity for these proceedings. Most importantly, I thank the authors and presenters for sharing their invaluable insights. To all our participants, I wish you an incredibly enriching, inspiring, and successful conference. May the discussions sparked here lead to lasting collaborations and breakthroughs that resonate far beyond these walls.

I wish the 3rd International Conference on Technological Research and Innovation every success!

Message from the Coordinator

Dr. A.L. Mohamed Rifky
Coordinator
3rd ICTRI 2026 - Faculty of Technology, EUSL

It is with great pleasure that I welcome you to the International Conference on Technology and Research Innovations (ICTRI 2026) organized by the Faculty of Technology, Eastern University, Sri Lanka. As the Coordinator of ICTRI 2026, I am honored to present these conference proceedings, which represent the collective scholarly efforts of researchers, academics, innovators, industry professionals, and students from diverse disciplines and institutions.

ICTRI 2026 has been organized with the vision of promoting innovative research, interdisciplinary collaboration, and knowledge sharing in the fields of science, engineering, technology, and research innovations. The conference provides an important academic platform for discussing emerging challenges, exchanging ideas, and presenting practical and sustainable solutions that contribute to societal and technological advancement.

The papers published in these proceedings have undergone a thorough peer-review and evaluation process carried out by our dedicated scientific committee and expert reviewers to ensure high academic standards, originality, and relevance. The accepted contributions reflect the growing research capacity and intellectual diversity within both local and international academic communities.

I would like to express my sincere appreciation to all authors, keynote speakers, reviewers, session chairs, organizing committee members, sponsors, and participants for their valuable contributions and continuous support in making ICTRI 2026 a successful international conference. Their commitment and enthusiasm have greatly strengthened the quality and significance of this event.

I sincerely hope that the knowledge shared through these proceedings will inspire further research collaborations, technological innovations, and meaningful academic partnerships in the future.

Thank you for being a part of ICTRI 2026, and I look forward to welcoming you to future conferences organized by the Faculty of Technology, Eastern University, Sri Lanka.

Thank you.

Message from the Secretary

Dr. (Mrs.) W. H. D. U. Pushpakumari
Secretary,
3rd ICTRI 2026 - Faculty of Technology, EUSL

With immense pleasure, I extend a warm welcome to all participants of the 3rd International Conference on Technological Research and Innovation – 2026 (ICTRI-2026), organized by the Faculty of Technology, Eastern University, Sri Lanka. This conference serves as a distinguished platform for academics, researchers, innovators, and industry professionals to share knowledge, foster collaboration, and discuss advancements that contribute to technological and societal progress.

ICTRI-2026 aims to encourage interdisciplinary research and promote innovative solutions to contemporary global challenges in areas related to technology, science, industry, sustainability, and development. The conference aspires to create meaningful discussions that inspire future innovations and strengthen research partnerships across diverse fields.

I would like to express my sincere gratitude to the Vice Chancellor of Eastern University, Sri Lanka, and the Dean of the Faculty of Technology for their continuous guidance and invaluable support in organizing this conference successfully. My heartfelt appreciation also goes to our keynote speakers, reviewers, session chairs, and panel members for generously contributing their expertise and time to enrich this academic gathering.

I further acknowledge the dedicated efforts of the academic staff, non-academic staff, and students of the Faculty of Technology whose commitment and teamwork have played a vital role in making ICTRI-2026 a reality.

On behalf of the Faculty of Technology, Eastern University, Sri Lanka, I warmly welcome all authors, delegates, researchers, participants, sponsors, and well-wishers to ICTRI-2026. We trust that this conference will provide an engaging and rewarding experience through insightful discussions, valuable networking opportunities, and the exchange of innovative ideas.

May ICTRI-2026 be a productive, inspiring, and memorable event for everyone involved.

Message from the Editor

Dr. (Mrs.) Vanitha Prasannath
Editor,
3rd ICTRI 2026 - Faculty of Technology, EUSL

Dear distinguished guests, esteemed researchers, academic professionals, and students,

It is with great pride and pleasure that I address you in my capacity as the Editor of the ICTRI-2026 Conference Proceedings, held at the Faculty of Technology, Eastern University, Sri Lanka. Research remains the cornerstone of discovery, offering valuable insights that advance knowledge, address critical challenges, and create new opportunities. The theme of ICTRI-2026, "Empowering Agri-Entrepreneurs through Technology and Innovation: Startups, Digital Agriculture, Rural Innovation Ecosystems," reflects a forward-thinking vision rooted in innovation, collaboration, and sustainable development.

The proceedings of this conference represent a rich compilation of scholarly contributions that bring together multidisciplinary perspectives to address pressing global issues. The four thematic tracks - Sustainable Agriculture and Green Innovation; Entrepreneurship and Rural Innovation Ecosystem; Value Addition to Agri and Food Products; and Information Technology and Digital Agriculture - demonstrate the diversity and relevance of the research presented.

As Editor, I am deeply encouraged by the quality, rigor, and originality of the papers included in these proceedings. I am confident that the ideas and findings shared will contribute significantly to both academic advancement and practical applications in the respective fields. I warmly invite you to engage with these contributions, reflect on the insights presented, and foster meaningful collaborations that extend beyond this conference. Let us collectively work towards a future where technology and innovation drive inclusive growth and sustainable progress.

I extend my sincere appreciation to the Dean, the organizing committee, reviewers, and all contributors for their dedication and commitment in making this publication possible. May ICTRI-2026 serve as a catalyst for continued research excellence and impactful innovation.

Thank you, and I wish you a rewarding and inspiring experience.

Abstract of the Guest of Honour Note

Professor Murodjon Samadiy
Professor,
Department of Chemical Engineering and Biotechnology
Karshi State Technical University

Distinguished guests, Vice Chancellor, respected academics, researchers, students, ladies and gentlemen,

It is a great honour and privilege to address the participants of the International Conference on Technology and Research Innovation (ICTRI 2026) organized by the Faculty of Technology of Eastern University, Sri Lanka.

I would first like to convey the sincere greetings and best wishes from Karshi State Technical University. I am so proud to present this address as I was invited to deliver this Guest of honour address under the topic "Impact of Inorganic Chemical Fertilizer on Sustainable Agriculture." I have been actively involved in international research cooperation in chemical engineering, environmental sustainability, and mineral resource technologies with institutions in China, Russia, Kazakhstan, Tajikistan, Germany, Turkey and other countries. However, he extends his deepest appreciation to the organizing committee of ICTRI 2026 and expresses his gratitude for the opportunity to contribute to this important academic platform.

Today, sustainable agriculture has become one of the most critical global concerns. Modern agriculture has undoubtedly achieved remarkable increases in food production through the extensive use of inorganic chemical fertilizers. Fertilizers containing nitrogen, phosphorus, and potassium have helped farmers improve crop productivity, enhance food security, and support the nutritional needs of rapidly growing populations.

The Green Revolution demonstrated the enormous potential of chemical fertilizers in transforming agricultural productivity. Nevertheless, while inorganic fertilizers contribute significantly to agricultural development, their excessive and uncontrolled application has created major environmental and ecological challenges.

One of the primary concerns is soil degradation. Continuous application of synthetic fertilizers reduces soil organic matter, disturbs microbial biodiversity, and weakens the natural fertility of agricultural lands. Over time, soils become increasingly dependent on chemical inputs, reducing long-term sustainability. Another serious issue is water pollution caused by fertilizer runoff and nutrient leaching. Excess nitrogen compounds enter rivers, lakes, and groundwater systems, resulting in eutrophication and contamination of drinking water resources. Additionally, nitrogen fertilizers release nitrous oxide into the atmosphere, which is one of the most powerful greenhouse gases contributing to climate change.

Therefore, the future of agriculture cannot rely solely on maximizing production. It must also focus on environmental conservation, ecological balance, and long-term sustainability. Sustainable agriculture requires integrated nutrient management approaches that combine inorganic fertilizers with organic amendments, compost, biofertilizers, crop rotation, and

precision farming technologies. Modern agricultural systems must prioritize efficiency, responsible resource utilization, and environmental protection.

I strongly emphasizes that universities and research institutions have a crucial responsibility in developing innovative agricultural technologies and environmentally friendly fertilizer management practices. International collaboration among scientists, researchers, and policymakers is essential to address the growing challenges of food security and environmental sustainability.

I would like to congratulate the Faculty of Technology, Eastern University, Sri Lanka, for organizing ICTRI 2026 and providing an excellent platform for knowledge sharing, scientific innovation, and global academic cooperation.

May this conference inspire productive discussions, meaningful collaborations, and innovative solutions for a more sustainable future.

Thank you very much.

Abstract of the Keynote Speaker Note

Professor Gamini Senanayake,
Emeritus Professor and Former Vice Chancellor,
University of Ruhuna

Keynote Speech:

Cultivating Sustainability: Harnessing Green Innovation and Circularity to Redefine Value Creation in the Agri-Food Chain

It is a great honour to address this distinguished gathering at ICTRI 2026, organized by the Faculty of Technology of Eastern University, Sri Lanka. This conference takes place at a critically important moment when nations across the world are reassessing the sustainability of their economic systems, particularly within the agri-food sector. Climate change, environmental degradation, resource scarcity, and food insecurity have collectively intensified the urgency for transformative approaches to agricultural development.

