Industrial Technology Institute
Ministry of Science & Technology

CISIR

# PROCEEDINGS

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# Industrial Technology Institute

# 2nd International/7th Biennial Research Symposium

"From Invention to Enterprise: Advancing Science and Technology for Cleaner and Progressive Sri Lanka in the Global Arena"

# Abstracts

2nd – 4th September 2025

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Former Electronic Engineer, Industrial Technology Institute

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Poster Presentations

## Message from the Honourable Minister of Science & Technology

It is with great pride and honor that I extend my warm greetings to the Industrial Technology Institute (ITI) on the occasion of the 2nd International and 7th Biennial Research Symposium 2025. This milestone is not only a celebration of ITI's rich legacy as the successor to the Ceylon Institute of Scientific and Industrial Research (CISIR) but also a reflection of its invaluable contributions to the advancement of science, technology, and innovation in Sri Lanka. The theme "From Invention to Enterprise: Advancing Science and Technology for a Cleaner and Progressive Sri Lanka in the Global Arena" is not only timely but also points towards a progressive future. As our nation strives to position itself competitively in a rapidly evolving global knowledge economy, the translation of scientific research into practical, industry-oriented innovations is paramount. ITI has been at the forefront of this journey, bridging the gap between research and commercialization, while fostering sustainable solutions that address national priorities. I am particularly pleased to note the wide spectrum of disciplines that this symposium will cover, from food and herbal technology to material science, biotechnology, environmental science, electro technology, and metrology. These fields are critical to ensuring food security, sustainable industrial development, environmental stewardship, and global competitiveness. The participation of both local and international experts reflects the collaborative spirit necessary to meet present and future challenges. As we celebrate ITI's remarkable journey of seven decades, let us also reaffirm our commitment to nurturing a culture of innovation and entrepreneurship that empowers our youth, strengthens our industries, and uplifts our economy. I commend ITI's dedicated scientists, researchers, and staff for their tireless efforts and achievements, and I encourage them to continue their pursuit of excellence in scientific and industrial research for national development. On behalf of the Ministry of Science and Technology, I extend my heartfelt congratulations to ITI for this significant milestone and wish the symposium every success in generating meaningful dialogue, partnerships, and outcomes that will shape a cleaner, progressive, and globally competitive Sri Lanka.

Prof. Chrishantha Abeysena
Hon. Minister of Science & Technology

## Message from the Secretary, Ministry of Science & Technology

It is with great pleasure and pride that I extend this message to mark the 2nd International and 7th Biennial Research Symposium organized by the ITI. This event stands as a testament to the enduring commitment of our scientific community to advance knowledge, foster innovation, and contribute meaningfully to the development of Sri Lanka.

The theme of this year's symposium, *"From Invention to Enterprise: Advancing Science and Technology for a Cleaner and Progressive Sri Lanka in the Global Arena"* resonates deeply with the Ministry's vision to position science and technology as the foundation of national progress. In an era defined by rapid technological evolution, global interconnectivity, and pressing environmental challenges, our ability to harness research and innovation will determine our trajectory toward sustainable and inclusive growth. As the Ministry entrusted with stewarding the nation's scientific and technological advancement, we recognize the pivotal role of institutions like ITI in driving transformative change. Through multidisciplinary research, technology transfer, and the cultivation of scientific talent, ITI continues to empower industries, elevate standards, and strengthen our global competitiveness.

I take this opportunity to commend the Director General, the organizing committee, and the dedicated staff of ITI for their unwavering commitment to excellence. I also extend my heartfelt appreciation to all researchers, collaborators, and participants whose contributions enrich this symposium and inspire future breakthroughs.

May this gathering catalyze bold ideas, meaningful partnerships, and impactful innovations that uplift our nation.

