# 12th INTERNATIONAL CONFERENCE ON DRY ZONE AGRICULTURE (ICDA 2026)

## "Smart Solutions for Commercial Agriculture"

## CONFERENCE PROCEEDINGS

## Faculty of Agriculture, University of Jaffna, Sri Lanka

**24th June 2026**
**Faculty of Agriculture, University of Jaffna**
**Ariviyal Nagar, Kilinochchi, 44000, Sri Lanka**

# PROCEEDINGS OF THE 12th INTERNATIONAL CONFERENCE ON DRY ZONE AGRICULTURE (ICDA 2026)

## "Smart Solutions for Commercial Agriculture"

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# Messages from Dignitaries

# Message from the Vice Chancellor

**Snr. Professor T. Velnampy**
**Vice Chancellor**
**University of Jaffna**
**Sri Lanka**



As the Vice Chancellor, I warmly welcome you to the 12th International Conference on Dry Zone Agriculture (ICDA 2026), organized by the Faculty of Agriculture, University of Jaffna. Your participation in this conference greatly enriches the academic environment of the University and contributes to the success of this prestigious international gathering.

Agriculture is a major sector in Sri Lanka's economy, supporting food security, employment, and rural livelihoods. Contributing approximately 8.4% to the national GDP in 2025, the sector continues to play a key role in national development. However, significant opportunities exist to enhance its contribution through innovation, value addition, and commercialization.

Sri Lanka is not an exceptional country for the global challenges such as pandemics, economic and fuel crises, climate change, and natural disasters. These challenges have underscored the need for resilient and sustainable agricultural systems that can ensure food security while supporting economic growth. Developing innovative solutions and adaptive strategies is essential to address emerging uncertainties and changing conditions. With the theme **"Smart Solutions for Commercial Agriculture,"** ICDA 2026 will provide an excellent platform to explore emerging technologies, innovative practices, and sustainable approaches for advancing commercial agriculture.

The conference will provide a platform to strengthen academic collaborations, expand business networks, and connect agricultural stakeholders while facilitating the effective transfer of research innovations and findings into practice. The participation of globally recognized scientists and distinguished experts will further enrich the conference and enhance its impact.

I congratulate the organizing committee and wish ICDA 2026 every success and a rewarding experience for all participants.

# Message from the Conference Chair

**Prof. K. Pakeerathan**
**Dean**
**Faculty of Agriculture**
**University of Jaffna**
**Sri Lanka**



It is with great pride and privilege to present the conference chair message to the proceedings of the 12th International Conference on Dry Zone Agriculture (ICDA 2026) from the bottom of my heart. As dry zone agriculture faces numerous challenges including climate variability, water scarcity, soil degradation, declining biodiversity, and socio-economic uncertainties, this year ICDA 2026 theme, "Smart Solutions for Commercial Agriculture" encapsulates the diverse research outcomes derived from scholarly findings and researchers, academics, policymakers, industry experts, development practitioners, and students, and providing an important platform to exchange scientific knowledge, innovative technologies, in the era driven by artificial intelligence.

It is obvious that identifying climate change challenges will not bring fruitful outcome unless formulating innovative plan and research-driven solutions, investment on R&D, and strong multidisciplinary partnerships among stakeholders. Faculty of Agriculture, University of Jaffna, as leading academic institution shouldering dry zone agriculture related fundamental and advanced research culture, organize its own 12$^{th}$ international conference with a diversified outstanding research papers submitted by both National and International researchers to disseminate groundbreaking research findings that are most appropriate to address dry zone agriculture challenges. Within the geopolitical crisis, successful organization of ICDA consecutively for 12 years is not a simple task in the absence of advanced planning and coordinated working of dedicated master minded academics with the strong support from the University administration.

ICDA's uniqueness has been deeply planted among the international Agricultural research community. As dean of the faculty and conference chair, I would like to express my sincere appreciation to chief guest, Plenary speaker, keynote speaker, session evaluators, authors, reviewers and volunteers for your immense contribution, support and guidance to the success of the ICDA 2026. Your active participation strengthens the collective effort to build sustainable and resilient agricultural systems for future generations.

# Message from the Convener



**Dr. S. Thatchaneshkanth**
**Senior Lecturer**
**Department of Animal Science**
**Faculty of Agriculture**
**University of Jaffna**
**Sri Lanka**

It is a distinct honor and privilege to welcome all participants, contributors, and distinguished guests to the 12th International Conference on Dry Zone Agriculture (ICDA 2026) hosted by the Faculty of Agriculture, University of Jaffna. The theme of this year's conference, "Smart Solutions for Commercial Agriculture," reflects the growing importance of science, technology, and innovation in transforming agricultural systems into more productive, resilient, and sustainable enterprises. As the global agricultural sector faces increasing pressures from climate variability, resource limitations, environmental degradation, and rising food demands, the need for intelligent and adaptive solutions has never been greater. Technological innovations are transforming agriculture through precision farming, digital technologies, and climate-smart practices. These advancements enhance productivity, support environmental sustainability, and, through research and collaboration, contribute to improved food security, rural development, and sustainable economic growth. ICDA 2026 brings together academics, researchers, industry professionals, policymakers, extension personnel, and students to exchange knowledge and develop innovative solutions to current agricultural challenges. The conference emphasizes multidisciplinary collaboration, while the proceedings showcase the scientific excellence and commitment of contributors toward advancing agricultural knowledge and promoting a sustainable future for dry zone agriculture.

I extend my sincere appreciation to all authors, keynote speakers, reviewers, sponsors, partners, and members of the organizing committee for their hard work and commitment, which have made this conference possible. Your contributions are deeply valued and are fundamental to the success of ICDA 2026. I wish all participants a rewarding conference experience filled with insightful discussions, productive networking opportunities, and lasting collaborations. May the outcomes of this conference inspire innovative solutions that advance commercial agriculture and the well-being of communities across the region and beyond.

# Message from the Finance Chair



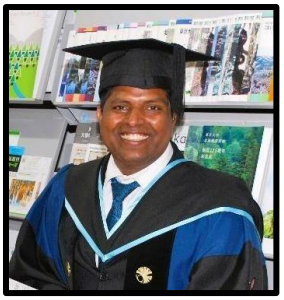
**Dr. S. J. Arasakesari**
**Senior Lecturer**
**Department of Agricultural Biology**
**Faculty of Agriculture**
**University of Jaffna**
**Sri Lanka**

With a deep sense of joy along with a great privilege, I meet you through the leaves of proceedings of the International Conference of Dry zone Agriculture 2026 as the financial chair of this prestigious event. This is prime event organized annually by the faculty of agriculture which serves a potential source of knowledge hub in the field of agriculture in the dry zone. Not only in academic matters, research and outreach but also open an avenue for international scientists to share their valuable findings of their yearlong efforts and dedicated hard work individually or as these are very important and needy messages to those in need especially the farming community. I am happy to work with absolutely hardworking committee members for the success of each and every facet of this conference. We know that the entire world is facing great challenges to fight against hunger, energy demand and the availability of domestic goods for better lining. As research which generate solutions is a continuous process to mitigate all the ill effects which hinders the progress of mankind.

I sincerely appreciate the support of the University of Jaffna for providing funds for meeting initial arrangements of this conference. The support of JICA -PRECIDA, a well-wisher's Japanese team which motivates us strongly always by the financial support. The support of the National Science foundation (NSF), Sri Lanka is commendable. Though the world is facing financial crisis, The World Vision, Avon Pharmo Chem and few other well-wishers opened their doors and extended their generous support when we knocked their doorsteps. We are extremely thankful to all the academic staff of the faculty for supporting financially to conduct this conference as a very successful one. Finally, I wish you all for your future endeavors.

# Message from the Joint Secretaries





**Dr. (Mrs) A. Shayanthan**
**Senior Lecturer**
**Department of Agricultural Chemistry**
**Faculty of Agriculture**
**University of Jaffna**
**Sri Lanka**

**Dr. K. Jeyavanan**
**Senior Lecturer**
**Department of Agronomy**
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**University of Jaffna**
**Sri Lanka**

It is our great pleasure to welcome you to the 12th International Conference on Dry Zone Agriculture (ICDA 2026) organized by the Faculty of Agriculture, University of Jaffna. On behalf of the organizing committee, we extend our sincere gratitude to the plenary speaker, keynote speaker, session chairs, evaluators, authors, presenters, reviewers, and supporters, and all other participants for contributing to this important international event.

Under the theme **"Smart Solutions for Commercial Agriculture,"** ICDA 2026 provides a valuable platform for sharing innovative research, emerging technologies, and practical solutions to address current challenges in agriculture. The conference brings together experts, academics, researchers, industry professionals, and students from diverse disciplines to exchange knowledge and strengthen collaborations.

We are confident that the plenary session, keynote address, scientific sessions, and networking opportunities will inspire new ideas and foster partnerships that contribute to sustainable agricultural development and commercial success.

Our sincere thanks go to all the funders and sponsors for their generous support in making this scientific event a great success.

We wish all participants a fruitful and rewarding conference experience and thank you for being part of ICDA 2026.

# Addresses from the Professional Excellencies

# Use of Biological Inocula in Agriculture



**Ivan J. Oresnik[1,2],** Matthew G. Bakker[1], Terrence H. Bell[3], Oliva Wilkins[4], Derek G. Brewin[5], and George C. DiCenzo[1,2]

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The ability to cultivate plants vital for agriculture to maintain a sustainable food supply has been a key trait that has supported the growth of a stable society. Plants are often considered primary producers because they use carbon dioxide as a source of carbon and sunlight to convert it into organic compounds. Beyond this, plants rely on other nutrients found in the soil where they grow. If we assume that atmospheric carbon dioxide and solar light are unlimited, it becomes clear that soil nutrients will limit plant growth. The major nutrients needed for plant growth are nitrogen, phosphate, and potassium. Among these, plant productivity is often directly correlated with the amount of nitrogen available.

Soil develops through a combination of biological and physical processes over time. Repeated crop cultivation on the same land without amendments results in decreased productivity and soil degradation (Meena et al., 2017). Agricultural output can only be sustained by adding fertilizers to meet the plants' nutritional needs.

The industrialization of the Haber-Bosch process, which uses natural gas to provide energy for converting atmospheric nitrogen into ammonia, triggered the Green Revolution that doubled the world's population over 50 years. It is estimated that this process directly provides up to 30% of the nutritional needs of the global population; ultimately, 50% of human protein comes from this process. Although industrial nitrogen fixation has been successful, it remains inefficient, with only 40-59% of the applied nitrogen being absorbed by plants (Lynch and Whipps 1990). Besides being economically wasteful, excess nitrogen runoff from fertilizer use is linked to numerous global ecological issues, including increased greenhouse gas emissions and ocean dead zones.

Since the 1960s, global fertilizer consumption has increased from approximately 28 million tonnes in 1961 to 183 million tonnes in 2023. While the use of phosphate and potassium grew 3.75 and 4.3 times, respectively, nitrogen use nearly increased tenfold (Hannah Ritchie et al., 2022). This rise in fertilizer use is connected to a global increase in crop production and a growing world population. Unfortunately, our reliance on

fertilizers for food production is affected by geopolitical events. For example, in Canada, about 90% of the nitrogen fertilizer used in Eastern Canada comes from Russia, which faced a 35% tariff due to the conflict in Ukraine in 2022 (McGregor, 2022). Phosphate fertilizer is a non-renewable, mined resource that some estimate could run out in 50 to 100 years, with 72% of rock phosphate reserves located in the disputed territory of Western Sahara (Kasprak, 2016). More recently, the 2026 conflict in the Persian Gulf has impacted 36% of the global urea supply. Although it's difficult to imagine agriculture without fertilizer amendments, our future should focus on reducing reliance on these inputs by using biological inoculants that can either replace or improve plant nutrient use efficiency.

**Plant growth promoting rhizobacteria**

Bacteria play a vital role in nutrient cycling. Plants exude carbon and nitrogen compounds through their roots, enriching bacterial growth in the area around the roots, known as the rhizosphere. It has been shown that compounds secreted by plants significantly influence which bacteria thrive and survive in the rhizosphere. Over the past 50 years, many reports have documented bacteria that positively affect plant growth, known as plant growth-promoting rhizobacteria (PGPR) (Vessey, 2003). The mechanisms attributed to PGPRs vary. Some involve direct interactions, such as reducing atmospheric nitrogen, increasing phosphate solubility, and promoting phytohormone production, while others involve indirect processes like inducing systemic resistance or biocontrol of potential pathogens (Nazari and Smith, 2020). Bacteria involved in these interactions can live within the rhizosphere or, in some cases, as endophytes. Extensive research has established that PGPRs are real, and bacteria capable of these functions do not come from a single species or bacterial family. It is also true that most reported effects have been demonstrated in controlled environments where PGPRs are essentially the only bacteria present. The potential of these organisms for sustainable agriculture has long been recognized, but their widespread industrial application remains unrealized. Although some products are commercially available, their effectiveness at the field level is often limited.

**What can we learn from microbial community analysis?**

The field of microbial ecology has been one of the fastest-growing fields. In large part, this has been driven by advances in sequencing technologies. Early studies based on amplicon sequencing of the 16S ribosomal region showed that agricultural soil contains more than $10^9$ viable bacteria per gram of soil, and that these can belong to over $10^4$ species (Handelsman 2004). This led to the concept of microbiomes in human health, and, in agriculture, the term plant microbiome was introduced in 2012 (Oresnik et al., 2016).

With the advent of Next Generation Sequencing technologies, metagenomic studies of soil allowed the isolation and sequencing of larger amounts of environmental DNA. With this, there was also an increase in the bioinformatic capability to handle these large data sets, and there was also a large increase in the number of isolated bacteria with fully sequenced genomes. Collectively, this has led to the ability to predict

community functionality. It has also enabled hypothesizing about how bacterial communities functioning.

**Synthetic bacterial communities**

The concept of a bacterial synthetic community (SynCom) is just over a decade old. In its infancy, it was used to model plant-microbial interactions and to help understand ecological processes. The goal of developing a SynCom is to first understand the microbiome associated with a specific plant, then use this data to assemble isolated bacteria that fulfill the predicted roles of the core microbiome originally identified (Shayanthan et al., 2022). This approach is very much a synthetic biology method for understanding plant-microbe interactions. Although it is a complex approach, it has produced positive results in some field studies (Wang et al., 2021). However, it is still difficult to see how a synthetic community with multiple members could be applied to a field crop under real-world conditions.

**How can we use PGPR's be used in agriculture?**

There is strong evidence that biologicals should be part of the strategy for sustainable agriculture. The main obstacle to widespread adoption of biologicals is their effectiveness, will the biologicals perform as promised? Most of our experience with applying biological inocula comes from legume crops where a single *Rhizobium* strain is applied at planting. The rhizobium-legume relationship may not be the best example of using diverse bacteria on other crops. For instance, the connection between rhizobia and its host plant is specific, and often the number of rhizobia added at planting greatly exceeds the resident rhizobia. Even with *Rhizobium*, competition can be an issue when the resident population is high (Mendoza-Suárez et al., 2021).

A key lesson from microbial community analysis is that bacterial species do form structured communities. Each bacterial species can have either mutualistic or antagonistic relationships. The literature also shows that PGP traits are not limited to a single bacterial species. A potential way forward is to determine if a PGPR can interact positively with the existing microbial population. To my knowledge, such studies have yet to be conducted. Additionally, although many bacteria are reported to have PGP traits, these are often not studied in great detail. Gaining a better understanding at the molecular level could help improve their effectiveness. Furthermore, understanding the organism's basic physiology can be useful. For example, how well do the bacteria survive in the field after growth in a fermenter with optimal nutrients? How well do the bacteria withstand industrial processes? Although many of these are fundamental questions, they are often not characterized until very late in development.

**Do plant breeding strategies need to be revisited?**

Breeding agricultural crops has significantly improved quality, overall yield, and resistance to many pathogens. However, breeding strategies tend to focus on phenotypes that are easy to observe and measure. This often means that what happens below ground is overlooked. Land plants have always coexisted with soil bacteria. Sometimes, breeding for one trait might result in the loss of another trait that was not initially targeted. In breeding programs, plants are usually grown under ideal

conditions, and their interactions with soil microbes are often not considered. There are known examples of plant genotypes that respond positively to specific microbes. Yet, in reality, we understand very little about what constitutes a positive plant-microbe interaction at its early stages. Gaining insight into these early interactions could be advantageous if we can identify quantitative molecular traits, enabling us to breed crops that effectively interact with PGPR. Similarly, even with legumes, many Rhizobia strains in culture collections have not been revisited for many years, and biological nitrogen fixation has not typically been included as a trait in legume breeding programs.