For decades, agricultural success has largely been evaluated through conventional indicators such as productivity, yield maximization, and market output. While these measures remain important, they are no longer sufficient in addressing the complex environmental and socio-economic realities of the twenty-first century. The central challenge confronting contemporary agriculture is not merely how much food can be produced, but how food can be produced sustainably, efficiently, and equitably while preserving ecological integrity for future generations.

In this context, green innovation and circularity have emerged as essential frameworks for redefining value creation within modern agri-food systems. These concepts represent not only environmental priorities but also strategic economic opportunities capable of enhancing resilience, competitiveness, and long-term sustainability.

Transitioning from Linear to Circular Agricultural Systems

Historically, agricultural systems have operated according to a linear economic model characterized by extraction, production, consumption, and disposal. This “Take–Make–Waste” approach has contributed significantly to soil degradation, biodiversity loss, excessive chemical dependency, and greenhouse gas emissions. Such practices are increasingly incompatible with the realities of climate volatility, declining natural resources, and rising global demand for sustainable production systems.

A transition towards circular agricultural systems is therefore imperative. Circularity emphasizes restoration, regeneration, and efficient resource utilization. Within this paradigm, waste is no longer perceived as an inevitable by-product but rather as a valuable resource capable of generating additional economic value. Sustainability, consequently, becomes a driver of innovation, profitability, and competitive advantage rather than merely a regulatory obligation or corporate responsibility initiative.

Circular systems aim to maximize the efficiency of material and energy flows by ensuring that outputs from one process become inputs for another. Such an approach strengthens resource security, minimizes environmental impacts, and supports the development of regenerative bio-economies capable of sustaining both economic growth and ecological balance.

Circular Bio-economy and Agricultural Waste Valorization

One of the most promising dimensions of circular agriculture is the valorization of agricultural residues and organic waste streams. Sri Lanka generates substantial quantities of agricultural biomass annually, including rice husks, coconut shells, fruit-processing residues, and crop by-products. Traditionally, many of these materials have been discarded, openly burned, or left to decompose, resulting in environmental pollution and inefficient resource use.

Advances in green technologies now demonstrate that these materials possess significant commercial and industrial potential. Agricultural residues can be transformed into biodegradable packaging materials, bio-char, organic fertilizers, renewable bioenergy, and high-value phytochemicals for nutraceutical and pharmaceutical applications. Such innovations not only reduce environmental waste but also create diversified income streams for rural communities and agri-based industries.

Globally, innovative enterprises are converting pineapple leaf fibres into sustainable textiles and cassava starch into biodegradable plastics. Sri Lanka, with its diverse agricultural base, possesses considerable potential to develop localized bio-refinery industries and biomass utilization technologies. Investments in these sectors can contribute to export diversification, rural industrialization, employment generation, and enhanced environmental sustainability.

Precision Agriculture and Technological Innovation

In parallel with circularity, precision agriculture has emerged as a transformative approach to improving resource efficiency within farming systems. Precision agriculture integrates digital technologies, data analytics, and automated systems to optimize agricultural inputs and management practices. By applying the right quantity of water, fertilizers, and crop protection measures at the appropriate time and location, producers can significantly improve productivity while minimizing environmental damage.

Several technologies are driving this transformation. Internet of Things (IoT)-based soil sensors enable real-time monitoring of soil moisture, nutrient status, and environmental conditions. Artificial Intelligence (AI)-enabled predictive systems assist in the early identification of pest infestations and crop diseases, reducing unnecessary chemical applications. Similarly, Unmanned Aerial Vehicles (UAVs) equipped with multispectral imaging technologies facilitate precision spraying and crop health assessment.

Importantly, precision agriculture in Sri Lanka must be developed within a framework of inclusivity and accessibility. Given the predominance of smallholder farming systems, technological interventions should prioritize affordability and adaptability. Frugal innovation approaches, including mobile-based advisory services, shared technology platforms, and low-cost digital tools, can enhance technology adoption among smallholder farmers while reducing financial barriers.

Sustainability, Traceability, and Global Market Competitiveness

Sustainability has increasingly become a defining factor in global agri-food trade and consumer preference. Modern consumers are not solely concerned with product quality and price; they are also interested in the environmental and ethical dimensions of production systems. Issues such as carbon emissions, biodiversity conservation, labour conditions, and supply-chain transparency now influence purchasing decisions across international markets.

This shift presents significant opportunities for Sri Lankan agri-food exporters. Enterprises that integrate verifiable sustainability practices into their operations can differentiate themselves within competitive global markets and command premium prices for environmentally responsible products.

However, sustainability claims must be supported by credible verification systems. Emerging digital technologies, including blockchain-enabled traceability platforms, provide mechanisms for transparent and immutable documentation of production processes throughout the supply chain. Such systems can strengthen consumer confidence and improve international market access for sustainably produced Sri Lankan agricultural products.

The development of internationally recognized sustainability certification systems, such as a "Green Product of Sri Lanka" framework, could further enhance the global positioning of Sri Lankan agri-food exports while encouraging environmentally responsible production practices at the domestic level.

Addressing Institutional and Structural Challenges

Despite the significant potential of green innovation and circularity, several barriers continue to impede large-scale implementation. High initial investment requirements, limited technological infrastructure, inadequate institutional coordination, and persistent digital literacy gaps remain substantial challenges, particularly within rural communities.

Addressing these constraints requires collaborative and multi-sectoral interventions. Innovative service-based business models, including Drone-as-a-Service and Smart-Irrigation-as-a-Service, can improve access to advanced technologies without imposing excessive financial burdens on individual farmers. Similarly, targeted policy incentives, capacity-building initiatives, and public-private partnerships are essential for accelerating the adoption of sustainable agricultural technologies.

Universities and research institutions also have a crucial role to play in generating localized scientific knowledge, developing context-specific technological solutions, and strengthening innovation ecosystems. Through interdisciplinary collaboration among academia, industry, policymakers, and farming communities, sustainable agricultural transformation can be effectively advanced.

Conclusion

The agri-food sector stands at a decisive historical crossroads. One path continues patterns of resource depletion, environmental degradation, and declining resilience. The alternative pathway embraces sustainability, regeneration, technological innovation, and circular economic principles.

Green innovation and circularity are not abstract theoretical concepts; they are practical and economically viable strategies capable of redefining agricultural value creation in the modern era. The critical question before us is not whether we can afford to adopt these approaches, but whether we can afford to delay them.

As we conclude this discussion at ICTRI 2026, let us reaffirm our collective commitment to advancing sustainable agricultural transformation through science, technology, and collaborative innovation. By harnessing circularity and green innovation, Sri Lanka can transform agricultural waste into economic opportunity, strengthen rural livelihoods, enhance global competitiveness, and build a resilient agri-food system capable of supporting future generations.

Sustainable Agriculture and Green Innovation

An Affordable, Mechanized Seed Planter for Small-Scale Farmers

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Abstract

In traditional agricultural practices, conventional manual seeding operations are highly labor-intensive, time-consuming, and economically burdensome, particularly for small-scale farmers. As the global agricultural sector evolves to meet escalating food demands, there is a critical need for innovative, soil-friendly planting techniques that optimize crop yield without prohibitive costs. While advanced automated solutions exist, they frequently remain inaccessible to marginal farmers due to high capital and maintenance requirements. To bridge this gap, this project presents the design and development of a highly adaptable, manually operated seed sowing machine. The primary objective of this project is to design an adaptable manual seed planter that enhances precision and reduces labor for rural farmers. Constructed using cost-effective, readily available raw materials, the proposed implement features a simplified, robust mechanical design that requires no specialized technical training to operate. A primary advantage of this machine is its dynamic versatility; it is engineered with an adjustable seed metering system, allowing it to accommodate diverse seed types and sizes while enabling variable inter-seed spacing to suit specific agronomic requirements. By mechanizing the precise placement of seeds, this ergonomically designed planter significantly reduces human fatigue, lowers labor costs, and mitigates the spatial inconsistencies traditionally associated with manual planting methods. Furthermore, the machine operates without degrading soil texture, ensuring uniform depth and spacing for optimal germination rates. Ultimately, this low-cost, high-efficiency sowing machine provides an accessible and pragmatic solution to enhance planting precision, reduce labor dependency, and improve overall agricultural productivity for small-scale farming communities.