Mr. Y. L. Mohamed Navavi
Secretary, Ministry of Science & Technology

## Message from the Chairman

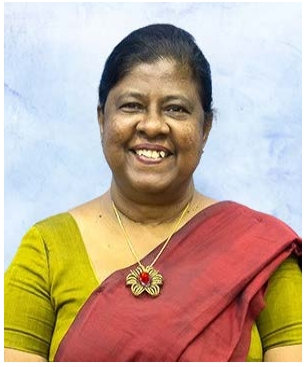
It is with immense pride and profound honour that I extend my heartfelt wishes to the Industrial Technology Institute (ITI) as it commemorates its 70th Anniversary and convenes the 2nd International Symposium and 7th Biennial Research Symposium 2025. The well-defined theme, *"From Invention to Enterprise: Advancing Science and Technology for a Cleaner and Progressive Sri Lanka in the Global Arena*," perfectly captures the spirit of national priorities aligned with the ongoing new Science and Technology Transformations of Sri Lanka. It provides a pathway to "think globally and act locally," thereby reflecting the urgent need to transform research into practical innovations towards a sustainable and progressive future for our people. This significant gathering demonstrates our longstanding commitment to fostering scientific research, technological advancements, and knowledge sharing at both national and international levels. I am pleased to announce that Prof. Chrishantha Abeysena, Hon. Minister of Science & Technology, and Mr. Y.L. Mohamed Navavi, Secretary to the Ministry of Science and Technology, will grace this occasion together with distinguished local and international professionals. Their participation reflects the significance of research and innovation in advancing national development and fostering global collaboration.

Since its inception in 1955 as the Ceylon Institute of Scientific and Industrial Research (CISIR), ITI has evolved into a national leader in diverse areas of Science and Technology, providing one roof for Chemical Technology, Food Technology, Herbal Technology, Biotechnology, Electro Technology, Environmental Science, Material Science, and Industrial Metrology. With such ever growing strength over the decades, ITI has played a pivotal role in advancing Sri Lanka's industrial development through impactful research, innovations, and community engagements, staying true to its vision of being a Center of Excellence in Scientific and Industrial Research for national development. I take this opportunity to extend my sincere appreciation to all international dignitaries who have accepted our invitations to deliver plenary speeches, and to all invitees who have honored us with their presence. I convey my heartfelt gratitude to those who have contributed to ITI's success story, and I warmly congratulate all recipients of awards for their achievements in Science and Technology, as well as the presenters who will share their valuable research during the technical sessions of this symposium.

Finally, I wish the Director General, the Organizing Committee, and my fellow Scientists, Engineers, Technologists, and staff of ITI every success in making this symposium a remarkable and fruitful event. May this forum inspire new collaborations, spark innovative ideas, and pave the way for a brighter future through Science and Technology.

Prof. S. Malavipathirana
Chairman, Industrial Technology Institute

## Message from the Director General



Industrial Technology Institute (ITI) celebrates its seventy years of excellence in Research & Development & Innovation geared towards the rapid industrial development of the country. As a multidisciplinary R&D and technical service provider of the country, ITI is committed to supporting the industry by undertaking research & development, technology transfer, consultancy, troubleshooting, monitoring environmental pollution, training, and providing technical services, including calibration services. I am deeply honoured and privileged to serve as the symposium advisor and the organizing chair of the 2nd International / 7th Biennial Research Symposium of the Industrial Technology Institute (ITI), which will be held from 2–4 September 2025 at the Modern R&D Complex, Thalahena, Malabe, Sri Lanka.

I warmly welcome the respected invitees, international speakers, scientists, engineers, technologists, academia, policy makers, industrialists, entrepreneurs and general public who have joined the event either in physically or virtually. The ITI symposium will be a good scientific platform for the researchers to disseminate the key findings of their research in multidisciplinary sciences with greater emphasis on Food Technology, Herbal Technology, Materials Technology, Biotechnology, Environmental Technology, Microbiology, Industrial Metrology, Electronics, Chemical, and Physical sciences. The symposium will also provide an opportunity for scientists, technologists, postgraduate, and undergraduate students to publish their valuable research findings as an abstract in the symposium proceedings.