**Conclusions**

Biologicals hold significant promise for developing more sustainable agricultural practices. This has been recognized for a long time. It is also evident that biologicals are unlikely to replace conventional fertilizers. The goal for the future is to better understand how to use microbial inoculants to reduce fertilizer use, protect the soil, and reduce ecological harm caused by overuse.

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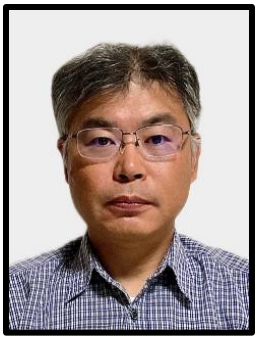
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# Digital Transformation in Forestry: Challenges and Opportunities



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## Introduction

In the business and management literature, digital transformation (DX) is defined as "a change in how a firm employs digital technologies to develop new digital business models that create and appropriate more value" (Verhoef et al. 2021). DX is commonly understood as a process consisting of three stages: digitization, digitalization, and digital transformation (Verhoef et al., 2021). Digitization refers to the conversion of analog information into digital formats. Digitalization involves the use of digital technologies to improve or transform existing operational processes. Digital transformation represents the most advanced stage, characterized by organization-wide change and the development of new business or management models that may be novel to an organization or, in some cases, to an entire industry.

In recent years, DX has progressed rapidly in Japan's forestry sector (Kajisa & Teraoka, 2022). The Forestry Agency of Japan defines forestry DX as initiatives that leverage technologies such as remote sensing, artificial intelligence (AI), and information and communication technology (ICT) to fundamentally transform conventional forestry operations through data digitization and utilization (Forestry Agency, 2026). Forestry DX is increasingly being promoted as a means to address long-standing challenges such as low labor productivity and high occupational risks, while simultaneously enhancing the attractiveness and sustainability of the sector (Shikata et al., 2025). The government has further set a policy target to achieve the "full utilization of digital technologies" among motivated forestry managers by 2028 (Forestry Agency, 2023).

In northern Japan, the University of Tokyo Hokkaido Forest (UTHF) manages uneven-aged mixed conifer–broadleaf forests under the stand-based silvicultural management system (SSMS; *Rinbun Segyo-ho* in Japanese). Since the late 2000s, UTHF has actively introduced geospatial information technologies and digital tools to support forest management operations (Owari, 2022). As a representative case of forestry DX in Japan, this keynote presents recent technological developments at UTHF and discusses how digital technologies can contribute to the development of more sustainable, adaptive, and data-driven forest management systems under changing environmental and socio-economic conditions.

**About the University of Tokyo Hokkaido Forest (UTHF)**

UTHF was established in 1899 as a field research and experimental forest of the College of Agriculture, Tokyo Imperial University. As of May 2026, it covers 22,708 ha in central Hokkaido, northern Japan (43°10′–43°21′ N, 142°23′–142°41′ E). Elevation ranges from 190 m to 1,459 m above sea level, and the terrain is characterized mainly by gentle slopes. At the arboretum (230 m a.s.l.), the mean annual temperature is 6.6 °C (2011–2020 average), with recorded extremes of 35.9 °C and −25.7 °C. Mean annual precipitation is 1,196 mm, and the average maximum snow depth is 85.6 cm. Snow cover typically begins in late November and persists until early April. The forest is dominated by mixed conifer–broadleaf stands composed of hemi-boreal evergreen conifers and cool-temperate deciduous broadleaved species (Figure 1; The University of Tokyo Hokkaido Forest, 2025).



Figure 1: Distant view of the University of Tokyo Hokkaido Forest
Photograph: Makoto Ishiguro

SSMS has been implemented at a business-operational scale for nearly 70 years since its introduction in 1958 (Owari et al., 2025). Forests ecosystems provide both ecological/public functions and economic functions related to timber production. The performance of these functions depends on forest structure and management practices, making appropriate silvicultural interventions essential for long-term sustainability (Takahashi, 2001).

The SSMS is designed for managing structurally heterogeneous natural forests and is based on six fundamental principles: (1) promoting and maintaining a pre-climax stand condition; (2) avoiding intensive forestry operations; (3) adapting management to stand-specific conditions; (4) maintaining tall, multi-layered stand structures; (5)

retaining trees with superior traits; and (6) promoting mixed conifer–broadleaf forest composition (Takahashi, 2001; Owari et al., 2025).

Within the SSMS framework, forests are classified into management units based on stand density, species composition, size structure, and regeneration status. Silvicultural operations such as harvesting, planting, and tending are tailored to each unit. Of approximately 20,000 ha of managed forest, naturally regenerated stands suitable for sustainable timber production are managed under a single-tree selection system, with harvesting conducted at 15–20 year intervals at an intensity of approximately 10–17% of standing volume (The University of Tokyo Hokkaido Forest, 2022).

Annual operations within each designated management area generally follow the sequence: (1) spatially explicit forest classification for silvicultural planning; (2) forest inventory to determine the allowable cut; (3) single-tree marking for harvesting; (4) stumpage sales and logging operations; and (5) site preparation (scarification) and planting in areas with insufficient natural regeneration (Owari et al., 2025). At UTHF, each management unit is assigned to a responsible team, and natural forest management is primarily carried out by three teams: the First Survey Team, the Second Survey Team, and the Civil Engineering and Harvesting Team. As of May 2026, each team consists of four technical staff members responsible for planning and implementing operations within their assigned management areas.

**Forestry DX in Practice**

**1. Forest Classification**

Under the SSMS, forests are classified according to stand characteristics and management objectives, and detailed forest classification surveys provide essential information for silvicultural management planning (The University of Tokyo Forests, 2022). Between autumn and winter of the year preceding operations, the responsible team conducts forest classification surveys and prepares the silvicultural management plan maps using ArcGIS Pro (Esri, Redlands, CA, USA).

To improve survey efficiency and accuracy, UTHF introduced a laser compass surveying system in 2008 and global navigation satellite system (GNSS) receivers in 2012. Since 2021, forest surveys have been conducted using a low-cost dual-frequency real-time kinematic (RTK) GNSS receiver (Figure 2; DG-PRO1RWS; BizStation Corp., Japan) in combination with Android smartphones and the ArcGIS Field Maps application (Esri, Redlands, CA, USA). This system provides sufficiently high and stable positioning accuracy while enabling efficient one-person field surveys (Owari et al., 2025).

Airborne light detection and ranging (LiDAR) data and ortho-rectified aerial imagery are available for the entire forest area. In addition, RTK-equipped unmanned aerial vehicle (UAV) surveys are conducted prior to forest classification surveys using a

Matrice 300 RTK with a Zenmuse P1 camera (Figure 3) and a Mavic 3 Multispectral system (DJI Ltd., Shenzhen, China).



Figure 2: Forest classification survey using a low-cost RTK-GNSS receiver
Photograph: Nozomi Oikawa

Forest types are delineated by integrating multiple spatial datasets within ArcGIS Field Maps, including digital canopy height models (DCHMs), curvature–slope (CS) maps, aerial imagery, and normalized difference vegetation index (NDVI) data. These integrated geospatial datasets have substantially improved both the efficiency and accuracy of forest classification surveys (Owari et al., 2025).

In recent years, increasing attention has been paid to UAV-mounted LiDAR systems for forest resource assessment. In 2024, UTHF introduced the Zenmuse L2 LiDAR sensor mounted on the DJI Matrice 350 RTK UAV platform (DJI Ltd., Shenzhen, China) to further enhance forest resource assessment and support precision forest management in complex, uneven-aged stands.

**2. Plot Inventory**

Following the forest classification survey, sample plot measurements are conducted to assess stand volume, tree density, species composition, and size structure for each forest type within each sub-compartment. The total plot area typically covers 5–10% of the designated management area allocated to each forest type. Sample plot locations (typically 50 m × 50 m square plots) are predetermined on the silvicultural management plan map, located using GNSS coordinates, and measured on a tree-by-tree basis. Although diameter at breast height (DBH) is still measured using tree calipers, field data entry has been digitized through a custom-built relational database application developed with FileMaker Go (Claris International Inc., Cupertino, CA, USA), enabling direct digital data entry in the field using Apple iPad tablets (Apple Inc., Cupertino, CA, USA).



Figure 3: Aerial image acquisition using an RTK-equipped UAV
Photograph: Eiichi Nobu

To improve the efficiency and accuracy of plot inventory measurements, backpack and handheld LiDAR systems have been tested since 2024. Three-dimensional (3D) individual-tree data were acquired using the LiGrip H120 handheld laser scanner (Figure 4; GreenValley International Inc., Berkeley, CA, USA) at an experimental site within UTHF. In addition, as part of an international collaborative research project with the University of Ljubljana, inventory plots were established in the experimental forest, and individual-tree measurements were conducted using three types of instruments: tree calipers, the LA03 backpack laser scanner (mapry Co., Ltd., Tamba, Japan), and the FARO Focus static terrestrial laser scanner (FARO, Lake Mary, FL, USA). In 2025, individual-tree surveys were conducted in UTHF using both conventional measurements and LiDAR-based systems (LiGrip H120 and LA03), and the accuracy of individual-tree detection and DBH estimation was evaluated.



Figure 4: Backpack LiDAR surveys using the LiGrip H120 (left) and LA03 (right)
Photographs: Nozomi Oikawa, UTHF

### 3. Tree Marking for Harvest

Tree-marking surveys are conducted in forest stands designated for harvesting under the silvicultural management plan (Owari et al., 2025). The objective of these surveys is to identify trees suitable for removal while maintaining the long-term productivity and structural integrity of the stand. Trees selected for harvesting typically include decayed or declining individuals, as well as dominant canopy trees that suppress the growth of younger cohorts, whereas vigorous and healthy trees are retained whenever possible. During the selection process, technical staff evaluate tree condition, competitive status, and spatial distribution to determine appropriate harvest candidates.

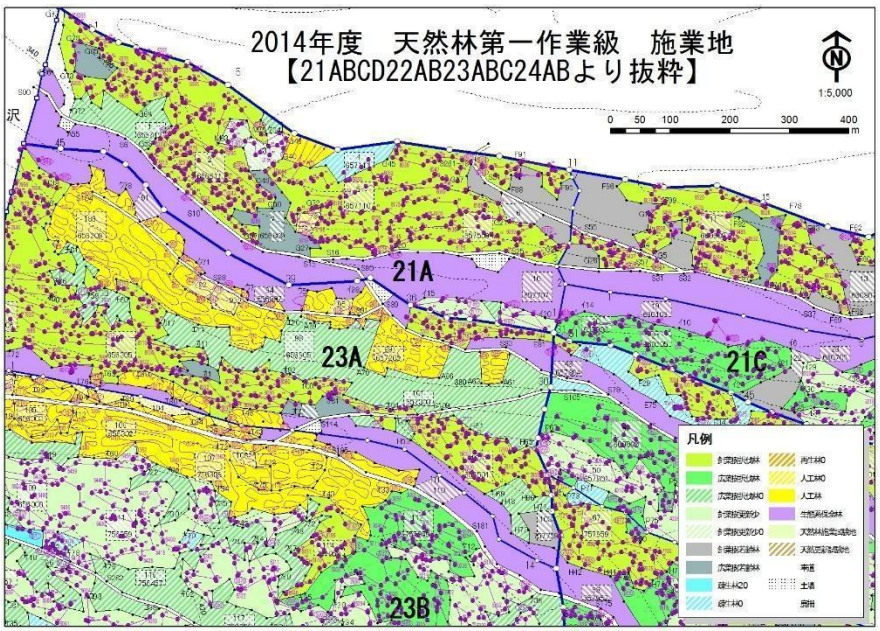



Figure 5: Locations of marked trees (shown as points on the map)
Source: UTHF

During tree-marking surveys, the walking trajectory of the surveyor is recorded using the RWM.DC mobile RTK-GNSS receiver (BizStation Corp., Japan). This device supports the Centimeter Level Augmentation Service (CLAS), a correction service broadcast by the Quasi-Zenith Satellite System (QZSS), enabling RTK-level positioning accuracy. As in the plot inventory survey, an Apple iPad and Claris FileMaker Go are used for digital field data entry. Because the surveyor's position is recorded simultaneously with data entry on the iPad, the geographic coordinates of individual marked trees can be automatically assigned without requiring manual GNSS measurement for each tree. Visualizing the locations of marked trees on digital maps (Figure 5) improves the efficiency of tree identification for standing timber buyers and facilitates operational supervision by logging contractors during harvesting operations.

**4. Logging Operations**

Trees selected during the tree-marking survey are sold either as standing timber or as processed logs. In the case of standing timber sales, harvesting operations are carried out by the purchaser, typically a private forestry company. In contrast, for log sales, harvesting is conducted either directly by UTHF or outsourced to external contractors. Direct harvesting operations are primarily implemented in management areas classified as the second Natural Forest Working Group. These operations are typically conducted from September to November over a period of approximately three months (Owari et al., 2025).

UTHF currently employs a cut-to-length (CTL) harvesting system for direct timber production using an F801 forwarder (Figure 6; Kato Works Co., Ltd., Japan) equipped with a grapple crane (Kesla Oyj, Finland), although felling and log processing operations have not yet been fully mechanized. Following tree marking, designated trees are felled, delimbed, and extracted to machine trails using a grapple-equipped excavator. These initial harvesting operations are outsourced to external contractors, whereas subsequent log processing and transport are carried out directly by UTHF technical staff (Owari et al., 2025).

At UTHF, a dual-antenna RTK-GNSS receiver (RWM.DC) with Moving Base technology (Figure 6; BizStation Corp., Japan) has been tested since 2024 for recording machine trajectories. The Moving Base system estimates the relative position between two antennas in real time, enabling the determination of antenna orientation (absolute heading) and tilt even under stationary conditions. By integrating real-time machine positioning with precise spatial information on standing trees and logs, this system is expected to improve operational efficiency and worker safety, while reducing damage to residual trees during harvesting operations.




Figure 6: F801 forwarder (left) and dual antennas of the RWM.DC receiver (right)
Photographs: Makoto Ishiguro, UTHF

## 5. Assisted Regeneration Operations

In natural forests where dense dwarf bamboo covers the forest floor and natural regeneration is limited, assisted regeneration operations are implemented (Owari et al., 2025). These operations currently combine site preparation (soil scarification) with relatively low-density planting (800–1,200 seedlings per hectare) of conifer seedlings to promote the early development of mixed conifer–broadleaf forests. Since 2016, silvicultural trials of a "precision planting" technique have been conducted as a potential alternative to conventional assisted regeneration operations (Owari et al., 2015). In this technique, suitable planting microsites (i.e., cut stumps) are identified immediately after selection cutting, and multiple container seedlings are planted around each stump without site preparation. In addition, the use of the FlyCart 100 heavy-lift delivery UAV (Figure 7; DJI Ltd., Shenzhen, China) has recently been explored for seedling transportation, potentially providing new opportunities for regeneration operations in remote or difficult-to-access terrain.



Figure 7: DJI FlyCart 100 heavy-lift delivery UAV
Photograph: Toshiaki Owari

## Challenges and Opportunities

### 1. Finance and Economy

Promoting DX in forestry involves several financial challenges. The introduction of advanced digital technologies such as UAVs, LiDAR systems, and RTK-GNSS receivers requires substantial initial investment. In addition, forestry organizations must bear ongoing costs for equipment maintenance, software updates, data storage, and staff training. Given the limited financial resources of many forestry organizations, these costs can represent a significant barrier to the adoption of digital technologies.

At the same time, forestry DX creates important economic opportunities. Digital technologies can improve operational efficiency, reduce labor requirements, and minimize damage to residual trees and other forest resources during harvesting operations. More accurate and timely forest information also supports better management decisions and contributes to the long-term economic sustainability of forest management.

The economic benefits of forestry DX are often uncertain and may only become evident in the long term. Nevertheless, increasing governmental support for DX, as well as carbon-neutral and nature-positive policies, may provide additional opportunities for external funding and investment.

**2. Capacity Building**

Another major challenge in promoting forestry DX is the development of human resources capable of effectively utilizing digital technologies. Forestry planners and managers are increasingly required to acquire skills in remote sensing, UAV operation, data analysis, and digital field management systems. However, opportunities for technical training and education remain limited, while the aging workforce in the forestry sector further complicates the transfer of digital knowledge and skills. In addition, some workers may be reluctant to adopt unfamiliar technologies.

At the same time, forestry DX offers important opportunities for human resource development. Digital technologies can make forestry operations more efficient, safer, and less physically demanding, thereby improving the attractiveness of the forestry sector for younger generations. Collaboration among universities, research institutions, government agencies, and private companies can further promote interdisciplinary education and practical training in digital forestry. As digital technologies become more widely adopted, new career opportunities in areas such as smart forestry, forest data science, and environmental monitoring are expected to emerge.