Keywords: Crop Yield, Planting Efficiency, Smallholder Agriculture and Soil Conservation

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Utilization of Agricultural Waste for Environmental Friendly Biodegradable Packaging Materials

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Abstract

The excessive use of petroleum-based plastics has caused serious environmental pollution, landfill accumulation, and ecological toxicity due to their poor biodegradability. In Sri Lanka, large volumes of fruit and vegetable processing waste rich in cellulose remain underutilized. This study aimed to develop biodegradable packaging materials by combining agricultural waste with recycled paper pulp as a sustainable alternative. Cellulose-rich fibers were extracted from carrot, orange, mango, papaya, pineapple, tomato, cabbage, and passion fruit peels, while waste paper was processed into pulp. Three formulations were prepared: T_1 (75% agricultural waste and 25% used paper), T_2 (50:50), and T_3 (25:75). Corn starch served as a binder, while an Aloe vera–glycerol coating improved flexibility and barrier properties. A Completely Randomized Design was applied, and samples were evaluated for their physical, chemical, mechanical, biodegradability, and microbial properties. Significant differences ($p<0.05$) were observed among treatments. T_2 showed superior performance, recording the highest thickness (91.16 µm), balanced hardness (1.56 kg), moderate density (5.64 g/cm³), and optimal cellulose content (59.89%). It achieved greatest biodegradability (9.31%within 10 days), near-neutral pH (7.71), moderate moisture content (12.55%), controlled water absorption (186.12%), and the lowest solubility (3.06%). Color analysis confirmed improved brightness (L*= 43.36), while microbial testing revealed reduced bacterial and fungal growth due to Aloe vera–glycerol coating. Overall, the 50:50 blend provided the best balance of strength, biodegradability, water resistance, and safety, making it a promising eco-friendly alternative to conventional plastic packaging.

Keywords: Agricultural waste, Biodegradable packaging, Paper waste, Sustainable

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The Status of Use of Hydroponic Systems by Farmers in Western Province

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Abstract

Hydroponic systems refer to a method of growing plants without soil, using mineral nutrient solutions in a water solvent. This technique allows for efficient use of resources such as water and nutrients and is often implemented within Controlled Environment Agriculture (CEA) setups to optimize growing conditions. In the Western Province of Sri Lanka, hydroponic systems are gaining traction due to their potential to increase agricultural productivity and sustainability. This study explores the status of hydroponic systems in the Western Province of Sri Lanka, focusing on key concepts such as hydroponics, Controlled Environment Agriculture (CEA), sustainability in agriculture, operational efficiencies, economic benefits, challenges, and contextual considerations specific to the region. The research identifies and analyzes various independent variables: access to capital, technical knowledge, perceived benefits, environmental conditions, and their impact on dependent variables: yield, cost savings, sustainability measures, and economic benefits. This study highlights the expected relationships between these variables and identifies gaps in the existing literature, particularly in region-specific studies and long-term sustainability assessments. The study employs a combination of surveys, interviews, and field observations to gather comprehensive data from farmers in the Western Province. The results and discussion begin with demographic information, including district distribution, gender, age, educational level, marital status, greenhouse ownership, and main income sources. Descriptive analysis, correlation analysis, and regression analysis are conducted to uncover significant associations and the impact of various factors on the adoption of hydroponic systems. The study also identifies strategies for overcoming challenges, documenting farmer experiences, and best practices. The findings offer valuable insights into the current state of hydroponics in the region and propose future research directions to address the identified gaps.

Keywords: Controlled environment agriculture, Hydroponic system, Productivity, Sustainability, Western Province.

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Evaluation of Bamboo Biochar as A Sustainable Hydroponic Growth Medium

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Abstract

The suitability of using bamboo biochar as a medium in supporting plant growth in soilless culture was assessed based on its physicochemical properties as a potential medium in sustainable hydroponic growth medium. Analytical methods were used to determine the properties of the biochar produced by controlled pyrolysis at 600 °C. Bamboo biochar chips and powder had moisture content values of - 1.82 ± 0.20% and 1.04 ± 0.17%. These values showed the high efficiency in drying and durability in storage. Low volatile matter content was also confirmed in the biochar chips (12.45 ± 1.24%) and powder (14.46 ± 1.25%), which showed the high temperature destruction of organic compounds. A high percentage of carbon was confirmed in the biochar chips (75.98%) compared to the powder (57.67%), which showed the suitability in long-term hydroponic growth medium. Both the powder and chips had a strongly alkaline nature, with a pH value ranging from 10.3 to 10.4. However, the chips had a low electrical conductivity value (1.19 dS m^{-1}) compared to the powder (4.29 dS m^{-1}), which showed the suitability in hydroponic growth medium in relation to the salinity hazard. The powder had a cation exchange capacity (CEC) value of 18 cmol kg^{-1}, which showed the suitability in the retention of nutrients. Based on the high moisture content, high percentage of carbon, moderate conductivity, and alkaline nature, the suitability of using the bamboo biochar in hydroponic growth medium was confirmed.

Keywords: Alkaline, Bamboo biochar, Cation exchange capacity, Growth medium, Pyrolysis.

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Physicochemical Characterization and Nutrient Potential of Water Hyacinth (*Eichhornia Crassipes*) Powder as an Agricultural Application

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Abstract

Water hyacinth (*Eichhornia crassipes*) is an invasive aquatic plant that grows rapidly, posing significant threats to freshwater eco systems. In spite of this harmful effect, its fast growth rate and capability to absorb nutrients could prove valuable for commercial agriculture purposes. This study focus to turning the water hyacinth into a powder which is a good agricultural resource and easy to handle while decreasing the environment pollution. Water hyacinth leaves and stems was Collected from batticaloa. Grinded after indirect sun drying and used 3 replicates for all findings. The evaluation of its physiochemical attributes and nutrition content will help identify its viability in agriculture. The water hyacinth powder showed interesting physiochemical, nutritional, and functional features. The moisture level (14.76 ± 0.24%) shows high stability during storage. The high ash level (22.92 ± 0.60%) and high electrical conductivity (10.06 ± 0.14 dS/m) show high mineral content. Also, the high concentration of essential elements, nitrogen (10.70 ± 0.56 mg/g) and phosphorus (5.16 ± 0.05 mg/g) is the evidence of its high value as a fertilizer. The slight acidity of the sample (pH = 5.93 ± 0.22) may affect interaction within the soil system. The high volatile matter content (78.56 ± 1.45%) shows the high percentage of thermolabile organic substances. From the functional side, the sample showed high water absorption ability (13.19 ± 1.64 g/g) and average swelling ability (22.67 ± 0.58 ml/g). Thus, all these properties emphasize the potential of water hyacinth powder for agricultural, environmental, and biomass-based applications.

Keywords: Biomass, Nutrient, Physicochemical, Soil-based, Water hyacinth

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Growth and Yield Responses of Okra (*Abelmoschus esculentus* L.) as Influenced by Red Large Onion (*Allium cepa* L.) Peel Liquid with Moringa Leaf Extract Organic Fertilizer

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Abstract

Abelmoschus esculentus L. (Okra) is a nutrient-rich vegetable widely cultivated in Sri Lanka and responds well to organic fertilizers. A pot experiment was conducted to evaluate the impact of red onion (*Allium cepa* L.) peel liquid (ACL) and moringa (*Moringa oleifera* L.) leaf extract (MLE) organic fertilizer on growth and yield of okra. The experiment followed a completely randomized design with 48 replications. Treatments included various combinations of MLE and ACL with half the recommended inorganic fertilizer dose, along with control (T1) using full inorganic fertilizer. Treatments were: T1 (control), T2 (100% MLE + ½ dosage of recommended inorganic fertilizer), T3 (100% ACL + ½ dosage of recommended inorganic fertilizer), T4 (20% MLE + 80% ACL + ½ dosage of recommended inorganic fertilizer), T5 (40% MLE + 60% ACL + ½ dosage of recommended inorganic fertilizer), T6 (50% MLE + 50% ACL + ½ dosage of recommended inorganic fertilizer), T7 (60% MLE + 40% ACL + ½ dosage of recommended inorganic fertilizer) & T8 (80% MLE + 20% ACL + ½ dosage of recommended inorganic fertilizer). Agronomic practices were followed as recommended for all treatments. Plants treated with 100% moringa leaf extract with ½ dosage of recommended inorganic fertilizer (T2) applied at 0.253 l/m^2 showed significantly (p<0.05) better performance (plant height, Number of pods per plant, pod length, pod girth and total yield per plant). The lowest performance was recorded in plants under T8. The study concludes that, 100% moringa leaf extract combined with half dosage of recommended inorganic fertilizer (T2) provides optimum nutrients for okra growth and yield, while promoting sustainable and environmentally friendly alternatives to conventional fertilization techniques.

Keywords: *Allium cepa* peel liquid, Foliar spray, Moringa leaf extract, Plant nutrition, Sustainable agriculture

Author Biography

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Effect of Biogas Slurry Foliar Application on Growth And Yield Performance Of Red Onion (*Allium Cepa* L.)