I take this opportunity to wish all my fellow research scientists, engineers, and technologists a successful future, leading to further scientific inventions and innovations that will uplift the country's economy. As the symposium chair, I wish to extend my gratitude to the Chairman and Board of Directors, members of the management, symposium secretaries, the organizing committee and all staff who contributed to the success of the symposium. I would like to extend my sincere thanks to all the distinguished invitees, plenary speakers of the sessions. I greatly appreciate the financial and other assistance given by our sponsors and the Ministry of Science &Technology to glamorize this event. I wish all of you an informative and interactive symposium

Prof. (Ms.) Ilmi G. N. Hewajulige,
Director General / CEO
Symposium Organizing Chair

## Plenary Lectures

# Herbal Medicines: Research and Commerce - Global Perspectives

Prof. Mamta Shah

*Department of Pharmacognosy, L. M. College of Pharmacy, Ahmedabad, India*

## Abstract

There is a growing global recognition that herbal drugs are not only effective but also relatively safer, leading to a surge in the use of plant-based medicines worldwide, including in India. The global herbal market is currently valued at around US$90 billion and is expanding at an annual rate of 8–10%, with projections to surpass US$5 trillion by 2030. Despite this rapid growth, challenges remain regarding global acceptance, primarily due to insufficient quality control and the lack of scientific validation of the safety and efficacy of most herbal drugs and formulations. The development of monographs by regulatory bodies for assessing safety, efficacy, and quality (identity, purity, and strength) is complex, as medicinal plants may be categorized differently as food, functional food, dietary supplements, or herbal medicines depending on the perspective. This ambiguity in categorization is often exploited to market products based on the regulations of a particular country. The safety and efficacy of herbal medicines are closely linked to the quality of source materials, which are determined by intrinsic genetic factors and extrinsic factors such as environmental conditions, cultivation and harvesting practices, and post-harvest handling, transport, and storage. In cases where extracts are used as raw materials, processing methodologies, extraction techniques, and shelf-life determination of phytopharmaceuticals become crucial considerations. The introduction of the new drug category “Phytopharmaceuticals” in 2016 has further expanded opportunities for the use and export of scientifically validated plant-based drugs. However, the herbal industry continues to face significant challenges such as adulteration and substitution. In domestic markets, it is common for different species, or even unrelated taxa, to be sold under the same vernacular name, undermining confidence in product quality. To overcome these challenges, it is essential to source raw materials (plant parts/extracts) in compliance with pharmacopeial quality standards, supported by proper collection, processing, and analytical methods such as High Performance Thin Layer Chromatography (HPTLC)/ High Performance Liquid Chromatography (HPLC) fingerprinting. Ultimately, the development of herbal drugs based on traditional knowledge requires accurately identified, safe raw materials and rigorous scientific validation. Ensuring a consistent supply, whether from cultivated or wild sources, necessitates adherence to Good Agricultural Practices (GAP), Good Collection Practices (GCP), Good Ethical Practices (GEP), Good Procurement Practices (GPP), Good Safety Practices (including compliance with WHO standards on pesticides, heavy metals, and microbial load), and Good Storage Practices (GSP). These measures are vital to building global confidence in Indian herbal products and realizing their full economic and therapeutic potential.

# A Pharmaceutical and nutritional approach to value addition in Tamarind and Turmeric: An innovative idea

Suresh Kumar Agarwal, Anand Prakash Singh and S.K. Jha

*Food Processing Division of Astec Bitumen Products Pvt Ltd. Ranchi-834001, Jharkhand, India*

## Abstract

Turmeric, widely used as a culinary spice, is renowned for its extensive health benefits due to its bioactive compounds, particularly curcumin and other curcuminoids, which exhibit strong antioxidant, anticancer, anti-inflammatory, and neuroprotective properties. India, being the world's largest producer and exporter of turmeric, plays a central role in harnessing its potential. Similarly, both tamarind and turmeric are highly valued for their pharmaceutical and nutritional properties and are well-documented in the Ayurvedic system of medicine for their therapeutic applications. With the aim of developing value-added products to enhance public health, a functional health drink enriched with turmeric and tamarind pulp was formulated. However, the processing of tamarind and turmeric presents significant technological challenges. To address these, innovative methods were developed for the efficient separation and utilization of tamarind components, including shell removal, pulp powdering, seed skin processing, and kernel value addition. The synergistic combination of turmeric with processed tamarind kernel powder offers a promising avenue for creating nutritionally rich, health-promoting products with substantial value addition.