**3. Creation of New Forest Management Models**

It remains challenging to develop new forest management models through the integration of digital technologies into conventional forestry systems and organizational structures. Forestry has traditionally relied heavily on field experience and long-term management practices, and organizational resistance to change may therefore arise. In addition, the development of new management models requires the integration of diverse datasets, continuous monitoring systems, and close collaboration among forest managers, researchers, contractors, and policymakers. Issues related to data standardization, data sharing, and the long-term reliability of digital systems also remain important concerns.

At the same time, DX provides significant opportunities to develop more adaptive, data-driven, and sustainable forest management models. By integrating technologies such as UAVs, LiDAR, GNSS, AI, and cloud-based data platforms, forest managers can obtain detailed, real-time information on forest conditions and operational activities.

This enables site-specific management, improves operational efficiency, and enhances the balance between timber production and environmental conservation. Digital technologies may also facilitate more transparent and collaborative forest management systems and contribute to new approaches for carbon management, biodiversity conservation, and ecosystem service assessment.

## Conclusion

Forestry DX has the potential to support more resilient, sustainable, and data-driven forest management under climate change and increasing societal demands for ecosystem services. At the same time, successful DX requires not only technological innovation, but also long-term investment in human resources, institutional collaboration, and adaptive management systems. The experience at UTHF suggests that integrating digital technologies with silvicultural knowledge and field-based management practices can play an important role in the future development of sustainable forestry.

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# ABSTRACTS

# Agribusiness, Agri-extension, and Policies

# Effectiveness of WhatsApp-Based Weather Information Dissemination - A Case Study Based on Two Cascade Systems under CRIWMP in the Dry Zone, Sri Lanka

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Changing climatic conditions are serious challenges to agricultural productivity, especially in the Dry Zone in Sri Lanka. In such contexts, timely, accurate weather information is critical for enabling climate-resilient agricultural decisions. The Climate Resilient Integrated Water Management Project (CRIWMP) has introduced WhatsApp-based weather information dissemination to support farmers. Despite the availability of WhatsApp-based weather information, its effectiveness in supporting farmers' decisions remains unclear. This study examines the effectiveness of this approach, considering two cascades that benefited from CRIWMP; the Thuduwakkaikulam cascade and the Sivalakulama Cascade. Rogers's Diffusion of Innovations theory, which highlights factors influencing adoption, including relative advantage, compatibility, complexity, trialability, and observability, was used as the framework guiding the study. A qualitative case study design was adopted, employing purposive sampling to select farmers in WhatsApp groups. Data were collected through Focus Group Discussions conducted in Sinhala and translated into English. Thematic analysis generated five key themes: Establishment and Institutional Support, Information Type, Comprehension, Accuracy and Information Use, and Limitations and Unmet Needs. Findings indicate that WhatsApp groups provide localized, timely, and actionable weather information, enhancing decisions related to irrigation, fertilizer and pesticide application, harvesting, and tank management. Challenges included comprehension difficulties, message overload, limited digital literacy, and insufficient awareness of group existence. Addressing language barriers, simplifying messages, and raising awareness of group availability can improve adoption and impact. These findings show the potential of WhatsApp as an information source to strengthen climate adaptation strategies for farmers in Sri Lanka's Dry Zone.

**Keywords**: Climate-resilience, Weather information dissemination, WhatsApp groups

# From Participation to Empowerment: A Case Study of Women's Changing Roles under the CRIWMP in Dry Zone Cascade Systems

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Women in the Dry Zone of Sri Lanka, play a major role in agriculture, contributing to farming, livestock management, household food security, and water-related activities. However, this role is often undervalued. This study explores how the Climate Resilience Improvement and Water Management Project (CRIWMP) contributed to women's empowerment, with a focus on the Thuduwakkaikulam Cascade. This study was conducted as a qualitative case study. Primary data were collected by Focus Group Discussions (FGDs), Key Informant Interviews (KIIs), and field observations which involved female farmers, farmer leaders, and vulnerable women. Focusing on the dimensions of resources, agency, and achievements, the analysis was conducted with the guidance of Kabeer's empowerment framework. The findings showed CRIWMP interventions increased women's access to productive resources, reduced labour burdens related to accessing water, and diversified livelihoods through home gardening, groundnut cultivation, poultry rearing, and small-scale enterprises. This strengthened women's agency through the formation and enhancement of women-based community organizations, which provided access to training, low-interest credit, leadership opportunities, and collective decision-making. Multidimensional empowerment happened through women-led enterprises which generated off-season income and created local employment opportunities that helped in financing children's education and improved household resilience. Vulnerable women achieved independence in finance, and their mental well-being and social recognition within their families and communities improved significantly. Overall, the study showed that gender-responsive, climate-resilient water management interventions can drive empowerment. By integrating livelihood support, capacity building, and inclusive institutional mechanisms, CRIWMP contributed to transforming women's traditional roles within dry zone agricultural systems.

**Keywords:** Climate-resilient agriculture, Community-based water management, Dry zone cascade systems, Rural livelihoods, Women's empowerment

# Influence of Seasonal Farming Patterns and Paddy Variety Preferences on Seed Scarcity and Economic Stability in Ganewaththa Divisional Secretariat, Sri Lanka

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Seed scarcity has become a significant challenge in Sri Lanka's paddy sector, particularly during peak cultivation periods, affecting timely planting, production efficiency, and the economic stability of smallholder farmers. Limited access to affordable, quality seed paddy often compels farmers to delay cultivation, shift to alternative varieties, or reuse poor-quality seed, increasing production risks and reducing income stability. This study examined the influence of seasonal farming patterns and paddy variety preferences on seed scarcity and economic stability among paddy farmers in the Ganewaththa Divisional Secretariat of Kurunegala District, Sri Lanka. Based on Cobweb Theory, the study explored how farmers' responses to previous season price signals and delayed supply adjustments contribute to recurring seed shortages and price instability. A quantitative cross-sectional research design was adopted, and primary data were collected through a structured questionnaire administered to 70 randomly selected paddy farmers cultivating 2 to 5 acres from a population of 113 farmers. Data were analysed using descriptive statistics, chi-square tests, correlation analysis, and multiple regression analysis using SPSS and Microsoft Excel. The findings revealed that all respondents cultivated paddy during both *Maha* and *Yala* seasons, while 78.6% preferred hybrid varieties. High yield was the primary factor influencing variety selection, followed by market price and crop duration. Seed access difficulties were reported by 78.6% of respondents, mainly due to high seed prices and poor seed quality. Significant relationships were identified between seed access difficulties and income instability, and between delayed cultivation and economic instability. The study concludes that seasonal farming behaviour, paddy variety preferences, and price-responsive decision-making contribute significantly to recurring seed scarcity and economic instability. The findings emphasise the need to strengthen certified seed production, ensure timely seed distribution, improve market forecasting, and enhance agricultural extension services to support sustainable paddy cultivation and economic resilience.

**Keywords:** Cobweb Theory, Economic stability, Paddy variety preference, Seasonal farming patterns, Seed scarcity

# Addressing Skilled Labour Shortages in Coconut Harvesting: Evidence from Coconut Farmers in Kurunegala District, Sri Lanka

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The coconut sector is a vital component of Sri Lanka's plantation agriculture and is increasingly challenged by human-related nuances such as the shortages of skilled coconut pluckers where traditional coconut harvesting is known as super-skilled task. This study aimed to explore farmers' perceptions and experiences regarding how shortages of skilled coconut pluckers are associated with coconut production, market availability, cultivation practices, and coconut prices in the Kurunegala district of Sri Lanka. Qualitative phenomenological approach, grounded in the interpretivist paradigm, was employed. Data were collected through semi-structured interviews with 30 coconut cultivators selected judgmentally, ensuring that each participant owned at least 2.5 ha of coconut land. The data were analyzed using 6-steps reflexive thematic analysis in order to identify recurring patterns and themes in farmers' experiences and perceptions. The findings indicated that farmers perceive shortages of skilled coconut pluckers as increasing labour costs, delaying harvesting operations, and reducing harvesting efficiency. Participants associated these challenges with lower productivity, reduced market availability, and changes in coconut prices. Farmers also noted that employing unskilled workers may result in premature harvesting and damage to coconut palms, affecting nut quality and yield. Although mechanized harvesting was viewed as a potential solution, its adoption was constrained by high costs, limited technical knowledge, and low farmer confidence. The study highlights the importance of skill development programmes, youth engagement, extension services, and affordable mechanization. These findings provide qualitative insights into labour shortages in Sri Lanka's coconut sector and offer guidance for policymakers and industry stakeholders.

**Keywords:** Coconut harvesting, Labour shortage, Skilled coconut pluckers, Sri Lanka, Qualitative study

# Halal Food Consumption Behavior among Muslim Consumers in Sri Lanka

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This research examines the factors influencing halal food purchasing decisions among Muslim consumers in Sri Lanka. The research applies the Theory of Planned Behavior as the theoretical framework and examines the effects of Religious Commitment, Trust in Halal Certification, Perceived Product Quality, and Social Influence on halal food consumption behavior. This study is particularly relevant given the expansion of the global halal market and the existing knowledge gap concerning consumer behavior in the Sri Lankan context. A cross-sectional quantitative research design was used, and data were collected from 300 Muslim consumers through a structured online survey using a convenience sampling technique. The instrument was adapted from previously validated scales, and reliability and validity were confirmed prior to analysis. Descriptive statistics, reliability analysis, Pearson correlation, and multiple linear regression were applied to analyze the data. The findings showed strong reliability, with Cronbach's alpha values exceeding 0.70 for all constructs and an overall reliability coefficient of 0.912. The regression model accounted for 58% of the variance in halal food consumption behavior. The strongest predictors were Religious Commitment ($\beta = 0.351$, $p < 0.001$) and Trust in Halal Certification ($\beta = 0.285$, $p < 0.001$). Perceived Product Quality was also a significant predictor ($\beta = 0.152$, $p = 0.013$), but Social Influence did not reach statistical significance ($\beta = 0.105$, $p = 0.083$). The findings indicate that halal purchasing decisions among Muslim consumers are driven by religious commitment, confidence in halal certification authorities, and perceptions of product quality. These results imply that manufacturers and certifying bodies should ensure religious compliance, prioritize product quality in line with the Tayyib concept, and implement transparent digital verification systems to strengthen consumer trust. Future research may explore the moderating effects of age and Perceived Behavioral Control through longitudinal studies.

**Keywords**: Consumer behavior, Halal certification, Halal food, Perceived quality, Religious commitment

# Determinants of Knowledge, Attitudes, and Behaviours toward Aflatoxin Contamination: A Structural Equation Modelling Approach in Sri Lanka

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Aflatoxin contamination in food products is an emerging public health concern in Sri Lanka due to its carcinogenic and hepatotoxic effects. There is limited research on consumer knowledge, attitudes, and behaviours (KAB) regarding aflatoxin prevention, among Sri Lankan housewives. This study assessed the KAB of Sri Lankan housewives regarding aflatoxin contamination and examined the relationships among these constructs using Structural Equation Modelling (SEM). A cross-sectional study was conducted from November 2024 to February 2025 among 397 Sri Lankan housewives aged ≥18 years selected through voluntary convenience sampling using community flyers and social media platforms. Data were collected using a pre-tested interviewer-administered telephone questionnaire covering socio-demographic characteristics and KAB related to aflatoxin contamination. Ethical procedures were followed and informed consent was obtained from all participants. Data were analyzed using SPSS 26.0 and AMOS 23.0. Knowledge levels were categorized based on percentage scores. Confirmatory Factor Analysis (CFA) and SEM were used to validate constructs and examine relationships among KAB variables. Knowledge showed good reliability (Cronbach's $\alpha = 0.850$), while attitudes demonstrated excellent reliability ($\alpha = 0.992$). Behaviour reliability was comparatively low ($\alpha = 0.483$). SEM revealed a strong positive association between knowledge and attitudes ($\beta = 0.732$, $p < 0.001$) and a weak but significant association between knowledge and behaviours ($\beta = 0.181$, $p = 0.042$). However, attitudes were not significantly associated with behaviours ($\beta = -0.030$, $p = 0.727$). Education level significantly predicted both knowledge and attitudes ($p < 0.001$). Overall knowledge levels were low (48.9%) despite relatively positive attitudes and behaviours. These findings suggest that improving aflatoxin-related knowledge may support safer food practices among Sri Lankan housewives. However, findings should be interpreted cautiously due to the cross-sectional design, moderate model fit, and potential response bias associated with telephone-based surveys.

**Keywords:** Aflatoxins, Attitudes, Behaviours, Knowledge, Structural equation modelling

# Agro-Technologies and Digital Tools

# AI-Based Tea Leaf Disease Detection Using Deep Learning and Image Recognition

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Tea (*Camellia sinensis*) is one of the most economically important plantation crops in Sri Lanka; however, foliar diseases such as blister blight and brown blight continue to cause significant yield and quality losses if not identified at early stages. Conventional disease detection methods rely heavily on manual visual inspection, which is time-consuming, subjective, and difficult to scale across large plantation areas. To address these limitations, this study proposes a deep learning–based tea leaf disease detection system using image recognition and a custom Convolutional Neural Network (CNN), with an emphasis on real-time field applicability. A dataset of 1,200 tea leaf images was collected from tea estates in the upcountry region of Sri Lanka under natural field conditions. The dataset comprises three classes: healthy leaves, blister blight–infected leaves, and brown blight–infected leaves. Images were preprocessed using resizing, normalization, and data augmentation techniques to enhance robustness against lighting variations and background noise. The CNN model was trained and evaluated using a 70:15:15 train–validation–test split. Experimental evaluation demonstrates that the proposed model achieves an overall classification accuracy of 92.4% and an F1-score of 0.92, indicating effective discrimination among disease classes. The trained model was successfully integrated into an Android-based mobile application, enabling on-device inference with an average prediction time of less than two seconds per image, making it suitable for real-time agricultural use without continuous internet connectivity. Despite promising results, the study is limited by the moderate dataset size and variability in lighting conditions during image acquisition. Future work will focus on dataset expansion, improved robustness under diverse field environments, and large-scale field validation. The proposed system highlights the potential of deep learning–enabled mobile solutions to support precision agriculture and early disease management in Sri Lanka's tea industry.

**Keywords**: Artificial Intelligence (AI), Convolutional Neural Networks (CNN), Image Recognition, Precision Agriculture, Sustainable Farming

# Impact of Virtual Farm Tours on Agrotourism Destination Choice in Sri Lanka

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In the Tourism industry, agrotourism has gained more attention as a form of sustainable tourism and this helps to rural development, culture heritage preservation, enhancing the tourist knowledge about agricultural lifestyle. Sri Lanka can provide opportunities for tourists to engage with tea plantations, spice gardens, organic farms, and traditional rural communities. Potential tourist can experience farm environments before making travel decisions by using virtual farm tours, including video-based tours and interactive digital content. Limited research has explored how virtual farm tours shaping agrotourism destination selection. This study uses a quantitative approach with 300 agrotourism-interested respondents selected through purposive sampling. Data were collected via an online questionnaire after viewing a virtual farm tour video. Measures used a five-point Likert scale, and data were analyzed using SPSS (Version 26) with reliability, validity, and moderate analysis. Pearson correlation analysis revealed a moderate positive relationship between virtual farm tours and agrotourism destination selection ($r = .459$, $p < .01$), and between trust and destination selection ($r = .364$, $p < .01$). A strong positive relationship was found between trust and virtual farm tours ($r = .752$, $p < .01$). Moderation analysis further indicated that trust significantly strengthens the relationship between virtual farm tours and destination selection ($\beta = .098$, $p = .017$), explaining additional variance ($R^2 = .007$), confirming its moderating role. This study, based on the Stimulus–Organism–Response (S-O-R) framework, finds that virtual farm tours significantly influence agrotourism destination selection in Sri Lanka, with trust strengthening this relationship. The results highlight the importance of authentic virtual content. Tourism stakeholders should invest in realistic, high-quality virtual tours to enhance trust and attract global tourists.