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Abstract

The study was conducted to evaluate the effect of biogas slurry combined with the inorganic fertilizer on the growth and yield performance of red onion (*Allium cepa* L.).The experiment was laid out using complete randomized method (CRD) with four different treatments and five replicates, where T_1 with recommended fertilizer (control treatment),T_2, T_3 an T_4 consisted of biogas slurry diluted with water at ratios of 1:1,1:2 and 1:3 respectively, along with the 1/3 of recommended fertilizer by DOA. This solution was applied as foliar treatments at two weeks intervals with the amount of 75ml per pot ($0.03m^2$) from the 2nd week of planting at two weeks of interval for three times. Plant height, number of leaves were measured at weekly interval. Bulb diameter, number of bulbs and yield were measured at the time of harvesting at 6th week after planting. Analysis of variance was performed to determine significant differences among the treatments ($p<0.05$) by using Minitab 17.0 software. The results showed that these treatments, combining with inorganic fertilizers with biogas slurry significantly enhanced the growth and yield performance compared to the control treatment (T_1). Especially T_4 significantly enhanced plant height up to 52.14±2.79 cm, where T_1 shows 46.84±2.42cm, leaf number up to 8.60±0.24, and bulb's diameter up to 2.70±0.05 cm, where,T_1 shows 1.16±0.06 cm.These findings suggest that biogas slurry can serve as an effective organic foliar fertilizer when combined with inorganic fertilizer, and contributing to improved growth and yield in red onion cultivation than the control treatment.

Keywords: Biogas, Canopy, Comparison, Concentration, Slurry, Yield.

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Economic Viability and Impact of Backyard Poultry Farming System in Trincomalee District, Eastern Province, Sri Lanka

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Abstract

Rural small-scale backyard poultry farming plays a vital role in sustainable food security by providing essential animal-source protein, supporting rural livelihoods with minimal investment, and generating supplementary income with low adverse environmental impact. This study examines the current status, constraints, and livelihood opportunities of backyard poultry farming, with particular focus on women-headed households, unemployed youth, and elderly farmers. The study further assesses the impact of economic fluctuations, feed price volatility, and climate change on the viability and sustainability of smallholder backyard poultry operations. Data were collected from 250 backyard poultry farms with flock sizes of more than 10 birds, from five veterinary divisions Kinniya, Muthur, Padavisripura, Thambalagamam, and Echchilampattu in Trincomalee district. Farms were predominantly managed by women-headed households. Structured questionnaires, field observations, and direct farmer interviews were used to gather information on socio-economic characteristics, and basic farm management practices. Findings revealed that 40% of farmers relied on kitchen waste as the primary feed source, while 85% supplemented with poor-quality rice bran and broken rice; free-ranging birds additionally accessed green leaves and ground forage. Most poultry houses were constructed from locally available waste materials, keeping capital costs low, but increasing vulnerability to predators and climatic extremes. Predator attacks were the leading cause of bird mortality, reported by 65% of respondents, and only 28% of respondents had participated in any poultry farm training program. Key strategies identified include adopting climate-resilient housing systems, introducing climate-smart feeds using locally available raw materials, strengthened farmer awareness programs and expanded veterinary mobile services. Farmers expressed willingness to expand their operations to ensure sustainable income and to address malnutrition. Addressing these challenges through data-driven policies, farmer empowerment, and sustained institutional support from the Department of Animal Production and Health is essential for developing a resilient and self-sufficient backyard poultry sector.

Keywords: Backyard poultry, Food security, Free range, Livelihood, Sustainable

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Development of a Carbon Nanotube-based Enzymatic Electrochemical Sensor for Rapid Agricultural Pesticide Screening

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Abstract

Electrochemical sensing platforms originally developed for protein immobilization and redox characterization offer significant potential for translation into agricultural monitoring technologies. In this study, a functional electrochemical platform is adapted toward agricultural monitoring through the development of a sustainable pesticide sensing system utilizing environmentally compatible materials and locally accessible biorecognition elements. Conventional gold nanoparticle-based systems employing thiol self-assembled monolayers are replaced with carbon nanotube (CNT)-modified electrodes to improve electroactive surface area, charge transfer characteristics, and material sustainability. Functionalized CNT surfaces and non-functionalized direct adsorption approaches are investigated as versatile conductive interfaces for biomolecule immobilization and electrochemical transduction. Rather than relying on purified enzymes such as acetylcholinesterase, this work explores bio-derived esterase activity obtained from locally accessible biological sources as sustainable biorecognition elements. These enzymatic systems exhibit sensitivity toward organophosphate and carbamate pesticides through inhibition-based interactions, enabling electrochemical monitoring of pesticide-induced activity changes. Sensing performance is evaluated using cyclic voltammetry (CV), differential pulse voltammetry (DPV) and electrochemical impedance spectroscopy (EIS), where variations in electrochemical response and interfacial charge transfer characteristics are correlated with pesticide presence. The proposed system provides rapid, cost-effective, and field-applicable screening of neurotoxic pesticide residues in agricultural samples, including irrigation water and produce extracts. By combining CNT-based electrochemical interfaces with bio-derived recognition elements, this work supports greener and more sustainable sensing technologies with reduced reliance on noble metal materials. The platform offers a scalable approach for decentralized pesticide monitoring, with future potential for improved selectivity through advanced recognition elements.

Keywords: Biosensor, Electrochemistry, Enzyme, Nanotubes, Pesticides

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Evaluation of Morphological Variation and Lodging Status of Selected Traditional Rice Accessions (*Oryza sativa* L.) at the Vegetative Stage

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Abstract

Rice (*Oryza sativa* L.) plays a critical role in global nutrition and is fundamental to food security in Sri Lanka. Although breeding strategies focus primarily on reducing plant height to prevent this issue, traditional rice varieties provide an untapped genetic pool for discovering unique structural and physiological resistance traits. This study evaluated the morphological and physiological variation of 11 traditional Sri Lankan rice accessions (AN), along with the improved check variety AT 307, during the vegetative stage to identify traits contributing to structural integrity. A field experiment was conducted at the Faculty of Technology, Eastern University, Sri Lanka during the Maha season 2025, using a randomized complete block design with three replicates. Each replicate consisted of eleven plots measuring 2 m × 2 m. Significant phenotypic variation was observed among the evaluated genotypes. Plant height ranged from 79.13 ± 11.07 cm (AT 307) to 151.05 ± 8.86 cm (AN 4179), while culm length varied between 64.78 ± 7.15 cm (AT 307) and 122.74 ± 12.83 cm (AN 3912). Leaf number ranged from 14.80 ± 4.23 (AT 307) to 27.80 ± 10.21 (AN 6200), and flag leaf length varied from 24.56 ± 6.14 cm (AN 8657) to 43.83 ± 8.66 cm (AN 4772). Chlorophyll content, ranged from 33.50 ± 3.51 (AN 8657) to 43.36 ± 3.21 (AT 307). Categorization by lodging status revealed that more than half of the accessions (54.55%, representing 6 varieties) maintained structural stability with no lodging, whereas 27.27% showed partial lodging and 18.18% were fully lodged. Notably, several traditional accessions significantly taller than the check variety AT 307 remained upright, suggesting that lodging resistance in these ANs is not solely dictated by height. The findings highlight the potential of traditional rice accessions as valuable genetic resources for improving lodging resistance through traits beyond plant height.

Keywords: Lodging resistance, Morphological variation, Oryza sativa L., Traditional rice, Vegetative stage

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Determination of Correlation among Agronomic Traits of Selected Cowpea (*Vigna unguiculata* L.) Genotypes

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Abstract

Cowpea (*Vigna unguiculata* L.) is a vital grain legume cultivated across tropical and subtropical regions for its nutritional and economic importance. Enhancing cowpea yield requires understanding relationships among key agronomic traits. This study aimed to determine correlations among vegetative, flowering, and yield-related traits in selected cowpea genotypes. The experiment was conducted from July to October 2025 at the Faculty of Technology experimental farm, Eastern University, Sri Lanka. Twenty genotypes and improved varieties *Dhawala* and *Waruni* were evaluated in a randomized complete block design with three replicates, each plot containing 20 plants per genotype. Vegetative traits of plant height, leaf number, primary branches, leaf area, days to flowering and yield- related traits were measured at 4 and 6 weeks after planting. Correlation analysis was performed using R Studio version 4.5.0. The results revealed a positive correlation between plant height and primary branches (r = 0.46). Plant height and leaf area exhibited a negative correlation (r = –0.31). Pod length strongly positively correlated with hundred seed weight (HGW) (r = 0.81), linking larger pods to heavier seeds. Seeds per pod moderately negatively correlated with HGW (r = –0.55), indicating a seed number-size trade-off. Biomass yield and harvest index showed a positive correlation, reflecting efficient biomass partitioning in high-yielders. The identified correlations provide a useful basis for selecting superior genotypes and optimizing trait combinations for enhanced productivity under Sri Lankan growing conditions.

Keywords: Agronomic Traits, Correlation Analysis, Genotypes, Vegetative Traits

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Evaluation of Nutrition Composition of Selected Cowpea Genotypes (*Vigna unguiculate* L.)