# Key lessons from the CGIAR FRESH Project – What we have learnt on postharvest management and food safety

Prof. Daniel Tan

Tan, D.K.Y.[1*], Ekman J.[2], Absulio-Morales[3], W., Ernest, Z.[4], De Alwis, R. A.P.S.[5], Madhushani, K.D.[5], Lai Y.W.[1], Bradbury M. I.[1,6], Oakeshott, J.[2]and Hewajulige, I. G. N.[5]

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## Abstract

The One-CGIAR (Consortium Group on International Agricultural Research) project on Fruit and Vegetables for Sustainable Healthy Diets (FRESH) (2022 - 2024) focused on an end-to-end approach to increase fruit and vegetable intake, improve dietary quality, nutrition and health while enhancing livelihoods. Our work package 4 team addressed food safety, postharvest and inclusive markets in Sri Lanka, the Philippines, Tanzania, and Benin. In all four countries, protecting fruits and vegetables from damage using plastic crates or lined timber crates improved produce quality and reduced postharvest losses. In Tanzania, Sri Lanka, and the Philippines, pilot cool rooms with CoolBot controllers have been installed (or are in the process of being installed). In Tanzania, three cool storage methods - Low Energy Cooling Chamber (LECC), misting chamber, and cool room with CoolBot - were compared with ambient storage conditions. The cool room with CoolBot was most effective, extending the shelf life of tomatoes to two weeks compared to three days in ambient conditions. The misting chamber and LECC extended tomato shelf life to five and seven days, respectively. Leafy vegetables, however, experienced significant weight loss and colour changes by the third and fourth day in the misting chamber and LECC, leading to their early disposal. A cool box with ice cube technology was also

piloted with a select group of retailers in the Kilimanjaro Region, Tanzania. The technology kept vegetables fresh for more than a day, reducing postharvest losses and attracting more customers due to improved handling and a fresher appearance. In Sri Lanka, three commonly consumed green leafy vegetables - *Centella asiatica* (Gotukola), *Ipomoea aquatica* (Kankung), and *Alternanthera sessilis* (Mukunuwenna) -were sampled from Good Agricultural Practices (GAP)-certified and non-GAP certified farmers, local markets, and supermarkets located within the Western Province of Sri Lanka. Approximately 31% of the non-GAP samples were contaminated with pesticide residues, while the GAP samples were mainly not contaminated. In both Sri Lanka and Tanzania, irrigation water was monitored for faecal contamination, and the level was higher during the rainy season in both countries. In Sri Lanka, significantly higher *E. coli* levels were detected in surface water during the rainy season at all three sites: Nuwara Eliya, Walimada, and Boralanda. In Walimada, the mean count during the rainy season was $2.1 \times 10^4$ MPN/100 mL, compared with $2.8 \times 10^3$ MPN/100 mL in the dry season. Groundwater mostly remained uncontaminated in both seasons. In Tanzania, untreated irrigation water from Arusha (tank) and Kilimanjaro (tap) was monitored for 12 months, and both sources were found to be contaminated with *E. coli* for most months of the year (>100 MPN/100 mL). Higher contamination occurred after heavy rainfalls. A survey of *E. coli* on produce indicated that leafy greens had higher levels of *E. coli* compared to tomato (above ground) in both Arusha and Kilimanjaro markets. Pesticide residue analysis was also conducted in Tanzania. Vegetables from FRESH-supported production hubs were analysed alongside those produced by farmers with no technical support from the project. Preliminary data indicate that vegetable samples collected from farmers not supported by the hub had higher levels of pesticide residues compared to those collected from the hubs. In all four countries, GAP should be promoted along with close monitoring and surveillance of chemical and microbial hazards, underpinned by supporting policy frameworks at the national, sub-national levels, and Local Government Unit (LGU) levels. In Sri Lanka, a food safety policy brief has been submitted to the Ministry of Health to inform the new food safety policy, currently under discussion in the cabinet.

# Cultivating resilience: Postharvest handling strategies for a sustainable food supply

Dr. Pankaj B. Pathare

*Department of Soils, Water and Agricultural Engineering, College of Agricultural & Marine Sciences, Sultan Qaboos University, Oman*

## Abstract

The global demand for fresh produce continues to rise, yet substantial postharvest losses pose a serious threat to food security. Mechanical damage, such as bruising and cuts sustained during handling and transport, is a primary contributor to these losses. Such damage accelerates quality deterioration, including loss of firmness, discoloration, and nutrient degradation, thereby significantly reducing the economic value of produce and contributing to large-scale food waste. Traditional quality assessment methods are often destructive and costly, while advanced techniques such as image analysis and computer vision remain largely focused on detecting existing damage. We propose a fundamental shift from damage detection to damage prevention. By gaining deeper insights into the mechanisms of mechanical damage, its causes, progression, and influencing factors, proactive strategies can be developed and implemented. These strategies may include improved handling practices, innovative packaging solutions, and optimized logistics tailored to the specific properties of different fresh commodities. Ultimately, adopting a science-based, preventive approach is essential to building a more resilient and sustainable food supply chain, one capable of meeting the demands of a growing global population while withstanding future challenges.