**Keywords:** Agrotourism, Destination selection, Stimulus–organism–response (S-O-R) framework, Trust, Virtual farm tours

# Simulation-based Assessment of Maize Sowing Windows under Current and Future Climate Conditions in the Dry Zone of Sri Lanka

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Maize production in the dry zone of Sri Lanka is increasingly vulnerable to climate change, requiring adaptive strategies such as optimising sowing dates. This study assessed the impact of different sowing dates on maize (*Zea mays* L.) yield and phenology under current and future climate scenarios. Five sowing dates representing early and late planting periods were selected based on Department of Agriculture recommendations. The APSIM maize model for the Pacific variety, previously calibrated and validated, was used to simulate crop performance. 30 years of historical weather data from *Mahailupallama* meteorological station represented current dry zone conditions, while future climate projections under RCP 8.5 scenario for mid-century (2050) and late-century (2100) were taken from the latest IPCC report. Soil parameters were obtained from published literature, and simulations were conducted for both *Maha* and *Yala* seasons. Results indicated differential responses of sowing dates to climate conditions. In the *Maha* season, early sowing on 30$^{th}$ September produced the highest yield of 5066.65 kg ha$^{-1}$ under the present climate, while yields declined across all sowing dates under projected 2050 and 2100 climates to 4463.49 and 4735.68 kg ha$^{-1}$, respectively. Conversely, the *Yala* season demonstrated greater resilience and higher productivity with early sowing on 30$^{th}$ March producing an optimized yield of 6555.80 kg ha$^{-1}$ under present conditions. Yields were similar or higher under future scenarios, reaching 6659.94 kg ha$^{-1}$ in 2050 and 7057.68 kg ha$^{-1}$ in 2100. Days to flowering remained relatively consistent at 26 to 31 days, with slight reductions under warmer 2050 conditions These projections may vary with soil quality, management practices, and new varietal improvements. However, the findings suggest that shifting maize cultivation to the *Yala* season and adjusting sowing dates to seasonal climate are viable strategies for maintaining productivity in the dry zone of Sri Lanka under future climate uncertainty.

**Keywords:** Climate change simulation, Dry zone Sri Lanka, Maize production, Sowing window optimization

# Different Hydrothermal Treatments in Paddy Parboiling Process Enhance the Formation of Resistance Starch during Milling

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Parboiled rice exhibits several advantages over raw rice, such as strengthening kernel integrity by forming resistant starch, increased milling recovery and preventing the loss of nutrients during cooking and improve the Glycemic Index in digestibility. Recommended paddy varieties tested with red pericarp (At 362), red pericarp (Bg 366) and one commercially available red pericarp (Adakari). The main objective of this study is to investigate the effect of soaking duration and steaming method on milling yield and resistant starch formation during cooking of parboiled rice. Soaking was done in cold water (30 °C) for different time duration ( a day, 2 days, 3 days, 4 days, and 5 days) with a volume ratio of 1:1.5 and the steaming (boiling) was practiced for 20 minutes' duration as Pressurized Soak Steam as closed steam (PSS), Un-soaked Steam as semi open steam (USS), Soak Steam as open steam (SS), in an electric steam rice cooker with steamer. The parboiled paddy was dried under a conventional oven at 60 °C temperature for 3 hrs for safe milling. Head Rice Yield (HR), Broken rice yield, milling recovery, and texture hardness of parboiled rice were evaluated. Statistical analysis showed a significant interaction between soaking interval and steaming methods ($p < .005$). Cooking of parboiled rice was performed with water in a volume ratio of 1:1.2, duration of 20 minutes in an electric rice cooker and resistance starch (RS) formation during cooking was investigated by texture analyzer under Trigger Force of 0.05 N (auto). Results showed that the higher head rice yield was counted in the closed pressure steam (PSS) method with 2 days of cold soaking duration (48 hrs). Closed pressure steam (PSS) resulting formation of harder resistant starch parboiled rice during texture analyzing than other treatment methods investigated. Open and semi open parboiling treatments gave moderate head rice yield and hardness texture value. Closed pressure steaming parboiling (PSS) process was yield the high hardness texture value and improved yield product.

**Keywords:** Head rice yield, Hardness, Paddy soaking & steaming, Resistant starch

# Animal Science and Aquaculture

# Evaluation of Quality Characteristics of Chicken, Turkey and Quail Meat-based Traditional Meatballs

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The processed meat industry in Sri Lanka has responded to the growing consumer demand by offering a diverse range of value-added meat products, including meatballs. Among these, chicken meatballs are the most popular variety in Sri Lankan food culture. Other poultry meat sources, such as quail and turkey possess considerable potential as alternative raw materials for meatball production. Hence, this study aimed to develop rice-flour-incorporated meatballs from turkey and quail meat using pre-colonial recipes (*Mas guli/ Kurakkal*) and investigate the effect on proximate composition, physico-chemical properties and sensory qualities. A Preliminary study was conducted to evaluate three levels of rice flour incorporation (10%, 15% and 20%). According to the sensory and texture analysis results, 10% inclusion was the optimum inclusion rate of rice flour for this formulation. Based on these findings, three treatments (chicken, turkey, and quail meatballs) were developed using a standardized formulation and evaluated under a completely randomized design (CRD) with three replicates, where chicken meatballs served as the control. The quail and turkey meatballs had significantly ($P<0.05$) higher protein percentage and lower hardness compared to chicken meatballs. The highest ash content and lowest fat percentage were observed in quail meatballs ($p <0.05$). Significant differences ($P<0.05$) in the colour parameters were observed among the samples. The highest a* value (redness) was observed in quail meatballs, followed by turkey meatballs, while the lowest value was observed in chicken meatballs. Sensory evaluation results showed that quail meatballs had received the highest scores for colour, flavour, juiciness, and overall acceptability. In conclusion, developed quail meatballs exhibited better quality and sensory attributes than turkey and chicken meatballs.

**Keywords:** Physico-chemical properties, Proximate composition, Rice flour incorporation, Sensory evaluation, Texture analysis

# Assessment of Blood Metabolites and Haematological Profiles of Broiler Chickens Fed Diets Supplemented Ghee Residue

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This experiment was conducted to investigate the effect of different levels of ghee residue inclusion in finisher diets on the blood serum metabolites and haematological indices of broiler chickens at the finisher stage. Two hundred and sixteen broiler chickens were randomly assigned to six treatment groups in a RCBD, with three replicates per treatment. The treatments comprised diets containing 0% (T1), 3% (T2), 6% (T3), 9% (T4), and 12% (T5) ghee residue, where T1–T5 were self-formulated diets, while T6 was a commercially procured finisher diet. At 42 days, blood was collected from the jugular vein. Serum metabolites were analyzed using CRD, and results showed significant ($p < 0.05$) differences among dietary treatments. Birds were fed the T1 diet recorded the highest values for triglycerides (40.10 mg/dL), HDL (73.50 mg/dL), LDL (57.43 mg/dL), total cholesterol (138.47 mg/dL), and serum protein (3.90 g/dL), compared to the T1 (30.43 mg/dL, 59.03 mg/dL, 40.23 mg/dL, 105.50 mg/dL, and 2.77 g/dL, respectively). Birds fed the commercial finisher diet (T6) exhibited intermediate levels. In contrast, serum glucose concentration decreased significantly ($p<0.05$) with higher ghee residue inclusion, declining from 240.33 mg/dL in T1 to 221.10 mg/dL in T5. Haematological parameters were also significantly ($p<0.05$) affected by dietary treatments. The highest red blood cell count ($3.96 \times 10^6$/μL), haemoglobin (12.96 g/dL), PCV (40.10%), and MCV (129.67 fl) were observed in T5, compared to lower values in T1. White blood cells differentials, including neutrophils and lymphocytes, also differed significantly among treatments. In contrast, eosinophil and monocyte counts were not significantly affected ($p > 0.05$), and basophils were not detected in any of the treatments. The findings indicate that inclusion of ghee residue in broiler finisher diets at levels up to 12% significantly influenced the blood profile without causing any harmful effects and indicating that it can be considered a promising alternative feed ingredient in broiler production.

**Keywords:** Blood serum, Cholesterol, Finisher, Triglycerides

# Towards Dairy Self-Sufficiency: An Evaluation of Technical Efficiency and Productivity Constraints in Sri Lanka's Dry Zone

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The dairy sector is a fundamental component of the rural economy in Sri Lanka. However, production in the Dry Zone is hampered by low productivity and suboptimal resource allocation. This study was conducted to evaluate the factors influencing the technical efficiency of dairy production across diverse farming systems in the Dry Zone and to identify potential productivity improvements within existing resource constraints. Primary data were gathered from a sample of 215 dairy farmers, selected through a stratified random sampling technique across the Kurunegala, Anuradhapura, Hambantota, and Jaffna districts, encompassing intensive, semi-intensive, and extensive management systems. A stochastic frontier production function, employing the Cobb–Douglas functional form, was utilised to estimate technical efficiency, while an inefficiency effects model was applied to determine the impact of farmer-specific characteristics. The results demonstrate that the mean technical efficiency of dairy farming in the Dry Zone is 0.60, indicating that milk output could be increased by approximately 40% through the enhanced utilization of current inputs. Key farm-level determinants of milk production included the number of milking animals, the quantity of concentrate feed, pasture availability, frequency of water supply, and the provision of cattle sheds. The dairy sector was predominantly managed by male farmers (93%), with 77% of respondents aged 30–60 years. While 82% had education only up to the G.C.E. (O/L) level, more than 60% possessed over 15 years of dairy farming experience. Furthermore, farmer experience and participation in training programmes were found to significantly decrease technical inefficiency. District variations were evident, with higher efficiency levels recorded in Kurunegala and Anuradhapura compared to Hambantota and Jaffna, where extensive management practices are more common. These findings suggest that prioritizing herd optimization, ensuring consistent feeding and water access, and strengthening extension services are vital for enhancing productivity. Improving technical efficiency can reduce production costs, raise farm incomes, and support national objectives for dairy self-sufficiency.

**Keywords**: Dairy Production and Resource Constraints, Dry Zone Dairy Farming, Evaluation of Technical Efficiency, Factors Affecting Technical Efficiency

# Efficiency Assessment of Bamboo Leaves (*Bambusa vulgaris*), Indian Almond Leaves (*Terminalia catappa*), and Charcoal as Natural Filters for Aquarium Wastewater

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Untreated aquarium wastewater causes pollution and ecological risks. Advanced filtration used in large scale aquaculture is costly for small scale keepers. Thus low-cost, sustainable alternatives like plant-based materials are needed for pollutant removal. This study is evaluating natural materials such as Indian almond leaves, bamboo leaves, and charcoal in filtration to improve aquarium wastewater quality. Aquarium effluent water was collected and treated with leaf and charcoal combinations. T1 – Indian almond leaves, T2 and T3 – bamboo and Indian almond leaves at different ratios, and T4 – bamboo leaves, each with 1 g charcoal (2 g total). A control without plant materials was included to assess natural changes. Leaves were washed, sun-dried, crushed, briefly boiled, soaked for 24 h, and re-dried. Charcoal was washed, oven-dried, crushed, and sieved. Each material combination was placed in muslin filter pouches and submerged in wastewater for 28 days. Water quality parameters such as pH, electrical conductivity, turbidity, dissolved oxygen, biochemical oxygen demand, nitrate, nitrite, and phosphate were assessed on 0, 7, 14, 21 and 28 days. Statistical analysis showed significant differences among treatments ($P<0.05$). All combinations significantly reduced turbidity and nutrient concentrations compared to the control. Treatments stabilized electrical conductivity and pH within the range of 7.7–7.9. Dissolved oxygen improved, while biochemical oxygen demand decreased to 2.0 mg/L, indicating effective organic load reduction. The charcoal and bamboo leaf combination showed highest nitrate removal, whereas Indian almond leaves effectively reduced nitrite concentrations to <0.1 mg/L. Phosphate concentrations were significantly reduced to 0.108–0.175 mg/L across treatments. This study shows that bamboo leaves, Indian almond leaves, and charcoal, used individually or in combination, can significantly improve wastewater quality. All water quality standards adhered to Sri Lankan Central Environmental Authority acceptable standards. These findings confirm that natural leaf–charcoal filtration systems are sustainable, biodegradable, and cost-effective filters for small-scale and household aquaculture.

**Keywords**: Aquarium wastewater, Bamboo leaves, Charcoal, Indian almond leaves, Plant-based filtration.

# Seasonal Dynamics and Antimicrobial Susceptibility Patterns of Bovine Mastitis in Dairy Cattle of Anuradhapura District, Sri Lanka

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Bovine mastitis is a major constraint to dairy production in Sri Lanka, particularly in dry-zone districts such as Anuradhapura. This study investigated mastitis occurrence, seasonal variation, and antimicrobial resistance patterns among dairy cattle in Anuradhapura District from 2023 to 2025. Data were obtained from routine laboratory records covering all 22 veterinary divisions (n=841). Mastitis was assessed using the California Mastitis Test (CMT). Seasonal effects were analyzed using binary logistic regression and chi-square tests, while antimicrobial susceptibility was evaluated using Fisher's exact test. Seasonal patterns varied across years. In 2023, cows examined during the rainy season showed higher odds of CMT positivity than those examined during the dry season (OR = 2.17; p = 0.63). In 2024, rainy-season cattle exhibited lower odds of CMT positivity (OR = 0.63; p = 0.065). In contrast, a significant seasonal effect was observed in 2025, with rainy-season cows having significantly higher odds of mastitis than dry-season cows (OR = 2.29; p = 0.003). When data from all three years were combined, rainy-season cattle showed slightly higher odds of mastitis (OR = 1.14), but this association was not statistically significant (p = 0.35). Antimicrobial susceptibility testing revealed complete resistance to penicillin and amoxicillin across all samples, indicating widespread ineffectiveness of beta-lactam antibiotics. In contrast, enrofloxacin and gentamicin showed significantly higher susceptibility compared to penicillin ($p < 0.0001$), with no significant difference between the two drugs (p = 0.054). In conclusion, while rainy-season conditions may increase mastitis risk in certain years, Overall, season was not significantly associated with mastitis occurrence. Similar to previous studies, high beta-lactam resistance emphasizes the need for rational antimicrobial use and evidence-based mastitis control strategies in Sri Lankan dairy systems.

**Keywords:** Antimicrobial resistance, Bovine mastitis, California Mastitis Test, Sri Lanka Dry Zone, Seasonality

# Shelf-Life Assessment of Different Flavoured Drinking Yoghurts using Physicochemical and Microbiological Parameters

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Fermented milk products are important due to their nutritional and functional properties. However, shelf-life assessment of these products is often performed using single parameters, which may reduce the reliability of prediction results. Therefore, this study aimed to assess the shelf life of different flavoured drinking yoghurts using physicochemical and microbial quality parameters. Samples of vanilla, strawberry, mango, and aloe vera flavoured drinking yoghurts were obtained from a commercial dairy processing unit in Sri Lanka and stored under similar refrigerated conditions (4°C) throughout the experimental period. Key physicochemical parameters, including pH, titratable acidity, water-holding capacity, and syneresis, as well as microbial parameters such as yeast and mold count, and coliform count, were evaluated weekly over a four-week storage period. The results revealed a significant ($P < 0.05$) decrease in pH (4.30-3.97) and an increase in titratable acidity (0.75-1.40%). Syneresis and water-holding capacity remained within acceptable limits, while yeast and mold counts were TFTC and coliforms were absent in all samples. Graphical trend analysis and regression modelling demonstrated progressive product deterioration during storage. The statistically significant regression model ($Y=a+b(pH)+c(TA)$) demonstrated a relationship between storage time, pH, and titratable acidity. Shelf life was estimated based on physicochemical limits (pH 4.0 and titratable acidity 1.2%) and trend extrapolation. The developed prediction models indicated shelf lives of 29, 26, 25, and 24 days for vanilla, mango, strawberry and aloe vera flavoured drinking yoghurts, respectively. These findings indicate that physicochemical and microbiological parameters combined with trend analysis provide a reliable approach for shelf-life estimation.

**Keywords:** Drinking yoghurt, Microbiology, Physicochemical parameters, Regression analysis, Shelf-life

# A Case Study on Farm Formulated Layer Feeds

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Considering the high prices of commercial poultry feed, small-scale farmers tend to formulate their own poultry feeds. However, whether these feeds meet the required nutritional levels of poultry is poorly documented. Thus, the aim of this study was to evaluate the nutritional quality of farm-formulated layer feeds from three provinces and assess crude protein (CP) compliance with NRC 1994 standards. Layer feed samples were collected from small-scale farms across Western, North-Western, and North-Central Provinces (5 samples per province). A structured questionnaire was used to assess farmers' knowledge on feed formulation requirements and also of nutritional standards. Proximate analysis following AOAC methods determined CP, crude fiber (CF), crude fat (EE), ash, dry matter (DM) and organic matter (OM). Statistical analysis employed One-Way ANOVA for inter-provincial comparison, with NRC standards used as benchmarks for CP (15%) and dry matter (90%). North Central Province exhibited the highest ($p<0.05$) protein content (21.7±0.68%) exceeding North-Western Province (18.9±0.68%) but similar to Western Province (20.1±0.68%). Critically, all three provinces substantially exceeded the NRC (1994) recommended level of for laying hens in production. However, the DM content was according to the recommended level in all three provinces. North-Central Province had the lowest ($p<0.05$) EE (5.4±0.48%) compared to Western (7.2±0.48%) and North-Western (7.5±0.48%) Provinces. All respondents (100%, n=15) lacked awareness of NRC (1994) nutritional standards for layer feeds. Majority (60%) of the farmers obtained knowledge of feed formulation from a hired consultant, 20% through browsing the internet while the other 20% of the farmers obtained knowledge from the market formulas. None of the surveyed farmers had received formal training in feed formulation nor attended agricultural extension programs related to poultry nutrition in the last five years. This case study demonstrates critical protein over-formulation across all provinces, causing economic inefficiency and unnecessarily increased feed costs confirming the urgent need for targeted extension services to provide evidence-based feed formulation trainings.