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Abstract

Cowpea (*Vigna unguiculata* L.) is a nutritionally important legume valued for its high protein and carbohydrate content and its role in food security. This study aimed to evaluate seed morphology and nutritional composition of selected cowpea genotypes and to identify superior lines for breeding programs. Twenty cowpea genotypes obtained from the Grain Legumes and Oil Crops Research and Development Centre, Agunukolapelessa, Sri Lanka, were evaluated using a Randomised Complete Block Design with three replicates. Data were collected based on the seed morphology and nutritional composition,With affiliation Jayasinghe and analysed using ANOVA, Minitab 17 version. Significant variation was observed in qualitative traits of seed colour, texture, eye pattern, eye colour, and testa characteristics, indicating strong genetic diversity. Proximate analysis showed significant variation among genotypes: Protein (22.48% *CP 32*, 31.42%, *ANKCM 20-3*), Moisture (5.26% *ANKCM 20-4* and *CP 39*, 14.87% *CP 195*), Ash (3.2% *CP 158* and *ANKCM 20-3*, 6.5% *CP 247*), Crude fiber (1% *CP 158* and 5% *ANKCM 20-1, ANKCM 20-2, CP 16,*), Fat (1% *CP 21*, *CP 169, CP 16* and 3.1% CP 39), and Carbohydrates (50.72% *CP 16*, 61.30% *CP 32*). Genotypes *ANKCM 20-3, ANKCM 13-4*, and *CP 39* exhibited high protein content, while *CP 32* and *CP 158* showed higher carbohydrate levels. The observed variability in seed morphology and nutritional composition highlights the significant genetic potential available for cowpea improvement. These findings provide a valuable foundation for selecting elite genotypes to support future breeding strategies aimed at enhancing yield, nutritional quality, and adaptability under Sri Lankan agro-ecological conditions.

Keywords: Cowpea, Genetic variation, Nutritional composition, Proximate composition, Seed morphology.

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Study of Days to Flowering Variation Among Selected Cowpea Genotypes (*Vigna unguiculata* L.)

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Abstract

Cowpea serves as a vital source of plant protein, vitamins, and minerals in human diets and animal feed, while also enhancing soil fertility via biological nitrogen fixation. However, in Sri Lanka, cowpea productivity lags due to scarce improved varieties, environmental stresses, and limited breeding research. This study evaluated variation in days to flowering and yield-related traits across selected cowpea genotypes to identify promising lines for local agro-climatic improvement and cultivation. The experiment was conducted from July to October 2025 at the Faculty of Technology, Eastern University, Sri Lanka. Twenty genotypes, sourced from the Grain Legumes and Oil Crops Research and Development Centre in Agunakolapelessa, were tested in a Randomized Complete Block Design (RCBD) with three replications. Data were collected on days to flowering, number of pods per plant, seeds per pod, pod length, pod width, 100-seed weight and grain yield per plant, biomass yield, and harvest index. The dendrogram was constructed using Minitab version 17 to visualize the genetic relationships among the genotypes. Six clusters were separated according to measured morphological traits. Four cowpea genotypes belong to the early flowering (30-36 days) high yielding (13.01- 28.33 g) category *(CP 246, ANKUM13-4, Dhawala, Waruni*) which are suitable for cultivation during drought periods and for cultivation in dry zones. Other high yielders such as *CP39, ANKCM 20-4, ANKCM 14-2, CP 173, CP195, ANKCM 20-1, CP 158, CP247* have been identified but they are late flowering (39- 48 days). The highest yield of cowpea genotypes is late flowering CP 173 (28.33±0.03). These initial data can be used for future cowpea breeding programs in Sri Lanka.

Keywords: Breeding, Cowpea, Genotypes, Flowering, Yield

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Effect of Organic Fertilizer on Growth and Yield Performance of Selected Cowpea (*Vigna unguiculata* L.) Varieties

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Abstract

Cowpea (*Vigna unguiculata* L.) is an important grain legume widely cultivated in tropical regions due to its high nutritional value, adaptability to marginal soils, and role in improving soil fertility through biological nitrogen fixation. However, productivity remains limited due to poor soil fertility and excessive reliance on inorganic fertilizers, which contribute to environmental degradation. This study evaluated the effectiveness of vermicompost (VC) as a sustainable alternative to chemical fertilizers for enhancing the growth and yield performance of selected cowpea varieties under tropical conditions in Sri Lanka. The experiment was conducted in a completely randomized design with six treatments, including different proportions of vermicompost (25%, 50%, 75%, and 100%) and a recommended chemical fertilizer along with the control. Three cowpea varieties (ANKCP 2, MICP 1, and MI 35) were tested. Key growth and yield parameters were measured eight weeks after transplanting. Results indicated that 100% VC significantly enhanced measured vegetative parameters across all varieties, as evidenced by higher plant height (47.56 ± 3.41 cm, MI 35), number of leaves (39.00 ± 1.22, MI 35), number of branchers (14.20 ± 1.48, MI 35), and leaf area index (62.61 ± 5.26 cm²ANKCP 2 ($P<0.05$). The treatments of 50% and 75% also showed significant improvements compared to control and chemical fertilizer treatments. Additionally, VC application promoted earlier flowering (38.60 ± 1.51 days), seed length (0.64 ± 0.11 mm in ANKCP 2), and dry pod weight (2.40 ± 0.15 g, ANKCP 2), suggesting improved physiological efficiency. The findings demonstrate that VC is an effective and eco-friendly nutrient source that enhances cowpea growth and development while supporting soil health. The study highlights the potential of VC as a sustainable alternative to inorganic fertilizers in tropical agroecosystems. Further field-based research is recommended to validate these findings and assess long-term impacts on yield and soil properties.

Keywords: Cowpea (*Vigna unguiculata* L.), Growth performance, Sustainable agriculture, Vermicompost, Yield components

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Entrepreneurship and Rural Innovation Ecosystem

Impact of Marketing Strategies on Soft Drink Consumption Patterns in Attanagalla DS Division, Gampaha District, Sri Lanka.

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Abstract

The soft drink industry has a major impact on the world economy and consumer behavior, especially among the younger generations. The marketing strategies still influence the purchasing and consumption patterns of youth, even though there is increasing awareness of the risks to health from soft drinks. The objective of the study was to investigate the effect of marketing strategies on the soft drink consumption behavior of young consumers in Attanagalla DS Division, Gampaha District, Sri Lanka. A quantitative research approach was adopted and the data has been collected from 150 young consumers through pre-tested structured questionnaire. Data on demographic characteristics, brand preference, consumption pattern, health awareness, and perception of marketing strategies were obtained from the questionnaire. The data were analyzed by SPSS software using descriptive statistics, correlation and regression analysis. The results showed that the main reason for drinking soft drinks was refreshment where 63.3% of the participants reported. Most respondents were in the 21-25 age group (77.3%) and Sprite was reported as the most preferred brand by 30% of respondents. Marketing strategies still had a strong impact on behavior even though 73.3% of participants were aware that soft drink consumption could pose a health risk. Among the marketing variables, promotion had the strongest positive relationship with soft drink consumption behavior. Regression analysis indicated that promotion, place/distribution, gender and household monthly income were the significant predictors of consumption behavior. This study finding will be valuable for developing marketing tactics, targeted health interventions and policies that regulate.

Keywords: Correlation, Price, Promotion, Place, Regression analysis.

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Consumer Purchasing Patterns of Frozen Chicken in Vavuniya DS Division, Vavuniya District: A Market-Based Study

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Abstract

In recent years, frozen chicken consumption has notably grown because of changing consumer preferences and lifestyle. This research examines consumer purchasing pattern for frozen chicken products in the Vavuniya DS Division, Vavuniya District. It aims to understand the key factors influencing purchase decisions, and primary barriers to consumption. The study utilized a structured pre-tested questionnaire to gather information from 150 consumers, using the convenience sampling method. Data on marketing factors such as price, place, promotion, product, halal certification, brand loyalty, purchasing behavior, physical attribute of consumer -purchasing patterns were obtained from the questionnaire. The data were analyzed by SPSS software using descriptive statistics Regression analysis. Key findings from the study revealed that consumers' primary rationale for purchasing frozen chicken had to do with convenience and easy storage (32.9%), with purchasing from a supermarket being the first (20.8%). The most prevalent barrier to purchase was lack of trust in freshness or quality of product (34.1%). Regression analysis indicated that physical attribute (PA) (B=0.335, p=0.000) and product (B=0.364, p=0.000) have significant positive effects on purchasing behaviors and attributes of the products indicating these factors were significant predictors to purchasing behavior. These findings will assist other stakeholders in the frozen poultry sector to more effectively develop tailored strategies to enhance product appeal and market penetration, which ultimately contributes to grow and sustain the frozen poultry sector in the region.

Keywords: Behavior, Consumption, Demographic factors, Regression, Vavuniya DS Division.