# Fundamentals of plasma and its applications

Prof. R. R. Deshmukh

## Abstract

Plasma is energetically the fourth state of matter, consisting of electrons, ions, radicals, Ultraviolet (UV)-visible radiations, and neutrals. More than 95% of the universe is made of plasma. Plasma can be created in a laboratory by applying a high electric field between the two electrodes. It can be divided into two groups: plasma in thermal equilibrium (hot plasma) and plasma in thermal non-equilibrium (cold plasma). Plasma in thermal non-equilibrium is also called non-thermal plasma, which can be effectively used for surface modification of polymers and textiles, functionalization of materials, transforming hydrophobic surfaces into hydrophilic and vice versa, creating highly antimicrobial surfaces etc. Plasma can also be used in tissue engineering and biomedical applications.

Technical Session

Oral Presentations

# Impact of rainfall on faecal contamination levels in pre-harvest water sources used for agricultural purposes

De Alwis, R.A.P.S[1]., Karunaratne, S.H.S[1]., Hewajulige, I.G.N[1*]., Nanayakkara, C.M[2]., Rajawardena, D.U[1]., Bradbury M.I[3,4]., Lai, Y.W[3]. and Tan, D.K.Y[3]

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## Abstract

Irrigation water plays a major role in ensuring the safety of fresh produce, particularly when consumed raw. In tropical agricultural regions, rainfall is a key environmental factor influencing faecal contamination in water used for irrigation. This study investigates the seasonal variation in *E. coli* levels in pre-harvest water sources from three major cultivation areas in Sri Lanka: Nuwara Eliya, Walimada, and Boralanda, focusing on the differences between the rainy (October, November, January) and dry (December, February) seasons. Irrigation water samples were collected on a fortnightly basis (15 points × 2 samples). Groundwater samples were collected in triplicate, while for surface water, a single grab sample was taken. Enumeration of *E. coli* was carried out according to ISO 9308-2:2012. Welch's t-test was applied to compare data between the two seasons. Significantly ($p < 0.001$) higher *E. coli* levels were observed in surface water during the rainy season across all three sites. In Walimada, the mean count during the rainy season was $2.1 \times 10^4$ MPN/100 mL, compared to $2.8 \times 10^3$ MPN/100 mL in the dry season. Similar trends were observed in Boralanda and Nuwara Eliya, where contamination levels increased up to $9.2 \times 10^4$ and $1.0 \times 10^5$ MPN/100 mL, respectively, during the rainy season. Groundwater remained mostly uncontaminated in both seasons, suggesting its relative safety due to natural filtration mechanisms. Therefore, this study concludes that rainfall significantly increases faecal contamination levels in surface waters in agricultural settings. The increase is attributed to surface runoff and sediment mobilization during rainfall, which transports faecal matter from agricultural fields and livestock areas. These findings highlight the necessity for seasonal water quality monitoring and the implementation of Good Agricultural Practices, including water treatment, protected water sources, and withholding periods following heavy rainfall.

Acknowledgment: Financial assistance from the University of Sydney, Australia (FP 138)

# Pesticide contamination in leafy green vegetables grown in the Western Province, Sri Lanka

Madhushani, K.D[1]., Hiddallaarachchi, C.S[1]., Asfa, A.F[1]., Liyanaarachchi, G.V.V.[1]*, Somasiri, H.P.P.S[1]., Hewajulige, I.G.N[1]., Tan, D.K.Y[2]. and Kaumal, M.N[3]