**Keywords**: Feed cost, Feed formulation, NRC standards, Proximate composition, Small-scale layer farming

# Crop Science

# Phenotypic Plasticity of Qualitative Leaf Traits in Cinnamon (*Cinnamomum Verum*) Accessions across Two Agroecological Regions in Sri Lanka

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Abstract: Ceylon cinnamon (*Cinnamomun verum*) is a globally demanded spice and positioning as a world's largest exporter. However, Sri Lanka currently has only two improved cultivars, Sri Gemunu and Sri Wijaya which yield up to 1500 kg $ha^{-1}$ under optimal conditions and vegetatively propagated for genetic uniformity. These cultivars exhibit phenotypic plasticity that complicates reliable identification. This study evaluated the environmental stability and phenotypic plasticity of qualitative leaf morphological traits in twenty cinnamon accessions across two agroecological regions of WM3a (Mid country Research Station [MRS]) and WL2a (Thalgampola, Galle) in Sri Lanka. The experiment was conducted using a Randomized Complete Block Design with three replications. Mother plants at MRS were compared with their vegetatively propagated clones established in Thalgampola for two years. Standardized leaf sampling from the 5th and 6th nodes below apical shoot tips were assessed for six qualitative traits of leaf arrangement (opposite, subopposite, opposite or subopposite in different branches and opposite to subopposite within the same branch), shape (elliptic, broadly elliptic, narrowly elliptic, ovate, broadly ovate, oval, lanceolate, ovate-lanceolate, and oblong-lanceolate), apex (acute, obtuse, acuminate, long acuminate, narrowly acuminate, and acuminate with broad acumen), base (acute, subacute, cuneate, rounded, sub-cordate, and obtuse contracted into petiole then shortly cuneate), venation, and margin. Chi-square and Cramér's V analyses revealed that leaf arrangement, apex, base, and venation were environmentally stable ($p > 0.05$, $V < 0.5$). Leaf shape showed moderate plasticity ($p = 0.033$), while leaf margin exhibited strong environmental responsiveness ($p < 0.001$), varying between entire and slightly undulate forms across regions. These findings indicate that environmentally stable traits serve as reliable taxonomic markers for cultivar identification across diverse sites, while phenotypically plastic traits may indicate adaptive responses, supporting breeding and propagation strategies.

**Keywords:** *Cinnamomum verum*, Environmental stability, Leaf morphology, Phenotypic plasticity

# Effects of Different Concentrations of Banana Male Bud Tonic on the Growth and Yield of Salad Cucumber under Polytunnel Conditions

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Plant-based biostimulants are increasingly recognized as sustainable inputs for enhancing crop growth and productivity under protected vegetable cultivation. However, information on optimal application rates under polytunnel conditions remains limited. Banana male bud tonic is a plant-derived biostimulant rich in bioactive compounds that can stimulate plant growth and improve yield performance. This study evaluated the effects of different concentrations of banana male bud tonic, applied as soil drench at 10-day intervals during the vegetative phase, on the growth, flowering, and yield of salad cucumber (*Cucumis sativus* L. 'Bonafide F1') grown under polytunnel conditions at the Faculty of Agriculture, Rajarata University of Sri Lanka. The experiment was carried out in completely randomized design (CRD) with four treatments; T1 - Albert's solution only (control); T2 - Albert's solution + banana male bud tonic (1:5); T3 - Albert's solution + banana male bud tonic (1:10) and T4 - Albert's solution + banana male bud tonic (1:15) and replicated four times. Data were analyzed using one-way analysis of variance, and treatment means were separated using the Dunnett's test at the 5% probability level. Plant height increased over time, but the height was not significantly influenced by banana male bud tonic applications up to first flowering ($p>0.05$). Soil drench application of banana male bud tonic significantly increased yield per plant ($p<0.05$), with the highest yield recorded in T3 (792.45±45.83 g plant$^{-1}$), followed by T4 (672.20±50.50 g plant$^{-1}$). These treatments increased yield by approximately 97% and 67%, respectively, over the control (401.75±50.88 g plant$^{-1}$). Fruit length and diameter were not significantly affected by treatments. In conclusion, soil application of banana male bud tonic at a 1:10 concentration effectively enhances salad cucumber yield under protected cultivation, highlighting its potential as a sustainable biostimulant for vegetable production.

**Keywords**: *Cucumis sativus*, Plant biostimulant, Protected cultivation, Soil drench

# Comparative Study of the Performance of Selected Rice Genotypes in terms of Root Attributes under Stress and Non-Stress Conditions in the Vegetative Stage

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Rice (*Oryza sativa* L.) is one of the largest staple food crops worldwide, particularly in Asia. Abiotic factors such as drought stress are a key factor that has reduced the yield of rice, especially at the initial stages, and the root system architecture is also significant in adaptation of plants to water – stress conditions to increase its ability to gain water and nutrients. In this study, the drought tolerance of plants at the vegetative stage was assessed in ten rice varieties, such as IR116713D, Bg 374, IRRI 264, Bg 22 – 3434, IR21C1106, IR21C1071, IR21C1100, Bg 377, IR93980S and IR21C1061. Among the chosen rice lines, Bg 374 and Bg 377 are released as cultivars in Sri Lanka, but other rice lines are still not released but have a possibility of later evaluation under local agronomic conditions. Drought stress caused notable impact on root length and root volume with stress conditions generally facilitating the promotion of root development although the responses of the varieties differed depending on the genetic variation in the drought tolerance. Root length and root volume were measured at 45 days after using root scanner (WinRHIZO model). Drought stress significantly *($p$*<0.05, ANOVA) affected root traits, with genotypic variation. IR21C1071 exhibited the greatest root elongation (12.3 cm), while IR116713D showed the highest root volume increase (11.4 $cm^3$), reflecting superior adaptive capacity under stress. IR21C1071 and IR116713D are promising donors for breeding programs targeting drought-prone environments. Variation in root architecture, particularly elongation vs. volume expansion, provides a basis for selecting resilient rice genotypes at the vegetative stage.

**Keywords**: Drought stress, Rice, Root scanner, Root system architecture, Vegetative stage

# Evaluation of Palmyrah-Based Growing Media on Growth, Yield and Quality of Cantaloupe (*Cucumis Melo* L.) under Protected Cultivation

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Cantaloupe (*Cucumis melo* L.) is a high-value crop cultivated under protected conditions, where the growing medium plays an important role in plant growth, yield, and fruit quality. This study evaluated palmyrah-based growing media as sustainable alternatives for cantaloupe production under protected cultivation at the Regional Agricultural Research and Development Centre (RARDC), Kilinochchi, Sri Lanka. The experiment was conducted in a net-house using 14 × 14 inch grow bags and arranged in a Randomized Complete Block Design (RCBD) with four treatments and three replications, comprising five plants per replication. Treatments were T1: Soil + Compost + Partially Burnt Rice Husk (2:1:1, v/v), T2: Cocopeat + Partially Burnt Rice Husk (3:1, v/v), T3: Cocopeat + Palmyrah Dry Flowers + Partially Burnt Rice Husk (2:2:1, v/v), and T4: Palmyrah Dry Flowers + Partially Burnt Rice Husk (3:1, v/v). Growth, reproductive, yield, fruit quality, and media chemical properties were evaluated. Data were analyzed using ANOVA, and means were separated using the LSD test at the 5% significance level. Significant differences ($P \leq 0.05$) were observed for media chemical properties, fruit weight, and total soluble solids (TSS). Palmyrah-based media maintained favourable pH (6.07–6.10), moderate electrical conductivity (0.565–0.673 dS $m^{-1}$), and higher nitrogen content (1.06–1.18%) than the conventional medium. The highest fruit weight (712 g) and TSS (13.88 °Brix) were recorded in T4, while the lowest values were observed in T1 (573 g and 11.78 °Brix, respectively). Plant height, stem girth, and leaf area index were not significantly affected by the treatments. These findings indicate that T4 has strong potential as a low-cost and sustainable growing medium for protected cantaloupe cultivation, although further validation under different environmental conditions and production systems is recommended before large-scale adoption.

**Keywords**: Cantaloupe, growing media, palmyrah residues, protected cultivation, dry zone agriculture

# Land Productivity of Seedling and Budded Cashew Plants under Plantation Conditions in the Dry Zone (DL3) of Sri Lanka

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Cashew (*Anacardium occidentale* L.) is an important plantation crop in Sri Lanka's dry zone, where improving land productivity is essential for sustainable development. This study evaluated seedling and budded cashew plants under plantation conditions in the Dry Zone Low Country (DL3) of Sri Lanka. The experiment was established in 2011 at the Puttalam Plantation of the Sri Lanka Cashew Corporation using a randomised complete block design (RCBD) with two replicates. WUCC 19 budded plants and seedlings were planted at 6 m × 6 m (80 plants acre$^{-1}$) and 9 m × 9 m (40 plants acre$^{-1}$), respectively, based on recommended spacing systems. Each plot measured 0.5 acre and contained 20 seedling plants or 40 budded plants. Annual nut yield data were recorded to 2025, and land productivity was calculated as kg acre$^{-1}$ year$^{-1}$. Data were analysed using ANOVA, and mean separation was performed using Tukey's HSD test at $p \leq 0.05$. Budded plants initiated bearing in 2013, while seedlings began in 2015. At the initial productive stage (2015), land productivity was 28 kg acre$^{-1}$ year$^{-1}$ for budded plants compared to 4 kg acre$^{-1}$ year$^{-1}$ for seedlings. In 2020, productivity reached 576 kg acre$^{-1}$ year$^{-1}$ and 200 kg acre$^{-1}$ year$^{-1}$, respectively. At maturity (2025), budded plants achieved 772 kg acre$^{-1}$ year$^{-1}$ compared to 290 kg acre$^{-1}$ year$^{-1}$ for seedlings ($p < 0.05$). Differences in productivity reflect combined effects of planting material and spacing. Budded plants provided earlier economic returns due to earlier bearing. Limited to two replicates; more replicates and multi-location trials are recommended. Overall, the findings indicate that budded cashew plants exhibit earlier bearing and higher land productivity than seedlings, highlighting their potential for improving cashew production in Sri Lanka's dry zone.

**Keywords:** Budded plants, Cashew, Land productivity, Seedling plants, WUCC 19

# Evaluation of Submergence Tolerance in Twenty-two Rice (*Oryza sativa* L.) Genotypes based on Anaerobic Germination

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Flash flooding during germination limits direct-seeded rice in rainfed lowlands. Twenty-two rice genotypes were evaluated for submergence tolerance during germination stage. Materials included improved varieties from Rice Research and Development Institute, Bathalagoda; traditional varieties collected from local farmers; and six genotypes selected from previous studies, representing both red- and white-pericarp genotypes. The experiment was conducted from July to August 2025 at the Crop Farm, Ariviyal Nagar, Kilinochchi District, Agro Ecological Zone $DL_3$ on low-humic gley soils using Completely Randomized Design with three replicates. Seeds were sown in plastic containers filled with puddled soil at the depth of 5 cm and subjected to controlled submergence for 3($T_2$), 7($T_3$), 10($T_4$), and 14($T_5$) days, with non-submerged seeds as control($T_1$). Germination percentage, shoot length (cm), root length (cm), and seedling vigor index were recorded 7 days after submergence. Data were analyzed using analysis of variance (ANOVA) with mean comparisons by Duncan's Multiple Range Test (DMRT) at 5% significance level in SAS 9.4. Rice genotypes were classified as tolerant, moderately tolerant, or susceptible based on germination percentage using the IRRI (2013) descriptor, and cluster analysis. Under seven days of submergence ($T_3$), *Pachaiperumal, Bw 372* (red pericarp) showed >75% germination and were identified as tolerant; *Mottaikaruppan karainagar, Mottaikaruppan Ariyalai, At 362, Pachaiperumal, Analvariyan, At 307, Mottaikaruppan Karainagar, Bg 379/2* exhibited as moderately tolerant under seven days of submergence ($T_3$) compared to < 25% germination in susceptible genotypes. *Mottaikaruppan Ariyalai, Mottaikaruppan Karaiainagar, Bg 400-6, Pachaiperumal, Bw 372* showed >50% germination and identified as moderately tolerant even under fourteen days of submergence ($T_5$). *Bw 372, Pachaiperumal* and *Bg 400-6* were identified as superior submergence tolerant genotypes at germination. Tolerant genotypes exhibited shoot elongation and seedling vigor, enabling better establishment in anaerobic conditions. These are valuable genetic resources for flood-prone direct-seeded rice systems and require multi-location validation.

**Keywords**: Anaerobic germination, Cluster Analysis, Flood tolerance, *Oryza sativa* L., Sri Lanka

# Food Science: Food and Nutrition

# Chemical Profiling of Sri Lankan Black Tea: Regional and Grade-Based Variations in Caffeine, Polyphenols, and Dry Matter

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The chemical composition of tea, especially its dry matter content, caffeine, and polyphenols, has a significant impact on its quality. The purpose of this study was to examine the dry matter content, caffeine concentration, and total polyphenol content (TPC) of specific black tea grades that were gathered from two main Sri Lankan tea-growing regions: Ruhuna (low-grown) and Dimbula (high-grown). Standard ISO methods were used to analyze four tea grades (BOP, OP, Dust, PF1), with ten samples per grade collected from different factories. Total polyphenol content was measured by the Folin–Ciocalteu method (ISO 14502-1) and caffeine by UV-Visible spectrophotometry (ISO 3103). Dry matter was determined by oven-drying at 105 °C. Significant differences were observed across regions and grades, with Dimbula BOP showing the highest polyphenol content (24.55 ± 1.81% DW). Low-grown tea showed lower TPC with Ruhuna OP (18.31 ± 1.30% DW). Caffeine was highest in Ruhuna PF1 (879.39 ± 39.54 mg CE/L (Caffeine Equivalents)) and lowest in Ruhuna Dust (504.11 ± 6.51 mg CE/L). Dry matter ranged from 91.65 ± 0.79% to 96.56 ± 0.95%, indicating consistent processing. These results clearly show that high-grown and low-grown teas have very different chemical compositions. Analysis of variance (ANOVA) was performed using Minitab (2022), revealing statistically significant differences in total polyphenol content (TPC) and caffeine content across tea grades and regions ($F = 4.96\text{-}8.17$, $p < 0.001$).These differences are extremely useful for creating analytical tools, particularly sensor-based devices like electronic tongues (E-tongues) that can distinguish between different types of tea based on geographic location. The chemical variations identified in this study represent strong identifiers that can be integrated into equipment calibration and classification models, thereby enhancing tea authenticity verification and quality control.

**Keywords**: Black tea, Caffeine content, Total Polyphenol content, Regional variation, UV-Visible spectrophotometry

# Morphological, Structural, and Physicochemical Characterization of Starch Extracted from Madu (*Cycas* sp.) Grown in Sri Lanka

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*Cycas* sp. is an underutilized carbohydrate source in Sri Lanka that holds significant potential for integration into the human diet. Starch obtained from *Cycas* could serve as a viable alternative to commonly used starch sources in food applications. This study focused on characterising *Cycas* starch, evaluating its structural, physicochemical, and morphological properties to understand its functionality and potential uses. The proximate composition revealed low crude protein (0.70 ± 0.02%), crude fat (0.27 ± 0.06%), and ash (0.23 ± 0.01%), indicating higher purity in extracted starch. The moisture content was 8.23 ± 0.54%, which is within the acceptable range for starch stability and storage. Microscopic examination showed predominantly spherical shaped granules, with diameters ranging from 0.68 to 1.72 μm. FTIR spectral analysis confirmed the typical carbohydrate nature of the starch, with characteristic absorption bands consistent with those of standard starches. XRD pattern revealed that *Cycas* starch was a type-A with relative crystallinity of 27.92%. The amylose content was found to be 15.89 ± 2.62%, suggesting a lower amylose level while the bulk density and pH were recorded as 0.56 ± 0.00 g/ml and 7.28 ± 0.06, respectively. Colour measurements showed $L^*$, $a^*$, and $b^*$ values of 97.51 ± 0.41, -0.42 ± 0.13, and 0.57 ± 0.12, with the notably high $L^*$ value indicating a higher level of whiteness. Water-holding and oil-holding capacities were 1.39 ± 0.09 g/g and 1.15 ± 0.18 g/g, respectively. Solubility and swelling power both increased with temperature, reaching their maximum values at 80 °C, demonstrating typical thermal behaviour of starch. The study shows that the underutilized starch from *Cycas* sp., exhibit physicochemical and functional properties suitable for food industry applications, and holds potential for use in various food formulations.