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Formulation of Herbal Soap Based on Consumer Preference: A Study Among Undergraduates in Eastern University, Sri Lanka

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Abstract

The growth of herbal-based cosmetics, especially soaps that contain plant-derived ingredients, has been aided by the rising desire for natural and environmentally friendly personal care products. This study aims to develop herbal soap formulation that aligns with consumer preferences and evaluating its physiochemical properties and assessing its acceptability among undergraduates in Eastern University, Sri Lanka. This study was conducted among 100 undergraduate students from EUSL. Using non-probability sampling method, the students were represented all faculties. A standardized questionnaire was given and got results from undergraduates to gauge consumer preferences for natural ingredients, essential oil, and color. The collected data for this study were analyzed using Excel and Statistical Package for Social Sciences (SPSS) version 27.0. The descriptive analysis shows out of 100 respondents, 81% of undergraduates are female category and 19% of undergraduates are male category. Majority (52%) of respondents are preferred Aloe vera, 29% of respondents prefer rosemary oil, and 32% of respondents prefer green color for the herbal soap formulation. The Aloe vera soap was formulated based on the study that more undergraduates prefer Aloe vera soap. This soap was achieved to its favorable physicochemical properties and high consumer acceptability. This study suggested that producer, the purity, safety, and demonstrated skin benefits should be given top priority when choosing herbal extracts, essential oils, and natural additions to improve the soap's effectiveness and appeal to consumers and consider consumer preferences when formulating herbal soaps. Aligning product attributes with consumer expectations might be facilitated by conducting frequent surveys or sensory evaluations.

Keywords: Ayurvedic importance, Cold saponification, Consumer preference, Herbal soap, Physiochemical properties.

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A Study on Consumer Preferences and Demand for Value-Added Tea Products in Kuruwita DS Division, Rathnapura District, Sri Lanka

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Abstract

Tea is one of the most important beverages. In recent years value addition of commodity has become as a key strategy to increase the sale and competition with diversifying income, and meeting customer demand for innovation. A study was conducted to identify consumer preference and asses demand and to identify most preferred type's features and key aspects considered by producers and consumers during purchasing. This study was conducted using a sample of nearly 300 consumers, 10 producers and 10 retailers Data were collected through structured questionnaires and then collected data were analyzed through Microsoft Excel and SPSS statistics software version 22. Findings shows that the consumer preference and demand of the tea was 101.7 kg/month and average monthly purchase per consumer was 339 g per consumer. The most preferred types of tea were value-added black tea grade and most preferred types of key features were ingredients (23.2%) and flavor (33.5%). The main key aspects considered by consumers during purchasing were types of tea, varieties, brands names, discounts giving, market segmentation, packaging aspects, packing materials, purchasing place, taste, purpose of drinking etc. The study concludes that value-added tea products exhibit strong market demand with flavor and ingredients identified as the key consumer preferences and a clear alignment observed between consumer demand and producer strategies.

Keywords: Beverage, Black Tea, Ingredients, Questionnaire, Taste

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Impact of Social Media on the Academic Performance of Higher National Diploma Students from Information Technology, Accountancy and Agriculture Streams of Hardy Advanced Technological Institute

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Abstract

Social media has become an integral part of students' daily lives, raising important questions about its influence on academic outcomes. This study examines the impact of social media use and time spent on social media on the academic performance of Higher National Diploma (HND) students enrolled in the Information Technology, Accountancy and Agriculture streams at the Hardy Advanced Technological Institute, Ampara, Sri Lanka. A quantitative, cross-sectional research design was adopted, with primary data collected through a structured closed-ended questionnaire administered to first- and second-year students of the three programmes. A total of 450 students approached, 420 valid responses were returned (93 per cent response rate). Two null hypotheses were tested using Pearson correlation and multiple linear regression analysis in SPSS, with the use of social media and time spent on social media specified as the independent variables and academic performance as the dependent variable. The findings reveal a strong positive correlation between use of social media and academic performance ($r = 0.706$, $p < .01$) and a moderate positive correlation between time spent on social media and academic performance ($r = 0.497$, $p < .01$), leading to rejection of both null hypotheses. The results suggest that purposeful, academically oriented engagement with social media can enhance learning outcomes rather than detract from them, providing evidence from an under researched developing country context. Educators, curriculum designers, and policymakers are encouraged to meaningfully integrate social media into teaching and learning and to organise awareness sessions to help students adopt productive social media practices for academic gain.

Keywords: Academic performance; Social media usage; Time spent on social media; Higher education; Sri Lanka.

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Value Addition to Agri and Food Products

Value Addition of Medicinal Plants: Formulation and *In-Vitro* Antibacterial Evaluation of a Polyherbal Balm Using *Cynodon dactylon* and *Azadirachta indica*

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Abstract

Wound infections by pathogenic microorganisms are a significant healthcare issue that may slow recovery and result in complications. The traditional alternative therapeutics also include medicinal plants as they have antimicrobial and wound-healing properties. *Azadirachta indica* (neem) has been claimed to contain high antibacterial, anti-inflammatory properties, *Cynodon dactylon* (Bermuda Grass) has been utilized in wound treatment and has been reported to have antimicrobial action. The lack of wound-healing balms that incorporate these plants and the fact that little has been done on *C. dactylon* in Sri Lanka made this study necessary to determine their antibacterial properties and come up with a low-cost herbal product that can be used to treat wounds. The aim of the paper was to prepare a polyherbal balm using ethanolic extract of *A. indica* and *C. dactylon* and assessing its antibacterial activity against pathogens of choice in wounds through in vitro methods. The aims were to contrast the antibacterial activities of the single extracts and a combination of extracts with *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa* on agar well diffusion and to design and test the antimicrobial activity of the balm. The new plant material was collected and identified, dried in shade and using Soxhlet procedure with ethanol. Separate and combined tests of crude extracts of 50 mg, 75 mg, 100 mg concentrations were done against Selected pathogens. The positive control was ciprofloxacin and negative control was Tween 80. Initial results showed that the initial trial lacked any antibacterial activity. In trial two, the *A. indica* extract had an inhibition zone of 8-11 mm against the *S. aureus* ATCC 6538. No activity was shown against other bacteria and *C. dactylon* extract and the combination formulation did not significantly affect it. These results show strain-specific response and indicate that further optimization should be made to enhance formulation.

Keywords: Polyherbal balm, *Azadirachta indica*, *Cynodon dactylon*, Antibacterial activity, Wound infections.

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Development of Cardamom Flavored Toffee Enriched with Red Rice Bran and Palm Sugar

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Abstract

The growing consumer preference for healthier and functional confectionery products has encouraged the development of nutrient-enriched toffees using natural ingredients. This study focused on the development and evaluation of cardamom-flavored toffee enriched with red rice bran and palm sugar as a value-added alternative to conventional sugar-based toffees. Five toffee formulations (T_1 – T_5) were prepared using different ratios of red rice bran and milk powder as follows: (T_1) 0 g:42 g, (T_2) 4 g:38 g, (T_3) 8 g:34 g, (T_4) 12 g:30 g, and (T_5) 16 g:26 g, while keeping the other ingredients constant. The experiment was conducted using a completely randomized design with three replicates for each treatment. The formulated toffees were evaluated for physico-chemical, nutritional, microbial, and sensory properties to determine the most suitable formulation for consumer acceptability. Physico-chemical analysis revealed that increasing red rice bran levels significantly ($p \leq 0.05$) increased moisture, ash, and fiber contents, while slightly decreasing protein, fat, and total soluble solids. Sensory evaluation was conducted using 30 semi-trained panelists and a seven-point hedonic scale to assess color, flavor, texture, taste, and overall acceptability. Among the formulations, T_3 received the highest preference scores due to its smooth texture, pleasant cardamom flavor, and balanced sweetness. Microbial studies indicated that all samples remained within acceptable limits, while T_3 demonstrated the best microbial stability with minimal bacterial and fungal growth. The study concluded that cardamom-flavored toffee enriched with red rice bran and palm sugar provides a balanced combination of nutritional value, functional properties, and sensory acceptability, showing potential as a functional confectionery product for health-conscious consumers.

Keywords: Cardamom flavored toffee, Nutritional quality, Physico-chemical properties, Red rice bran, Sensory attributes.

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Effect of Brining Time on the Quality of Wet Salted Dried Tilapia Fish

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Abstract

Tilapia is an excellent source of macro and micronutrients. It has a very short shelf life (12 to 24 hours) at normal temperature. Preservation method is very important to extend its shelf life. Combining salting and drying is one of the important preservation methods of tilapia. This study focus on effect of brining time on the quality of wet salted dried tilapia fish. The research evaluated the effect of different brining times on the physicochemical properties, sensory characteristics and ensure microbial qualities of wet salted dried tilapia fish. Five different time such as 1 minute (T_1), 30 minutes (T_2), 1 hour (T_3), 1 hour 30 minutes (T_4), 2 hours (T_5) were used to wet salting the tilapia fish. Physicochemical analysis revealed that with increasing the salting time, ash and protein content increased, while moisture content, fat content and pH decreased. The color L* value (lightness) increased, whereas a* value (green to red) and b* value (blue to yellow) decerased with increasing wet salting time. Sensory evaluation was conducted by 30 semi trained panalist, using seven point hedonic scale to assess texture, flavor, taste, color and overall acceptability. The results showed that 2 hours wet salting tilapia fish (T_5) received the highest preference scores among tested duration. Microbial analysis after 48 hours of incubation the fungi and bacterial colonies of microbes were reduced according to increasing salting time of tilapia. Tilapia fish at 2 hours of wet salting (T_5) had better results than the other treatments. The study offers valuable insights into the wet salted preservation of tilapia, demonstrating that an optimal brining time significantly enhances the effectiveness of the preservation process.