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## Abstract

Sri Lanka is an agricultural country that depends on domestic crop production to fulfill the nutritional needs of its population. Leafy Green Vegetables (LGVs) play a major role in the Sri Lankan diet due to their nutritional and medicinal benefits. However, the widespread use of pesticides causes contamination in food, posing potential health risks. This study investigates three commonly consumed LGVs: *Centella asiatica* (Gotukola), *Ipomoea aquatica* (Kankung), and *Alternanthera sessilis* (Mukunuwenna), sampled from Good Agricultural Practices (GAP)-certified and non-GAP certified cultivations, economic centers, traditional markets, and supermarkets located within the Western Province of Sri Lanka. Samples were collected from selected locations, including Millaniya, Bandaragama, Chilaw, Gampaha, and various retail markets within the western province. Pesticide residue analysis was carried out using Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS) and Gas Chromatography-Tandem Mass Spectrometry (GC-MS/MS) with a QUECHERS-based sample preparation approach. From the analyzed 81 LGV samples, 25 samples (31%) were contaminated with pesticide residues detected in the range of 0.005-15.60 mg/kg. Out of them, 23 samples (92%) exceeded the Maximum Residue Levels (MRLs) (as defined by CODEX Alimentarius Commission or the European Union). Out of the 93 analyzed pesticide residues, Fipronil, Tebuconazole, Chlorantraniliprole, Profenophos, Novaluron, Tebufenozide, Methoxyfenozide, Thiamethoxam, Azoxystrobin, Metalaxyl, Clothianidin, Etofenprox, Pyraclostrobin were detected in the analyzed LGV samples. *Gotukola* (n=37) was the most contaminated among the analyzed LGVs, followed by *Mukunuwenna* (n=22). In contrast, no pesticide residues were found in any of the 22 *Kankung* samples, despite being collected from non-GAP farms. Pesticide contamination in the non-GAP samples (n=69) was 31% while no pesticide contamination was observed in any of the GAP samples (n=12). In general, pesticide contamination was consistently linked with the samples from non-GAP farms. These findings highlight the importance of GAP in minimizing pesticide contamination in LGVs and offer guidance to enhance risk management and promote safer agricultural practices.

Acknowledgment: Financial assistance from the University of Sydney, Australia, through the FRESH CGIAR project (FP 138)

# Sub-chronic toxicity study on hot water extract of *Tragia involucrata* Linn. in rats

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## Abstract

*Tragia involucrata* L., *Wel Kahambiliya* in Sinhala, and Indian stinging nettle in English, is a widely used indigenous medicinal plant in Sri Lanka. Experimental studies have been conducted to investigate the pharmacological actions of *T. involucrata*, including anti-inflammatory, wound-healing, anti-cancer, analgesic, anti-diabetic, hypolipidemic, diuretic, and antioxidant activities. The present study investigates the sub-chronic toxicity of the Hot Water Extract (HWE) of *T. involucrata* to assess its possible toxicological effects. The sub-chronic toxic potential of *T. involucrata* was evaluated using the therapeutic dose of 550 mg/kg in adult male Wistar rats. The HWE at a dose of 550 mg/kg was administered for 42 consecutive days, and daily observations were carried out to evaluate the general toxic effects, such as overt signs of toxicity and moribund status, or mortality. At the end of 42 days, effects on hematological parameters, serum enzyme levels, and external morphology and histopathology of selected organs were determined. Results revealed that HWE of *T. involucrata* did not result in sub-chronic toxic effects in terms of (a) hepatotoxicity (as judged by SGOT, SGPT, GGT, ALP concentration and protein, albumin, globulin, total bilirubin levels), (b) renotoxicity (as judged by blood urea and serum creatinine) or (c) hemototoxicity (as judged by WBC, RBC counts and Hb concentration, PCV, MCV, MCH and MCHC values, platelet count), (d) gross morphology and weights of organs, (e) stress and aversive behaviors. In conclusion, the result of the sub-chronic toxicity study revealed that HWE at the therapeutic dose of 550 mg/kg did not produce any serious sub-chronic toxic side effects on adult male Wistar rats.