**Keywords**: *Cycas* sp., Microscopy, Physicochemical properties, Starch, Underutilized crop

# Regional Variation of Total Polyphenol Content and Dry Matter in BOPF Black Tea from Selected Sri Lankan Tea-Growing Regions

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Polyphenol composition in black tea plays an important role in antioxidant activity, sensory quality, and health benefits. Understanding regional variations in polyphenol content is important for tea quality assessment and origin authentication. This study aimed to compare the total polyphenol content (TPC) and dry matter content of Broken Orange Pekoe Fannings (BOPF) black tea from selected Sri Lankan tea-growing regions and evaluate their potential for regional differentiation. BOPF was selected because its fine particle size facilitates efficient extraction and provides reliable analytical measurements. It is also one of the most widely used grades in tea bags and commercial blends. Tea samples were collected from five major tea-growing regions of Sri Lanka: Sabaragamuwa, Dimbula, Ruhuna, Udu Pussellawa, and Uva. Ten factory-grade samples were obtained from each region to ensure representative sampling. Dry matter content was determined according to ISO 1572 and used to express results on a dry weight basis, while TPC was determined using the Folin–Ciocalteu colorimetric method according to ISO 14502-1:2005(E). Absorbance was measured at 765 nm using a UV–Visible spectrophotometer. All analyses were performed in triplicate, and statistical evaluation was conducted using one-way analysis of variance (ANOVA). The mean (±SD) TPC values ranged from 15.38 ± 1.36 %DW in Uva to 24.31 ± 1.98 %DW in Ruhuna. Dry matter content ranged from 90.92 ± 0.51 % in Dimbula to 94.60 ± 0.70 % in Sabaragamuwa. ANOVA revealed significant regional differences in both TPC ($F = 12.11$, $p < 0.001$) and dry matter content ($F = 20.61$, $p < 0.001$). These variations may be influenced by regional agro-climatic conditions, including elevation, temperature, rainfall, and soil characteristics, as well as differences in factory-level processing practices. The findings demonstrate that TPC and dry matter profiles provide region-specific biochemical information that may support future studies on tea origin verification, quality assessment, and future analytical approaches for regional classification of Sri Lankan black tea.

**Keywords**: BOPF black tea, Total polyphenol content, Dry matter content, Regional variation, Sri Lankan tea

# Analysis of Phytochemical Content and Bioactive Properties of *Kappaphycus alvarezii* Methanolic Extract

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Seaweeds are one of the important living resources of the marine environment. *Kappaphycus alvarezii*, a marine red seaweed, is primarily grown in Sri Lanka and has been reported to contain valuable bioactive compounds; however, its importance remains unknown. The bioactive properties, including antioxidant, antidiabetic, anti-inflammatory, and antibacterial activities of 70% methanolic extract of *K. alvarezii* were investigated using an *in vitro* method. *K. alvarezii* powder was extracted using 70% methanol (1:10) and freeze-dried. The yield of the methanolic extract was 22.16 ± 0.49%. Total phenolic and flavonoid contents were 0.99 ± 0.03 mg gallic acid equivalents/g of extract and 0.40 ± 0.06 mg rutin equivalents/g of extract, respectively. The crude extract showed antioxidant activities, including 2,2-diphenyl-1-picrylhydrazyl (DPPH) scavenging activity ($IC_{50}$: 10.48 ± 0.22 mg/mL), total antioxidant (3.16 ± 0.06 mg ascorbic acid equivalents/g extract), reducing ability (1.67 ± 0.02 mg ascorbic acid equivalents/g extract), and $H_2O_2$ scavenging activity ($IC_{50}$:2.06 ± 0.07 mg/mL). The antidiabetic potential was assessed by inhibiting alpha-amylase activity, with an $IC_{50}$ value of 16.40 ± 0.72 mg/mL. Antioxidant and antidiabetic activities increased significantly with increasing concentration, indicating a dose-dependent response. It showed anti-inflammatory activities, including inhibition of bovine serum albumin denaturation (50.00 ± 3.72%), trypsin inhibition (24.33 ± 0.84%), and heat-induced haemolysis (22.62 ± 1.09%) at 1 mg/mL and antimicrobial potential with inhibition zones at 250 mg/mL and 500 mg/mL concentration against *Staphylococcus aureus* (8.50 ± 0.71 mm and 10.50 ± 0.71 mm), *Bacillus subtilis* (10.50 ± 0.71 mm and 13.50 ± 0.71 mm), and *Escherichia coli* (8.50 ± 0.35 mm and 11.25 ± 0.35 mm), respectively. However, no activity against *Salmonella enterica*. Results demonstrated that methanolic *K. alvarezii* extract could be used as a potential source of bioactivity and may have great importance as a therapeutic agent in the food and pharmaceutical industries.

**Keywords:** Antioxidant, Antidiabetic, Antimicrobial, *K. alvarezii*, Phenolics, Seaweed

# Nutritional Composition, Mineral Profile, Anti-nutritional Factors, and Anti-Diabetic Potential of Poruthumaan; An Underexplored Plant Species

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Poruthumaan is an underutilized medicinal creeper widely grown in the Northern Province of Sri Lanka and traditionally consumed for relieving menstrual discomfort, enhancing bone strength, and managing arthritis. Despite its long-standing use in local diets, its nutritional and functional values have not been scientifically reported. This study aimed to analyze the nutritional composition, mineral profile, anti-nutritional factors and anti-diabetic potential of Poruthumaan leaf powder. Poruthumaan leaf powder was prepared by grinding cabinet-dried (40°C for 12 hours) mature leaves into fine powder. The sample was analyzed for nutritional composition, mineral profile, anti-nutritional factors and anti-diabetic potential (using α-amylase inhibition assay). The results revealed that dried Poruthumaan leaf powder is highly rich in fiber (24.12 ± 1.39%). The crude protein, crude fat, and ash contents of the dried leaf powder were 8.94 ± 0.08%, 1.07 ± 0.02%, and 8.37±0.09%, respectively. Mineral analysis reported a notably high calcium content (1835±10.2 mg/100g). Further, the results demonstrated that Prothumaan leaf powder is a good source of other minerals such as Mn, Zn, Fe and Mg. Anti-nutritional factors such as tannins (hydrolysable tannin (92.9 ± 067 mg/100g) and condensed tannin (1.08 ± 0.12 mg/100g) and oxalates (352.24 ± 3.18 mg/100g) were detected at concentrations similar to those of commonly consumed medicinal leaves. The α-amylase inhibition assay showed strong enzyme inhibitory activity ($IC_{50}$=28.05 µg/mL) comparable to the standard (Quercetin) ($IC_{50}$=35.69 µg/mL). This study revealed that the first scientific evidence validating the nutritional richness and bioactive potential of Poruthumaan leaf. Future studies should focus on bioactive compounds profiling and underlying mechanisms responsible for the anti-diabetic effects, assessing mineral bioavailability and safety, and validate the functional potential through in-vivo experiments.

**Keywords:** Anti-diabetic, Anti-Nutrition, Antioxidant, Medicinal leaf, Poruthumaan

# Evaluation of Antioxidant Properties of Heen bovitiya (*Osbeckia octandra* L.*)* Leaf Extract

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Antioxidants neutralize free radicals and reduce oxidative damage in biological systems and food matrices. Growing concerns over synthetic antioxidant safety have driven interest in plant-based alternatives. *Osbeckia octandra* (Heen Bovitiya) is an indigenous Sri Lankan medicinal plant traditionally used in herbal treatments, known for its rich phytochemical profile. This study evaluated the antioxidant properties of *O. octandra* leaf extract. Leaves were dried, powdered, and extracted using 80% (V/V) methanol under varying shaking times (1, 6, 12, 24, and 48 hours) and dilution factors (1:10, 1:50, 1:100, 1:200, and 1:250; sample: solvent). Statistical analysis was performed using R Studio, with mean values compared via Tukey post-hoc test in triplicates. Total phenolic content (TPC) and total flavonoid content (TFC) were determined using Folin–Ciocalteu and Aluminium Chloride colorimetric assays, respectively. The highest TPC (888.37 ± 0.1 mg GAE/g (mg gallic acid equivalents per gram)) was recorded at 24 hours with 1:250 dilution, while maximum TFC (2.27 ± 0.06 mg QU/g (mg quercetin equivalents per gram)) was obtained at 24 hours with 1:100 dilution. Antioxidant activity was assessed through DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS (2,2'-azino-bis (3-ethyl benzo thiazoline-6-sulphonic acid)) radical scavenging assays. The DPPH $IC_{50}$ was 37.17 µg/mL at 24 hours and 1:250 dilution, comparable to standard ascorbic acid, while the ABTS $IC_{50}$ was 24.00 µg/mL under the same conditions, reflecting stronger activity. Overall, *O. octandra* leaves demonstrated significant ($p<0.05$) antioxidant properties. The biphasic extraction pattern observed indicates differential compound release and stability, with prolonged extraction potentially causing degradation. These findings support the development of standardized extraction protocols and establish Heen bovitiya as a promising natural antioxidant for food preservation and functional product applications.

**Keywords:** ABTS, Antioxidant, DPPH, Extraction kinetics, Heen bovitiya

# A Comparative Study on Microbial and Sensory Quality of Sri Lankan Green Tea Produced by Different Manufacturing Methods

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Despite its global reputation, Sri Lankan green tea faces microbiological quality concerns. This study evaluated the microbiological and sensory quality of Sri Lankan green tea produced by steaming, panning, handcrafting methods and examined compliance with Sri Lanka Tea Board standards. Green tea samples were collected from 15 operational green tea factories (n=15) during 2025, with three replicate samples obtained from each factory. Microbiological analyses followed ISO 11287:2011. Each sample was analyzed in triplicate for Total Plate Count (ISO 4833-1:2013), Yeast & Mold (ISO 21527-2:2008), Total Coliforms (ISO 4831:2006) and *Escherichia coli* (ISO 7251:2005). Sensory evaluation used a seven-point hedonic scale by seven trained tea tasters from Sri Lanka Tea Board, assessing dry leaf, liquor, and infused leaf quality. Statistical analyses were performed using IBM SPSS Statistics version 27. One-way ANOVA followed by Tukey's post hoc test was used to compare microbiological and sensory parameters among manufacturing methods at $p<0.05$. The handcrafted method recorded the lowest mean yeast and mold count ($6.19\times10^2$ CFU/g), total plate count ($3.39\times10^2$ CFU/g), and total coliform count ($4.35\times10^2$ MPN/g) and the highest sensory quality ($p = 0.002$). In contrast, the panning method showed the highest microbial loads, with yeast and mold counts of $4.21\times10^5$ CFU/g and total plate counts of $8.15\times10^5$ CFU/g, while steaming had moderate levels, yeast and mold counts ($1.20\times10^5$ CFU/g) and total plate counts ($5.45\times10^5$ CFU/g). Although all green tea samples were free from *Escherichia coli*, a substantial proportion failed to comply with the microbiological safety limits of Sri Lanka Tea Board Circular ALMQS-02/2021; however, samples were complied with the Tea & Herbal Infusions Europe (THIE) recommended microbiological limits for *Camellia sinensis* with minor yeast and mold deviations. These findings highlight the improved sanitation and quality control, particularly in automated manufacturing systems. Overall, handcrafted green tea demonstrated superior quality compared to other manufacturing methods.

**Keywords:** Green Tea, Manufacturing Methods, Microbial Quality, Sensory Quality, Sri Lanka

# Food Science: Food Processing and Product Development

# Development and Nutritional Characterization of Jam Incorporated with *Hibiscus* Flowers and Winter Melon Pulp

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Jam is a semi-solid product obtained by cooking fruit with sugar to enhance flavor, texture, and shelf life. This study developed a nutritionally enriched jam using *Hibiscus rosa-sinensis* flower extract and winter melon, commonly known as ash gourd pulp, through optimized formulations: Control (0:40:60 *Hibiscus*: melon: water), T1 (60:40:0), T2 (40:60:0), T3 (20:80:0), and T4 (80:20:0), each with 45 % sugar and 5 % citric acid. Jam was prepared by extracting *Hibiscus* petals, processing melon pulp, and boiling the mixture. Jam preparation involved extracting Hibiscus petals, processing melon pulp, and boiling the mixture at approximately 105 °C until reaching a final total soluble solids content of 68 °Brix. Sensory evaluation was conducted on T1, T2, T3, T4, and the control. Based on the sensory evaluation, T1 and the control were selected and subjected to proximate analysis using AOAC Methods. Sensory evaluation was conducted using a 5-point hedonic scale method with semi-trained 35 panelists. Statistical significance was determined using SPSS Version 25, employing the Friedman test ($p < 0.05$). The results of the sensory evaluation revealed that T1 received the highest score, followed by the control, T3, T2, and T4. Based on this, the T1 formulation was selected. Nutritional analysis revealed an overall improvement in the nutrient and mineral profiles from the control to T1 formulation. Specifically, a reduction was observed in salt (0.09→0.06 g/100g, control to T1, respectively), magnesium content (69.12→65.01 mg/100g), and reducing sugars (4.727→3.954%), while sodium (18.26→19.63 mg/100g), potassium (53.3→54.69 mg/100g), calcium (24.68→25.01 mg/100g), and protein levels (0.05→0.518 g/100g) increased and fat content remained constant at zero. T1 formulation showed favorable titratable acidity (1.185±0.15 %), pH (3.7), moisture (1.24±0.15 %), and yeast/mold count ($<1\times10^2$ CFU/g). Overall, *Hibiscus rosa sinensis* and *Benincasa hispida- based* jam, particularly the T1 formulation, showed improved nutritional quality, acceptable sensory properties, and good microbial stability, indicating its potential as a value–added jam product.

**Keywords**: *Hibiscus* flower, Jam, Melon, Sensory evaluation

# Development of a Gluten-Free Fibre- and Iron-Rich Snack Bar Using Palmyrah Tuber Flour

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Snack bars serve as convenient, nutrient-dense energy sources; however, the utilization of underutilized tropical crops like Palmyrah remains limited. This study aimed to formulate a healthy, gluten-free fibre rich snack bar using Palmyrah tuber flour (PTF) and Palmyrah jaggery as primary ingredients. Four formulations (F1–F4) were developed by varying the Palmyrah tuber flour ratio (10g, 20g, 25g, and 30g) while maintaining constant levels of auxiliary ingredients. The Sensory evaluation using a 9-point hedonic scale (n=20 trained panelists) identified F3 (25 g Palmyrah tuber flour) as the most acceptable formulation. The optimized bar contained 60.34 g/100 g carbohydrates, 8.20 g/100 g crude fibre, 3.83 g/100 g protein, 11.39 g/100 g fat, and 2.40 mg/100 g iron, delivering 420.15 kcal/100 g. Comparative analysis against a commercial Oat bar confirmed the Palmyrah snack bar's superior fibre and iron content alongside lower sugar and salt levels. Texture profile analysis indicated the formulated bar (hardness - 76.00 g) was slightly softer than the commercial counterpart (96.00 g). Shelf-life studies confirmed microbial stability for up to three months (90 days). A consumer survey (n=250) targeting health-conscious young adults (20–40 years) revealed strong commercial viability for the snack bar. Overall, 84.8% of respondents were willing to purchase the product, with health benefits identified as the primary purchase driver (75.7%). Product perception scores were highly positive. Supermarkets emerged as the preferred retail channel (40.4%). Regression analysis indicated that preference for traditional ingredients significantly influenced willingness to pay ($p<0.05$). Future work should prioritize gluten-free certification, standardized production protocols, and targeted marketing emphasizing Palmyrah's superior fiber, iron content, and traditional heritage to maximize commercial potential.