Keywords: Brine salting, Microbial quality, Physiochemical quality, Salt penetration, Sensory evaluvation.

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Effect of Dietary Supplementation of *Bacillus subtilis* and *Bacillus licheniformis* on Growth Performance of Commercial Broilers

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Abstract

The use of antimicrobials as growth promoters in livestock, including poultry, is banned in Sri Lanka due to concerns regarding antimicrobial resistance development. Probiotics offer a safer alternative for antibiotic growth promoters; however, the efficacy of many commercially available probiotic products in enhancing poultry growth performance has not been adequately evaluated. Therefore, this study aimed to evaluate the effect of a probiotic combination containing *Bacillus subtilis* and *Bacillus licheniformis* on growth performance of commercial broilers. The experiment was conducted in a completely randomized design (CRD). A total of 270, day-old Ross 308 FF broiler chicks were randomly allocated into three groups; 90 per group, i.e. six replicates of 15 birds in each group. The control group received only the basal diet and was designated as Treatment 0 (T0). The test group 1 was given 400g/ton of probiotic added broiler feed (Treatment1: T1), while the test group 2 received 500g/ton probiotic added broiler feed (Treatment2: T2). Data on initial chick weight, daily mortality, weekly feed intake and body weight, and duodenal histology on day 35 were collected. Data was analyzed using one-way ANOVA under the CRD model. The results showed that supplementation with tested probiotic (T1 and T2) significantly improved broiler growth performance parameters, broiler performance efficiency index and duodenal morphometry, compared to the control group (T0). Furthermore, T1 exhibited the most favorable economic and biological impact on broiler growth performance compared to T2, indicating its suitability as an effective alternative to antimicrobial growth promoters in commercial broiler production.

Key Words: Probiotics, Duodenal Morphometry, Feed Intake, Broiler Performance Efficiency Index

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Development and Quality Evaluation of Biscuits Using Wheat Flour and Sweet Potato Flour

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Abstract

Biscuits are widely consumed bakery products due to their convenience, low cost, and long shelf life. However, those made from refined wheat flour provide limited nutritional benefits. This study aimed to enhance the nutritional quality of biscuits by partially replacing wheat flour with sweet potato flour, which is rich in dietary fiber and minerals. Five formulations were prepared: 100% wheat flour (T_0), wheat flour: sweet potato flour 90:10 (T_1), 80:20 (T_2), 70:30 (T_3), and 60:40 (T_4). All samples were produced under identical conditions and evaluated for physical, chemical, and microbial properties. Results showed that increasing sweet potato flour improved both nutritional and physical characteristics. Moisture content increased from 3.68% in T_0 to 4.45% in T_4, while ash content rose from 1.29% to 1.50%. Crude fiber also improved from 0.46% to 0.66%, indicating enhanced nutritional value. Protein content showed a slight decrease from 4.05% to 3.95%, and fat content reduced significantly from 25.45% to 20.21%, contributing to a healthier product. Improvements were also observed in total sugars, reducing sugars, antioxidant activity, pH, and total soluble solids. Physical analysis revealed that T_4 had the highest spread ratio, along with increased diameter and reduced thickness, indicating better dough expansion during baking. Microbial analysis after one week confirmed that all samples were safe for consumption, with T_0 recording 0.72 CFU/g and T_4 showing a lower value of 0.64 CFU/overall, T_4 (60% wheat flour and 40% sweet potato flour) was identified as the best formulation, offering improved nutritional quality, desirable physical properties, and acceptable microbial safety, making it a promising option for developing healthier bakery products.

Keywords: Biscuit development, Composite flour, Nutritional enhancement, Sweet potato flour, Wheat flour substitution

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Development and Quality Evaluation of Tea Bun Prepared from Jackfruit *(Artocarpus heterophyllus)* Seeds Flour

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Abstract

This study investigates the feasibility of utilizing jackfruit seeds as a sustainable and nutritious substitute for wheat flour in tea bun production. Jackfruit seeds are an underutilized by-product of jackfruit processing and are often discarded as waste, despite their rich nutritional composition, which includes protein, fiber, carbohydrates, minerals and bioactive compounds. In the context of increasing consumer demand for healthier bakery products and the need to reduce food waste, jackfruit seed flour offers a promising alternative ingredient for value-added food development. The main objective of this study was to optimize tea bun formulations by replacing wheat flour with jackfruit seed flour at different substitution levels while maintaining desirable sensory, physical, and nutritional qualities. Jackfruit seeds were collected, cleaned, steamed, peeled, sliced, oven-dried, ground and sieved to obtain jackfruit seed flour. Tea buns were prepared using five formulations: 0% (T_1), 10% (T_2), 20% (T_3), 30% (T_4) and 40% (T_5) jackfruit seed flour substitution. The products were evaluated for sensory attributes using a seven-point hedonic scale and for proximate composition using standard analytical methods. The results showed that increasing jackfruit seed flour significantly affected sensory and nutritional properties. T_1 recorded the highest scores for texture, flavor, taste, color and overall acceptability, while T_2 and T_3 maintained acceptable sensory quality, with no significant reduction in overall acceptability compared to the control. In contrast, higher substitution levels (T_4 and T_5) significantly reduced sensory scores. Proximate analysis revealed significant differences among treatments, with moisture, ash, protein, and fiber contents increasing progressively, while fat content decreased as jackfruit seed flour increased. Overall, tea buns containing 10% jackfruit seed flour showed the best balance between nutritional enhancement and consumer acceptability. This study demonstrates that jackfruit seed flour can be effectively incorporated into tea buns, offering a practical approach to waste valorization, nutritional improvement, and sustainable bakery product development.

Keywords: Jackfruit seed flour, Tea bun, Sensory evaluation, Proximate analysis, Wheat

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Formulation of Functional Milk toffee Fortified with Moringa Leaf Extract

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Abstract

The increasing demand for functional confectionery products has driven the incorporation of natural bioactive ingredients to improve both nutritional value and health benefits. *Moringa oleifera* leaves, recognized for their high content of proteins, vitamins, minerals, and antioxidants, offer strong potential as a fortifying agent in dairy-based sweets. This study focused on the development of milk toffee fortified with different concentrations of moringa leaf extract (T_1: 3 ml, T_2: 6 ml, T_3: 9 ml, and T_4: 12 ml), while an unfortified sample (T_0) served as the control. The formulated products were evaluated for proximate composition, physicochemical characteristics, antioxidant activity, microbial quality, and sensory properties. Among the treatments, the sample containing 6 ml of moringa leaf extract (T_2) demonstrated the most favorable overall quality. Fortification resulted in increased moisture (8.73%), ash (0.86%), and protein (2.99%) contents compared to the control (7.52%, 0.43%, and 2.90%, respectively), indicating enhanced nutritional value. Conversely, slight reductions were observed in fat (19.70%) carbohydrate (67.72%) and pH (6.20) content compared to control (20.20%, 68.95% and 6.53), while total soluble solids increased from 5.66 to 5.80. A substantial improvement in antioxidant activity was recorded in T_2 (18.90%) compared to T_0 (5.03%), confirming the beneficial contribution of moringa derived bioactive compounds. Microbiological analysis showed a reduction in total plate count from 1.2×10^2 CFU/g in the control to 0.9×10^2 CFU/g in T_2, with no detectable yeast or mold, indicating improved microbial safety. Overall, fortification with 6 ml of moringa leaf extract significantly enhanced the nutritional, functional, and microbial properties of milk toffee while maintaining acceptable sensory quality, highlighting its potential as a value-added functional confectionery product.