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# Development of a nutritionally and functionally enhanced instant vegan soup using local crops

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## Abstract

In today's busy world, many people struggle with a hectic schedule and limited time to prepare healthy meals, leading to a dependence on unhealthy fast-food options. This can lead to malnutrition and the development of Non-Communicable Diseases. To address this issue, the present research was conducted to develop nutritionally and functionally enhanced instant vegan soup using local crops. The developed soup powder contains oyster mushroom *(Pleurotus ostreatus)* as the main ingredient and moringa (*Moringa oleifera)*, mung bean (*Vigna radiata)* and pumpkin *(Cucurbita maxima)* as sub-ingredients. Four soup formulas were prepared with varying amounts of moringa powder (0%, 1%, 2%, and 3%) while maintaining other ingredients constant. Then, the sensory attributes (taste, texture, color, after taste and overall acceptability) were evaluated using a 7-point hedonic scale scorecard by 50 untrained panelists to identify the formula with the highest consumer acceptance. Proximate analysis, iron (Fe) and zinc (Zn) content, and shelf-life analysis by the total bacterial plate count method were done on the selected formula from the sensory analysis. Moreover, Total Phenolic Content (TPC), Total Antioxidant Capacity (TAC) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging ability were measured for all formulated soup samples. Data were analyzed using One-way ANOVA and Tukey's multiple comparison analysis test using SPSS software version 27. A $p$-value < 0.05 was considered statistically significant. In conclusion, Soup powder with 1% moringa had the highest consumer acceptance out of all developed formulas. Total plate count revealed that the formulated soup powder could be stored for 4 months without compromising its quality. An increase in TPC, TAC and DPPH free radical scavenging activity was recorded with the increasing moringa content in the formulated soup powders. Overall, the soup powder with 1% moringa was considerably high in protein, fiber, Fe, Zn, total phenolics, antioxidants and it was also low in fat, carbohydrates and energy. Therefore, it may serve as a convenient and effective way of delivering nutrients to the busy population, while contributing to the mitigation of protein insecurity. However, further research is required to assess the bioavailability of nutrients in the product.

# Assessment of microbial quality of selected dried fish varieties from processing sites and retail markets in Mirissa and Mannar, Sri Lanka

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## Abstract

Dried fish is a vital component of the Sri Lankan diet and a significant contributor to the national economy. However, the traditional processing methods commonly used can compromise its microbial quality and safety. This study aimed to assess the microbial quality of six dried fish varieties: Sailfish (*Istiophorus platypterus*/Thalapath), Skipjack Tuna (*Katsuwonus pelamis*/Balaya), Queenfish (*Scomberoides lysan*/Katta), Sprats (*Sprattus sprattus*/Halmessa), Baby Shrimp (Kunissa), and Maldives Fish (Umbalakada), collected from processing sites and retail markets in Mirissa and Mannar districts of Sri Lanka. Samples were evaluated for nine microbial parameters. Water activity (*aw*) was also measured to assess product stability. Unacceptable aerobic plate counts were found in samples from the Mirissa retail market and the Mannar processing site. Yeast and mould counts exceeded permissible limits in samples from all locations. At least one sample from each of the four sites tested positive for *Staphylococcus aureus*. Coliform and halophilic bacteria counts were within acceptable limits in all samples. Only the Baby Shrimp samples from the Mirissa retail market exceeded the acceptable limit for *Escherichia coli*, while all other samples tested were negative for *Escherichia coli*. All tested samples were free from *Salmonella* spp., *Listeria monocytogenes*, *Vibrio cholerae*, and *Vibrio parahaemolyticus*. Water activity values for all samples were within acceptable limits. Variation in microbial quality was observed between fish types across locations. Among the six tested varieties, only Maldives fish from Mirissa and Skipjack Tuna from Mannar complied with all microbial parameters at the retail level. In contrast, all varieties from the processing sites showed at least one parameter exceeding the maximum permissible limits. In conclusion, findings of the present study highlight the need for improved hygienic practices in production, handling, distribution, and storage to ensure consumer safety.