**Keywords:** Palmyrah tuber flour, Gluten-free snack bar, Functional food, Jaggery, Consumer acceptance, Shelf-life

# Formulation and Quality Evaluation of Flavored Peanut Spread Enriched with Jackfruit (*Artocarpus heterophyllus*) Seed Powder

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The development of food products using underutilized agricultural by-products has gained increasing attention as a sustainable approach to enhancing nutritional quality and reducing food waste. This study aimed to develop and evaluate the quality of flavored peanut spread formulations enriched with jackfruit seed powder. Jackfruit seed powder was incorporated to enhance the nutritional and functional properties of the flavored spread. Peanuts contributed high-quality protein, healthy unsaturated fats, and essential micronutrients, thereby enhancing the product's overall nutritional value. The study focused on evaluating the physicochemical, nutritional, sensory, and storage characteristics of flavored peanut spreads enriched with jackfruit seed powder. Three different flavored formulations, garlic (F2), vanilla (F3), cocoa (F4), and a control (F1) formulation were developed using peanut, jackfruit seed powder, sunflower oil, honey, vinegar, and salt. Sensory evaluation of the formulated spreads was conducted with 35 semi-trained panelists on a five-point hedonic scale to assess appearance, texture, spreadability, aroma, flavor, mouthfeel, and overall acceptability. Based on sensory scores, the garlic-flavor-incorporated formulation (F2) was identified as the most acceptable treatment (overall, $p<0.05$). Chemical analysis of the selected garlic-flavored peanut spread enriched with jackfruit seed powder (F2) formulation revealed a moisture content of 4.08%, pH of 6.3, ash content of 3.33g/100g, acidity (Oleic acid) of 0.49%, fat content of 33.83g/100g, and yeast and mold count of less than 1 × 102 CFU/g, indicating good product stability and microbiological safety. This research demonstrates the potential of jackfruit seed powder as a functional ingredient in peanut spread, adding value to an often- discarded by-product while supporting food innovation and functional food development.

**Keywords**: Cocoa, Garlic, Jackfruit seed powder, Peanut, Vanilla

# Production and Evaluation of Cassava Starch, Lime waste and *Aloe vera* Based Edible Film as Food Packaging Material

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Production of non-biodegradable plastic packaging is raising global concerns about environmental pollution. The main purpose of this study is to develop and evaluate an agricultural by-product-based renewable packaging material that can replace plastic packaging. The study investigated how different types of lime waste and *Aloe vera* gel influenced the properties of cassava starch-based edible films. Raw materials used in this study included cassava starch (extracted from fresh cassava tubers), dried lime waste flour (obtained from the valorisation of kitchen waste), *Aloe vera* gel (extracted from fresh leaves) and food-grade glycerol. Six different edible films were developed using three types of 1% (w/v) lime waste flour (dried lime peel (P1), dried lime pulp (P2) and a mixture of dried peel and pulp (P3)), with 10% (v/v) *Aloe vera* gel (A1) and without *Aloe vera* gel (A0). Cassava starch (3% w/v) and glycerol (1% w/v) were kept constant across all six treatments. Distilled water was then incorporated, and the mixture was homogenised at 90°C for 30 minutes. Thereafter, the solution was left to cool, and films were produced via the casting method. The resulting packaging materials were analyzed to investigate their properties. P1A0 (lime peel-based film without *Aloe vera*) showed the highest significant polyphenol migration of 94.88 mg GAE/kg of food simulant ($p<0.0001$), exhibited the lowest water solubility ($p=0.035$), and displayed a smooth, pale-yellow microscopic image. Similar, non-significant results were observed for thickness and moisture content ($p>0.05$) across all films and XRD results showed a specific peak at 29.5°, and FTIR showed the presence of hydrogen, C-H, C=N and C=C bonds. In conclusion, the P1A0 edible film delivers promising results for producing an edible film that can function as a food packaging material, while replacing synthetic plastic packaging and promoting a sustainable, eco-friendly solution.

**Keywords:** *Aloe vera*, Cassava starch, Edible film, Food packaging, Lime waste

# Development and Evaluation of Herbal Bio-coating from *Aloe vera,* Tulsi (*Ocimum sanctum*) and Lemongrass (*Cymbopogon citratus*) for Postharvest Preservation of Fruits

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The continuous growth of the global population has increased the demand for nutritionally rich fruits and vegetables, by considering quality and safety. Fresh fruits are highly perishable commodity, the development of natural and sustainable techniques to retain quality attributes and extend shelf life is vital important. The study was conducted to develop and evaluate herbal bio-coatings of *Aloe vera* gel, Tulsi extract, and lemongrass essential oil for postharvest preservation of climacteric fruits. The herbal materials were prepared individually and formulated with food-grade glycerol, lecithin, and xanthan gum to obtain a stable and uniform bio-coating solution. Three coating formulations (A, B, and C) with varying concentrations were developed and evaluated. Among them, formula B exhibited superior postharvest preservation and quality retention. Therefore, it was selected for further analysis. Mango, banana, and avocado fruits of uniform maturity and defect-free were coated using the dipping method and stored under ambient conditions. Postharvest quality parameters including physical and physicochemical weight loss, firmness, colour, pH, TSS (ºBrix), titratable acidity, water activity, moisture content, visual appearance, and microbial spoilage were evaluated at 3-day intervals over a 15-day storage period. The results exhibited that the herbal bio-coating significantly improved postharvest quality compared to uncoated control fruits. Coated fruits exhibited reduced weight loss and better firmness retention throughout the storage period. Ripening-related changes in pH and TSS were delayed. Improved moisture retention, enhanced surface appearance, and reduced shriveling were observed in all coated fruits. In addition, microbial spoilage was noticeably lower in coated samples, particularly during extended storage. Overall, the herbal bio-coating effectively enhanced postharvest quality and extended the shelf life of fruits, and highlighting its potential in fruit preservation.

**Keywords:** *Aloe vera*, Herbal bio-coating, Lemongrass, Storage, Tulsi

# *Aloe vera* Incorporated Edible Coating from *Canna edulis* for Post-harvest Quality Retention of Fresh Coconut

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Coconut (*Cocos nucifera L.*) is valued for its nutritional and functional benefits, particularly when its fresh; therefore, it's called the 'Tree of Life'. However, deshelled coconut kernel rapidly deteriorates due to moisture loss and oxidative spoilage. This study evaluated a *Canna* starch, aloe vera gel and glycerol coating to preserve selected quality attributes of coconut kernel. The coating was applied to approximately 2cm sized coconut pieces. Treatment and control samples were dried at 60°C for 2 hours to facilitate film formation and adhesion, which were then stored under ambient (25±5°C) and refrigerated temperatures (4±1°C) for a period of 15 days. Four treatments were evaluated including control samples, T1(Coated at ambient temperature), T2 (Coated at refrigeration temperature), C1 (Uncoated at ambient temperature and C2 (Uncoated at refrigeration temperature). Fresh coconut kernel had an initial moisture of (45.3±0.12%) and water activity of (0.96±0.04%). During storage, the coated sample at ambient temperature showed better retention of moisture (34.9±0.07%) and water activity (0.93±0.01%) than the uncoated control samples, which showed significantly lower values (3.3±0.01%) and (0.75±0.01%), indicating the effective moisture barrier properties. Furthermore, the coated sample exhibited improved oxidative stability indicated by a lower peroxide value (2.2 meq/kg) throughout the storage period than the uncoated control sample (20 meq/kg). By day 15, coated samples under ambient conditions also showed comparatively better non-ingestive sensory acceptability than the control samples. Overall, the developed coating shows potential for preserving fresh coconut kernel. However, further studies including microbiological analysis, expanded sensory evaluation and antioxidant properties are required to confirm preservative action and storage stability.

**Keywords**: *Aloe vera*, Canna starch, Coconut, Edible films, Moisture content

# Development and Nutritional Evaluation of Date-Based Energy Bar Formulated with Dehydrated Banana Chips

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Most commercial energy bars contain high levels of added sugars, refined syrups, and fats. Regular consumption of such products contributes to excessive calorie intake and increases the risk of non-communicable diseases. This study aimed to developed a date-based energy bar incorporated with dehydrated banana chips without the addition of sugar and salt. Dates, bananas, rice flakes, pumpkin seeds, sesame seeds, peanuts, mung beans, coconut oil, and banana flavor were used as ingredients. Three formulations were developed by varying the proportion of date paste and dehydrated banana chips and other ingredients were kept constant across all treatments. The formulations were evaluated for proximate composition, color parameters, microbial safety, and sensory attributes. According to the results, crude protein, crude fat, and dietary fiber contents ranged from 9.99-10.06%, 6.71-6.75%, and 6.99-7.165 respectively. However, ash and sugar contents showed significant differences among the treatments, ranging from 1.58-1.68% and 17.20-19.00% respectively. Moisture content, color and total plate count (TPC) were monitored throughout 21 days of the storage period room temperature (28±2 °C). Moisture content and color values increased significantly during storage. However, T1 exhibited the lowest moisture increase (12.24-13.37%) compared to T2 (15.13-19.03%) and T3 (12.72%-14.86%). T1 demonstrated the stable physiochemical properties, retaining the redness (a*) value (7.36 ± 0.19) by the third week of storage. T1 remained microbiologically safe during storage, with a final TPC of $1.0 \times 10^4$ CFU/g, well below the acceptable limit of $1.0 \times 10^6$ CFU/g. Sensory evaluation concluded that the T1 formulation provides favorable physical stability and sensory acceptability.

**Keywords**: Date paste, Dehydrated banana chips, Energy bars, Physiochemical properties, Proximate composition

# Development and Quality Evaluation of Fortified Instant Idli Batter Mix Enriched with Palmyrah Pulp

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Idli is a fermented breakfast food valued for its soft texture, easy digestibility, and health benefits. However, commercially available instant idli mixes often provide limited amounts of dietary fiber, antioxidants, and essential minerals. This study aimed to develop a nutritionally enhanced instant idli batter mix by fortifying it with Palmyrah (*Borassus flabellifer* L.) fruit pulp (PFP), an underutilized yet nutrient-rich resource commonly found in Sri Lanka. Five idli batter formulations ($T_0$, $T_1$, $T_2$, $T_3$, and $T_4$) were prepared by varying the proportions of PFP and semolina (0:80%, 10:70%, 20:60%, 30:50%, and 40:40%) respectively, while keeping the levels of other ingredients constant (black gram 15%, salt 3%, and yeast 2%). The developed batter samples were assessed for nutritional, physicochemical, microbiological, and sensory characteristics after the addition of yeast and one hour fermentation. Sensory evaluation using a 9-point hedonic scale indicated that formulation $T_3$ achieved the highest overall acceptability, providing an optimal balance of colour, aroma, taste, flavour, and texture. Based on these results, $T_3$ was selected as the optimized formulation, containing crude fiber (10.74%), crude protein (12.02%), crude fat (0.12%), ash (2.73%), salt (2.33%), moisture (62.19%), energy (316.76 kcal), pH (5.62), titratable acidity (0.24%), and °Brix (10.52). The inclusion of PFP significantly ($< 0.05$) enhanced the batter's dietary fiber, protein, fat, ash, salt, and mineral contents without adversely affecting sensory quality. Physicochemical parameters such as pH, titratable acidity, °Brix, moisture content, and energy varied among treatments but remained within acceptable limits, ensuring product stability. Microbiological analysis confirmed product safety, with the absence of coliforms and acceptable yeast and mold counts, indicating effective hygienic processing and satisfactory shelf stability. Overall, the study concludes that incorporating 30% PFP ($T_3$) into instant idli batter enhances nutritional quality while maintaining safety and consumer acceptability, supporting the value-added utilization of Palmyrah resources for functional foods.

**Keywords:** Fermentation, Idli batter, Palmyrah fruit pulp, Sensory analysis

# Formulation and Evaluation of Chocolate-Coated Millet Balls: A Sustainable, Functional Snack for Adults

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This study aimed to identify the optimal combination of chocolate-coated millet balls that enhances both nutritional and sensory value. Various formulations incorporating sorghum, finger millet, and kodo millet were tested alongside date paste and chopped peanuts. Through extensive sensory evaluations and nutritional analysis, the blend containing 40% millets, 40% date paste, and 20% chopped peanuts emerged as the most balanced and acceptable option. Millet balls were prepared with chosen ratios (40% millets, 40% date paste, and 20% chopped peanuts) and coated with chocolate, such as sorghum (T1), finger millet (T2), and kodo millet (T3), and control formulation (T4). A control treatment comprising 60% chopped peanuts and 40% date paste was used for baseline comparison, but lacked the same nutritional and sensory balance. These formulations demonstrated superior performance in terms of healthy fats, dietary fibre, and essential minerals. Moisture content, ash content, fibre levels, and mineral composition further validated its nutritional quality. Among the millet types, the chocolate-coated kodo millet ball (T3) received the highest sensory ratings, offering a well-rounded and appealing profile. Sorghum and finger millet variants also showed promise, though minor improvements in flavour and aroma were recommended. Overall, the findings suggest that combining millets with date paste and chopped peanuts yields a nutritious and enjoyable snack, with kodo millet as the most favourable base. This formulation holds potential for health-conscious consumers seeking functional and culturally resonant snack options. Kodo millet balls (T3) recorded the highest sensory acceptability (texture $3.83 \pm 0.12$, overall $p < 0.05$) and a balanced nutritional profile with 15.43% sugar, 10.8% fat, 4.42% fibre, and high potassium (333.58 mg/100 g) and magnesium (120.21 mg/100 g), confirming their functional value.

**Keywords**: Chocolate-coated millet balls, Date paste, Finger millet, Kodo millet, Sorghum

# Effect of Different Drying Methods on Nutrient Retention Characteristics of the Pearl Millet-based Functional Food Supplement Ingredients

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The development of functional foods requires careful selection of processing conditions that preserve the nutritional quality of raw materials while ensuring their suitability for formulation and storage. Cereals and legumes such as pearl millet (Pennisetum glaucum), green gram (Vigna radiata), and peanuts (Arachis hypogaea) are nutritionally rich; however, their macro and micronutrient content is susceptible to degradation during thermal processing. Therefore, identifying ingredient-specific processing conditions is essential. This study evaluated the effects of Low Temperature Long Time (LTLT) and High Temperature Short Time (HTST) processing on selected raw materials to identify the most suitable condition for nutrient retention and functional food application. Pearl millet, green gram, and peanuts were cleaned and processed under controlled LTLT and HTST conditions, followed by drying and grinding. The processed samples were compared with raw materials to assess the influence of thermal treatment on nutritional stability. The findings indicated clear ingredient dependent responses to processing conditions. Moisture content, expressed on a wet basis, decreased substantially after processing and was approximately 2-8%, indicating suitability for storage. Protein content of green gram and peanuts remained relatively stable under both processing conditions, with values in the range of 22-26% for green gram and 25-30% for peanuts. HTST processing resulted in greater moisture reduction in these two ingredients, suggesting improved shelf-life potential. In contrast, pearl millet exhibited higher protein retention under LTLT processing, with protein values of 10-13%, whereas HTST- treated pearl millet showed reduced protein levels of approximately 5-8%, indicating greater sensitivity to high-temperature exposure. Carbohydrate content remained within expected ranges for cereals and legumes (approximately 60-70%), with only marginal variation between processing conditions. Overall, the results confirm that HTST processing is suitable for green gram and peanuts, while LTLT processing is more appropriate for pearl millet, emphasizing the importance of ingredient-specific thermal processing strategies in functional food development.

**Keywords**: Functional food, HTST drying, Proximate analysis, Nutrient retention, LTLT drying

# Plant Protection and Biotechnology

# Evaluation of Resistant Rootstocks for Grafting Tomato (*Solanum lycopersicum*) Variety *Thilina* to Manage Bacterial wilt

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Bacterial wilt (BW) is an economically important, soil-borne disease of tomato (*Solanum lycopersicum*) that can cause severe yield losses up to 100%. Although the tomato variety *Thilina* has desirable fruit traits like thick pericarp, it shows only moderate bacterial wilt resistance. Grafting *Thilina* onto BW-resistant rootstocks offers an eco-friendly strategy for disease management. This study evaluated the BW resistance of *Thilina* grafted onto resistant rootstocks. Lanka Sour and T245 tomato varieties, *Pepino* (*Solanum muricatum* Aiton), and eggplant (*Solanum melongena* L.) cv. *Padagoda* were used as bacterial wilt–resistant rootstocks for wedge grafting onto the tomato variety *Thilina*. Non-grafted *Thilina* plants served as the control. All plants were transplanted in a field that had been heavily contaminated with the bacterial wilt during the previous cropping season. Wilting incidence, vegetative growth and fruiting parameters were evaluated. Data were analyzed using one-way analysis of variance (ANOVA) in SAS statistical software, and means were separated using Duncan's multiple range test at $p \leq 0.05$. A significantly lower wilting percentage was observed in plants grafted on Lanka Sour (0%), *Padagoda* (3.13%), and *Pepino* (4.17%) compared with the non-grafted *Thilina* (37.5%) and T245 (9.38%), at 60 days after transplanting. The greatest plant height was recorded in rootstock *Padagoda*, followed by T245 and Lanka Sour. The maximum number of primary branches was observed in rootstock Lanka Sour, followed by *Padagoda* and T245. The highest number of fruits was produced by *Thilina* grafted onto Lanka Sour. Number of fruits on T245, non-grafted and *Padagoda* plants were statistically similar, whereas grafting onto *Pepino* rootstock resulted in the lowest fruit yield. The study findings indicate that Lanka Sour, *Padagoda*, and *Pepino* rootstocks effectively reduced bacterial wilt in *Thilina* variety. Lanka Sour is recommended for complete resistance and optimal yield. *Padagoda* enhances plant growth whereas *Pepino* reduces yield despite its disease suppression.