Keywords: Antioxidant activity, Bioactive compounds, Moringa leaf extract, Proximate composition

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Development and Quality Evaluation of Value-Added Dates (*Phoenix Dactylifera*) Jam

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Abstract

Jam is a semi-solid product widely used as a spread in bakery products. Date jam is prepared from the pulp of ripe dates. The date palm (*Phoenix dactylifera*), belonging to the family Arecaceae, is one of the oldest cultivated fruit trees in the world. Dates are highly nutritious and rich in natural sugars, dietary fiber, vitamins, and minerals. This study aimed to develop date-based jam with improved nutritional and sensory qualities while ensuring food safety and shelf stability. Ripe date pulp was prepared by washing, soaking, deseeding, and blending. Four treatments were formulated: T0 (control), T1 (40% sugar), T2 (40% jaggery), and T3 (40% glucose syrup). The mixtures were cooked with pectin and citric acid until 105°C and 65–68 °Brix, then cooled, packed in sterilized jars, and stored at refrigerator between 3°C to 5°C temperature range. The research focused on producing a healthier alternative to jams containing artificial colors and sweeteners commonly available in Sri Lanka. Physicochemical analyses, including pH, moisture content, Total Soluble Solids, and Titratable acidity, were conducted using standard AOAC methods. Sensory evaluation was performed by 30 semi-trained panelists using a seven-point hedonic scale to assess texture, color, spreadability, taste, appearance, and overall acceptability. Results indicated that T3 (date pulp with glucose syrup) showed the highest scores in texture, color, spreadability, taste, and overall acceptability, while T2 had comparable appearance to T1. The findings revealed that glucose syrup-based date jam is the most preferred formulation among the tested samples. Furthermore, the initial bacterial and fungal population of the dates jam was 4.7×10^4 CFU/g and 1×10^4 CFU/g respectively, the minimum count was recorded in the prepared by T_3 dates pulp with glucose syrup jam, confirming its safety for consumption. In conclusion, date pulp-based jam demonstrates strong potential for commercial production as a nutritious and acceptable alternative to conventional jams.

Keywords: Dates, Jaggery, Nutritious, Sweeteners

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Assessing the Effectiveness of Food Safety Labels in Shaping Buying Behavior: A Study of Printed and Electronic Advertisements in Homagama DS Division, Colombo District, Sri Lanka.

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Abstract

Food Safety Labels act as a vital link between consumers and the food industry, serving as a mechanism for delivering health, nutrition, and safety information. Despite their importance, the effectiveness of these labels in shaping consumer buying decisions remains underexplored in Sri Lanka. This research aimed to evaluate the effectiveness of food safety labels in influencing consumer buying behavior, particularly examining the impact of printed versus electronic advertisements within the Homagama DS Division. A pre-tested, structured questionnaire was distributed to 100 consumers selected through convenience sampling. Quantitative data were analyzed utilizing descriptive statistics and multiple regression analysis via SPSS version 22. Results indicated that printed and electronic advertisements enhance consumer awareness; however, electronic media proved more effective due to its visual appeal and reach. Among the independent variables, consumer awareness and understanding ($p = 0.002$), trust and perceived quality ($p = 0.001$), and label design and format ($p = 0.030$) were statistically significant at the 0.05 level, while information content ($p = 0.082$) was significant at 0.1 level. In contrast, health and content claims ($p = 0.817$) showed no significant impact on consumer buying behavior. The research concludes that psychological and perceptual factors especially trust, label design play a crucial role than health content or demographics in shaping consumer decisions. These findings highlight the need for communication strategies that combine information with visually appealing and trustworthy label presentations, offering practical insights for policymakers, regulatory authorities, and manufacturers to enhance label credibility and promote healthier purchasing decisions in Sri Lanka.

Keywords: Consumer Buying Behavior, Consumer Trust, Food Safety Labels, Label Design, Printed and Digital Advertisements.

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Determination of Junk Food Consumption among Adolescents in Gampaha D.S. Division, Sri Lanka

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Abstract

The increasing prevalence of junk food consumption among adolescents poses significant health risks, particularly in developing countries like Sri Lanka. Adolescents need to develop adequate knowledge and adopt practices to reduce the health risks associated with the consumption of junk food. Therefore, this study was conducted to assess junk food consumption patterns and associated factors among adolescents aged 13-19 in the Gampaha D.S. Division. A cross-sectional study was carried out among 379 students selected using the described formula and random sampling technique. Data were collected using a pre-tested semi-structured questionnaire. Descriptive statistics and Pearson's chi-square test were used to analyze the data. The findings revealed that most participants were 14 years old, with a higher proportion of females. Most students had a nuclear family environment, and almost all lived with their parents. Although most adolescents were aware of junk foods, consumption remained high due to taste preference. Many consumed junk foods 1-2 times per week and spent Rs. 50-100 per day. The present study found that there was a significant association ($p < 0.05$) between knowledge about junk food and living status, father's education and mother's occupation. Also, there was a significant association ($p < 0.05$) between money expenditure on junk food and age, living status, father's education, father's occupation and family income. Furthermore, there was a significant association ($p < 0.05$) between knowledge about non-communicable diseases due to junk food consumption and some sociodemographic characteristics such as family type, living status and mother's occupation. The study highlights the need for targeted nutritional education programs and policy interventions to mitigate the adverse health effects associated with junk food consumption among adolescents. By addressing these factors, we can promote healthier dietary habits and improve the overall well-being of this vulnerable population.

Keywords: Adolescents, Disease, Gampaha, Health, Junk food.

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Formulation of Infant's Weaning Food Mixes Using Unripe Banana and Cereal Mix

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Abstract

Weaning foods are crucial for infant nutrition during the transition from milk to semi-solid foods. Unripe banana (*Musa spp.*) is rich in resistant starch, minerals, and bioactive compounds, making it a valuable ingredient for nutrient-enriched infant foods. This study aimed to develop and evaluate weaning food mixes prepared from unripe banana and cereal combinations to improve nutritional value, microbial safety, and sensory acceptability. Four treatments were formulated using different proportions of unripe banana powder and roasted rice flour, while the quantities of green gram flour, finger millet flour, sesame, and cardamom remained constant. T_1 (control) contained 0 g unripe banana powder and 50 g roasted rice flour, T_2 contained 10 g unripe banana powder and 40 g roasted rice flour, T_3 contained 20 g unripe banana powder and 30 g roasted rice flour, and T_4 contained 30 g unripe banana powder and 20 g roasted rice flour. The formulations were analyzed for moisture, ash, fibre, protein, fat, pH, titratable acidity, microbial quality, and sensory attributes. The experiment was conducted using a completely randomized design with three replicates for each treatment. Results showed that ash, fibre, protein, fat, pH, and titratable acidity significantly increased compared to the control, while moisture significantly decreased. Sensory evaluation revealed significant differences ($p<0.05$) among treatments. T_4 achieved the highest acceptability scores for colour, texture, flavour, taste, and overall acceptability. No microbial activity was detected in any treatment. The study concluded that T_4 provided the best balance of nutritional, microbial, and sensory qualities, making it a promising banana-based weaning food.

Keywords: Unripe banana, Weaning food, Infant nutrition, Sensory evaluation, Cereal combinations.

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An Integer Programming Model for Blending Optimization in Food Production Technology

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Abstract

Blending problems form an essential category of optimization models which have found extensive use in process industries, where a number of raw materials are blended into final products having desired quality characteristics. This research develops a MILP model of a blending problem in the food industry considering factors such as nutritional requirements, restrictions and economy taking into account production planning and advertising considerations. The proposed model considers n food products that have been manufactured using m raw materials. The raw materials are characterized in terms of their costs, availability and composition, whereas the products will be identified in terms of their selling prices, demands, and quality constraints. Two quality parameters are considered, a desirable quality, such as protein content which must satisfy minimum limits and an undesirable quality, such as aflatoxin which must remain below maximum allowable levels. In order to increase the realism of the model, advertising expense will be considered as a decision variable that affects demand for the products. Furthermore, the processing cost will be treated as a parameter representing the cost involved in converting raw materials to finished products. Finally, the parametric approach will be used to express demands, costs, capacities and quality constraints in symbolic form. An illustrative numerical example with $n = 3$ types of products and $m = 3$ kinds of raw materials is developed in this study, considering cereal manufacturing processes utilizing wheat flour, soy flour and corn flour. The solution shows that costs associated with advertising and processing had a considerable impact on the optimum mixing process. The proposed model can be used as an effective decision making tool for optimizing food blending operations and demonstrates the adaptability of classical blending models to modern food production systems.

Keywords: Blending optimization, Food production, Mixed integer programming, Advertising decisions, Processing cost.

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Analysis of Organic Acids in Root Crops

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Abstract

Organic acids are very common substances, like other important compounds found in plants - carbohydrates and proteins. They are found in the seeds, leaves, roots, flowers and fruits of plants. Organic acids are found in different parts of plants in different quantities. Fresh fruits and vegetables always have an acidic reaction (pH<7). Depending on the pH value, acidic (pH 2.5-4.5) and non-acidic (pH 4.6-6.5) plant materials are distinguished. Although this division is conditional, it determines the possibility of development of certain types of microorganisms and guides in choosing the sterilization mode of canned food. The most common acids in fruits and vegetables are malic, citric and tartaric acids. Oxalic, succinic, benzoic, salicylic and some other acids are also found in small quantities. Malic acid and its salts, as well as citric, tartaric and oxalic acids, are soluble in water. Potassium and sodium salts of citric acid are also soluble in water. The average calcium salt of citric acid is difficult to dissolve in cold water and easily in hot water. The solubility of cream of tartar in water is relatively small. Potassium and sodium salts of oxalic acid are soluble in water, and calcium oxalate is insoluble.

Keywords: Citric acid, Chromatographic method, Malic acid, Oxalic acid Roots, Tartaric acid.

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