**Keywords**: Bacterial wilt, Growth, Resistant rootstocks, *Solanum lycopersicum*

# *In Vitro* Antibacterial Activity of Theaflavin against *Ralstonia solanacearum*

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*Ralstonia solanacearum*, a soil-borne bacterium, is responsible for bacterial wilt in a variety of solanaceous crops, leading to significant yield losses. Using antibacterial agents to control bacterial wilt is expensive and may produce antimicrobial resistance. Theaflavin, a polyphenolic compound obtained from tea (*Camellia sinensis*), has shown antimicrobial effects previously. Hence, this study was carried out to evaluate the activity of theaflavin against *R. solanacearum*. A 100mg/mL stock solution was prepared using theaflavin powder and sterile distilled water as the solvent. A series of dilutions was prepared using the above to obtain the concentrations: 50mg/mL, 25mg/mL, 12.5mg/mL, and 6.25mg/mL. Tetracycline was used as the positive control, and sterile distilled water as the negative control. *R. solanacearum* was cultured on Muller-Hinton agar overnight, and a fresh bacterial suspension (McFarland 0.2) was prepared in Phosphate Buffer Solution. A well diffusion assay was performed on Muller-Hinton agar for the aforementioned concentrations against *R. solanacearum*. Antibacterial effect of theaflavin was measured by deducting the Diameter of the Inhibition zone by sterile distilled water and from the diameter of the inhibition zone due to theaflavin/ tetracyclin. All theaflavin concentrations tested inhibited *R. solanacearum*. Along with the reducing concentration gradient, the size of the inhibition zone decreased. The ZOIs were 11.50±0.7mm for 100mg/ml, 9.13±0.6mm for 50mg/mL, 7.50 ±0.6mm for 25mg/mL, 5.38 ±0.3mm for 12.5mg/mL and 3.75±0.5mm for 6.25mg/mL. ZOI for tetracycline was 16.75±0.5. These findings indicate that theaflavin has a concentration-dependent antibacterial effect against *R. solanacearum*, suggesting that theaflavin may be an alternative to control bacterial wilt.

**Keywords**: Antibacterial agents, Bacterial wilt, *Ralstonia solanacearum*, Theaflavin

# Eusocial Structure of *Macrotermes* Termites and Antagonistic Potential of Fungal Biocontrol Agents against *Termitomyces* Fungus and Termites

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The study was conducted to investigate the mutual relationship between *Macrotermes* termites and their symbiotic fungus *Termitomyces*, focusing on their structural organization and functional roles within the mound ecosystem. Additionally, the research explored the potential of using fungal antagonists as eco-friendly biocontrol agents for sustainable termite management. Field observations were conducted on ten *Macrotermes* mounds and detailed data were collected from only one representative mound, which was dome-shaped with multiple ventilation holes measuring 3–6 cm in diameter, an average height of 120 cm, and an average width of 190 cm. Internal examination revealed well-organized chambers containing fungus combs with a mean fresh weight of 230.47 ± 92 g, a perimeter of 37.5 ± 5 cm, and a volume of 1793.1 ± 926 $cm^3$, indicating advanced eusocial organization and efficient resource allocation. The isolated *Termitomyces* species displayed white, cottony mycelial growth with basidiomycete characteristics, including clamp connections observed microscopically. Dual culture assays with three replicates demonstrated strong antagonistic activity of *Trichoderma viride* against *Termitomyces*, achieving 83.33% inhibition of mycelial growth after 14 days. An eco-friendly substrate formulation containing tamarind seed and fenugreek seed supported maximum mycelial growth and sporulation ($6.23 \pm 0.3 \times 10^6$ spores $g^{-1}$) at an optimal pH range of 5.5–6.5. *T. viride* colonized sterilized termite combs more effectively than wild combs, suggesting that native microbial flora restricted colonization. Laboratory bioassays revealed a significant effect ($p < 0.05$) of entomopathogenic fungi on termite mortality, with *Paecilomyces cerevisiae* causing the highest mortality (85%), followed by *Metarhizium anisopliae* (75%) and *Beauveria bassiana* (49.3%). Overall, the findings support the use of fungal-based biocontrol agents in environmentally sustainable management of *Macrotermes* termites.

**Keywords**: Entomopathogenic fungi, *Macrotermes*, Termites, *Termitomyces*, *Trichoderma viride*

# An Attempt to Develop High-performance Edible Mushroom Hybrids through a Cross-Breeding-Based Approach

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Oyster mushrooms (*Pleurotus spp*) are highly valued edible fungi, accounting for 25% of global mushroom production, and are rich in protein (15-30% dry weight), essential vitamins, minerals, and dietary fiber. However, commercial cultivation faces challenges, including low biological efficiency, slow growth, and environmental sensitivity, necessitating the development of improved strains through systematic breeding approaches. This study examined six interspecific hybrid combinations among six oyster mushroom types: *Pleurotus ostreatus* (American Oyster), *P. cystidiosus* (Abalone), *P. djamor* (Pink Oyster), *P. pulmonarius* (Black Oyster), *P. sajor-caju* (Bhutan Oyster), *and P. ostreatus var. curly* (Curly Oyster) to identify superior hybrids for commercial-scale production. The experiment was conducted at the Agriculture Research Station, Thelijjawila, Matara, Sri Lanka, using a Completely Randomized Design (CRD) with 15 replicates per treatment. A total of six hybrid combinations were developed: Bhutan × American Oyster (T1), Bhutan × Abalone (T2), American Oyster × Curly (T3), Pink Oyster × Curly (T4), American Oyster × Black Oyster (T5), and Abalone × Black Oyster (T6). Clamp connection microscopic observation confirmed successful dikaryon formation. Marked variations ($P < 0.001$) were noted among treatments regarding spawn run duration, fruiting initiation, yield, stalk length, and cap diameter. T3 and T4 showed exceptional performance, attaining the shortest spawn run (~26 days), the earliest fruiting (16-28 days), and the greatest yields (83.71 g and 71.29 g), respectively. Performance variation was significant, with 84% range for spawn run time, 369% for fruiting start, and 187% for yield. Heritability study revealed that a substantial genetic regulation of stalk length ($R^2 = 85.34\%$) and modest effect on yield ($R^2 \approx 60\%$), whereas cap diameter was predominantly influenced by environmental factors ($R^2 = 36.96\%$). T3 and T4 are endorsed for commercial use owing to their enhanced productivity, swift growth, and reliability. The findings confirmed that interspecific hybridization is an effective breeding strategy for developing *Pleurotus cultivars* with enhanced biological efficiency and improved cultivation potential.

**Keywords**: Heterosis, Interspecific hybridization, Mushroom breeding, *Pleurotus ostreatus*, *Pleurotus* spp.

# Soil, Water and Environment

# Effect of Mulching on Soil Physical Properties under Dry Zone Condition: Evidence from Knol-khol (*Brassica oleracea var. gongylodes*) Cultivation in Kilinochchi, Sri Lanka

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Soil physical degradation and rapid moisture loss are major constraints to vegetable production in the dry zone of Sri Lanka. Although mulching is widely used to conserve soil moisture, information on its effects on soil physical properties under local conditions is limited. This study evaluated the impact of different mulching materials on soil moisture storage, soil temperature, bulk density, and soil organic matter during Knol-khol (*Brassica oleracea* var. *gongylodes*) cultivation in Kilinochchi District, Sri Lanka. A field experiment was conducted using a Randomized Complete Block Design (RCBD) with four treatments: paddy straw mulch, palmyra dry leaves mulch, polythene mulch, and a no-mulch control, each with three replicates. Organic mulches were applied at a thickness of 15 cm one week before transplanting. Soil moisture storage, soil temperature, bulk density, and soil organic matter were measured throughout the cropping period using standard field and laboratory methods. Data were analyzed using analysis of variance (ANOVA), and treatment means were compared using Dunnett's test at a 95% confidence level ($p \leq 0.05$). Mulching significantly improved soil physical properties. Mean soil moisture storage was highest under palmyra dry leaves mulch (23.8 ± 1.9%), followed by paddy straw (21.6 ± 1.7%), polythene mulch (20.2 ± 1.5%), and the control (17.4 ± 1.6%). Organic mulches also moderated soil temperature, recording lower values under palmyra dry leaves (27.1 ± 0.8 °C) and paddy straw (27.8 ± 0.9 °C) than under polythene mulch (29.4 ± 1.0 °C) and the control (30.2 ± 1.2 °C). Bulk density was lowest under palmyra dry leaves (1.42 ± 0.05 g $cm^{-3}$), while soil organic matter increased to 1.26 ± 0.08% compared with 1.02 ± 0.05% in the control. The results demonstrate that organic mulching, particularly palmyra dry leaves, is an effective and sustainable option for improving soil physical conditions, conserving moisture, and supporting Knol-khol cultivation in dry-zone environments.

**Keywords**: Bulk density, Mulching, Soil Moisture, Soil physical properties, Soil Temperature

# Nitrification Inhibition by Karanja (*Pongamia glabra* Vent) Seed Powder and Its Extract

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Nitrification inhibitors are applied to slow down the conversion of ammonium to nitrate, which will enhance nitrogen availability to crops, and nitrogen use efficiency in farming systems by reducing nitrogen losses. This study aimed to assess the nitrification inhibition potential of Karanja (*Pongamia glabra* Vent) seed powder and its extract. The experiment comprised three phases: incubation study, leachate study, and microbial study, with seven treatments -T1 (Soil), T2 (Soil + Urea), T3 (Soil + Urea + 5% Neem oil), T4 (Soil + Urea + 10% Karanja extract), T5 (Soil + Urea + 20% Karanja extract), T6 (Soil + Urea + 10% Karanja powder), and T7 (Soil + Urea + 20% Karanja powder). Baseline soil properties included pH 6.58, EC 67.73 µS/cm, CEC 67.36 cmol (+)/kg, phosphorus 12.46 ppm, potassium 228.07 ppm, and total nitrogen 0.023%. Karanja powder and Karanja extract contained 0.313% and 0.014% nitrogen, respectively. According to the incubation study the highest nitrification inhibition % was found in T3 (52.4%) followed by T5 (49.8) and T4 (46.2). Treatments T6 and T7 (Karanja powder) exhibited no significant inhibition. Leachate study showed a significant reduction in nitrate leaching loss in T3, T4 and T5 compared to T2, T6 and T7. Microbial analysis confirmed the inhibition by Karanja extract, supporting its role as an effective nitrification suppressor. The study concludes that Karanja extract and neem oil are potent natural nitrification inhibitors, while Karanja powder alone is ineffective in this regard. Further studies under field conditions are suggested to verify the results.

**Keywords**: Leaching, Nitrate, Nitrification Suppression, Natural Inhibitors

# Carbon Sequestration Potential of Cashew Plantations under Varying Tree Densities in a Dry Zone Agroforestry System

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Cashew (*Anacardium occidentale* L.) is an important perennial crop with significant potential for carbon sequestration in tropical dry zone agroforestry systems. However, information on the influence of planting density on biomass carbon and soil organic carbon (SOC) accumulation under long-term plantation conditions remains limited. This study evaluated the effect of five planting densities on above-ground biomass carbon (AGB), below-ground biomass carbon (BGB), SOC, and total ecosystem carbon (TEC) in a field experiment established in 2012 at the Puttalam Plantation of the Sri Lanka Cashew Corporation. The experiment was arranged in a Randomized Complete Block Design (RCBD) with three replicates using cashew variety WUCC 19. Five spacings were evaluated: 7.62 m × 7.62 m, 7.0 m × 7.0 m, 6.0 m × 6.0 m, 5.4 m × 5.4 m, and 4.8 m × 3.9 m. AGB was estimated using a DBH-based allometric equation, while BGB was derived using the IPCC (2019) Tier 2 root-to-shoot ratio model. TEC was calculated as the sum of biomass carbon and SOC. Data were analyzed using ANOVA followed by Tukey's HSD test at $p < 0.05$. Results showed a significant effect of planting density on carbon sequestration. TEC increased progressively with higher planting density, from 51.0 Mg C $ha^{-1}$ at 7.62 m × 7.62 m spacing to 67.0 Mg C $ha^{-1}$ at 4.8 m × 3.9 m spacing, while intermediate spacings recorded 54.5, 58.5, and 62.5 Mg C $ha^{-1}$, respectively. Similar increasing trends were observed for AGB, BGB, and SOC. The findings demonstrate that closer planting densities significantly enhance carbon sequestration potential in dry zone cashew agroforestry systems and provide a scientific basis for climate-smart plantation management.

**Keywords:** Agroforestry, Carbon sequestration, Cashew, Planting density

# Green Synthesis of Iron Nanoparticles using Made Tea and Refused Tea for Dye Removal in Wastewater

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Iron nanoparticles are emerging as cost-effective and eco-friendly materials for wastewater treatment. This study developed a sustainable method for synthesizing iron-based nanoparticles using aqueous extracts of made tea and refused tea from black and green tea varieties. Refused tea, which accounts for 4–6% of Sri Lanka's total tea production, is recognized as a waste material that can be used for environmental remediation. This study allowed tea extracts (10% w/v, pH ~5.5) to react with 0.10 M $FeCl_3$ under mechanical stirring at room temperature for 15 minutes, for the synthesis of nanoparticles. FTIR, UV-Visible Spectroscopy, XRD, and SEM were employed for characterization. FTIR confirmed involvement of polyphenolic functional groups in iron reduction and stabilization, while Fe–O vibrations verified iron oxide formation. Nanoparticle synthesis was confirmed by UV-Vis spectra, which showed strong absorption around 390 nm. XRD indicated predominantly amorphous structures with weak reflections corresponding to α-Fe. SEM analysis revealed irregular quasi-spherical particles (30–80 nm) with agglomeration due to magnetic interactions. Synthesis yield varied among tea types, with green tea samples showing higher yields than black tea. The nanoparticles were evaluated for methyl orange dye removal under optimized conditions (50 mg/L, pH 6.5, 120 min). Black made tea nanoparticles achieved the highest removal efficiency (80.5%), followed by green made tea, green refused tea, and black refused tea nanoparticles. Increased nanoparticle dosage further improved removal efficiency. The findings demonstrate the potential of tea-derived iron nanoparticles as sustainable and efficient adsorbents for dye-contaminated wastewater treatment while promoting tea waste valorization.

**Keywords:** Black tea; Green synthesis; Green tea; Iron nanoparticles; Methyl orange; Refused tea; Wastewater treatment

# Spatial Assessment of Soil Erosion in a Gently Sloping Coconut Plantation at Dambadeniya (IL1), Sri Lanka

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Soil erosion is a major land degradation process affecting agricultural sustainability, soil fertility, and long-term productivity. In low-country agricultural systems, erosion risk is often assumed to be minimal due to gentle slope conditions; however, variations in land cover and management can still generate spatial differences in soil loss. This study applied the Revised Universal Soil Loss Equation (RUSLE) model integrated with Geographic Information System (GIS) techniques to assess spatial soil erosion patterns in a coconut plantation managed by the National Livestock Development Board (NLDB) in Dambadeniya, Sri Lanka, within the Low Country Intermediate Zone (IL1). Rainfall data, soil properties, Digital Soil Map of the World, Digital Elevation Model (DEM), and satellite imagery were used to derive rainfall erosivity (R), soil erodibility (K), slope length and steepness (LS), vegetation cover factor (C), and support practice factor (P) .The P factor was assigned based on existing land-use conditions and published RUSLE literature, considering the absence of engineered soil conservation measures. ArcGIS was used to integrate all factors and generate an annual soil loss map. The study area covers 619 acres, including 495 acres (79.97%) cultivated coconut land and 124 acres (20.03%) uncultivated land. Estimated annual soil loss ranged from 0 to 3.58 t $ha^{-1}$ $yr^{-1}$, which falls within the low erosion category (<5 t $ha^{-1}$ $yr^{-1}$). Although overall erosion is low, spatial variability was observed across the landscape. Higher soil loss was mainly associated with reduced vegetation cover and weaker land management practices, while well-vegetated areas showed minimal erosion. The study demonstrates that in the study area, even gently sloping coconut landscapes exhibit spatially variable erosion controlled mainly by land cover. GIS-based RUSLE modelling effectively identifies erosion variability and supports targeted land management planning.

**Keywords:** Coconut plantation, GIS, RUSLE, Soil erosion, Spatial variability

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