Acknowledgement: Financial assistance by Treasury Research Grant (TG 22/227)

# Development and validation of a method for the determination of 2-Methyl-4-chlorophenoxyacetic acid (MCPA) in Tea by liquid chromatography-tandem mass spectrometry

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## Abstract

Beyond its cultural ubiquity, tea (*Camellia sinensis* L.) is a rich source of bioactive compounds. Ceylon tea holds a prominent position in the global market due to its superior quality. 2-Methyl-4-chlorophenoxyacetic acid (MCPA) is a selective herbicide commonly used to control broadleaf weeds in tea plantations; however, MCPA residues can leach into brewed tea. To ensure safety and quality, the Sri Lanka Tea Board has set a Maximum Residue Level (MRL) of 0.1 mg/kg for MCPA. This study aimed to develop an accurate, reliable, and validated method for quantifying MCPA residues in tea using Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS) with Electrospray Ionization (ESI) in negative mode. MCPA was extracted using acidified ultrapure water, followed by cleanup with ethyl acetate, freezing, and dilution with methanol in the final injection solution. This protocol effectively eliminated matrix interferences that caused problematic peaks in the existing methods. Chromatographic separation was achieved using an Atlantis T3 column (50 mm × 4.6 mm × 3 µm) with information-dependent acquisition mode. The recovery rates were 110%, 102%, and 94% for low, medium, and high concentration levels, respectively. The validated method demonstrated a wide linear working range of 0.025–5.00 mg/kg, with a correlation coefficient ($R^2$) of 0.996. Precision, evaluated through repeatability and reproducibility, showed a Relative Standard Deviation (%RSD) of less than 4% across the three fortified levels (low, medium, and high). The method's Limit of Detection (LOD) and Limit of Quantification (LOQ) were 0.025 mg/kg and 0.05 mg/kg, respectively. In conclusion, the developed and validated method is both accurate and reproducible, making it suitable for the quantitative analysis of MCPA residues in tea available in the local market and for export, thereby ensuring the continued quality and safety of Sri Lankan tea.

# Nutritional and sensory properties of Crackers incorporated with Canistel (*Pouteria campechiana* Kunth) fruit flour and rice flour

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## Abstract

Canistel, locally known as Lawulu (*Pouteria campechiana*), is an underutilized fruit rich in nutrients and antioxidants. Its gummy texture and unfavorable flavor have limited consumer acceptance. Currently, products made from Canistel fruit in the local market are rarely formulated to be low in sugar or gluten-free. Therefore, the present study focuses on developing a healthy snack cracker from Canistel fruit flour and evaluating its nutritional and sensory properties. The matured edible portion of the Canistel fruit was sliced, dried, powdered, and sieved into fine flour. The composite flour mixtures at the ratios of 20:70, 25:65, and 30:60 (canistel flour: rice flour) were used for cracker preparation with shortening and baking ingredients, while the control was prepared without adding canistel fruit flour. Sensory evaluation trials were conducted using 15 trained panelists who were asked to score sensory properties on 9-point hedonic scales. Samples were analyzed for proximate composition, fibre and mineral profile using acceptable methods as specified in AOAC. The shelf life of the developed crackers was determined using the accelerated method. The sensory analysis of crackers resulted in the highest scores for sensory attributes of appearance, colour, aroma, taste, texture/crispiness, aftertaste, and overall acceptability in 20:70 canistel fruit flour: rice flour. Comparison of the proximate composition of the most acceptable cracker with the control showed except for ash content, other parameters were significantly different ($p<0.05$). Mean value of mineral profile of aforesaid cracker and control were found to be Zn; (16.4, 18.9) mg/kg, Fe; (10.1, 8.8) mg/kg, Na; (0.93, 0.92) %, Mg; (393, 430) (mg/kg), Ca; (133, 118) mg/kg and K; (0.28, 0.16) % respectively while sodium remained within safe limits in both crackers (<1%). The mean values for total phenolic content of canistel fruit flour and crackers incorporated with canistel fruit flour were 351.56 mg GAE/100g, 69.89 mg GAE/100g and the mean values for total flavonoid content were 46.43 mg QE/100g, 8.82 mg QE/100g, respectively. The shelf life of the developed crackers was 60 days. The results showed that the optimal formulation of 20:70 canistel to rice flour had a high sensory acceptability, and those crackers were rich in micronutrients of Fe, Ca, K, and antioxidants. Further, the present study underscores the potential of underutilized canistel fruit in the development of functional foods and the growing demand for diverse, gluten-free products.

Acknowledgment: Financial assistance by Treasury Research Grant (TG 24/234)

# Investigation of *ortho*-anisaldehyde levels with the thickness of Ceylon Cinnamon (*Cinnamomum zeylanicum* Blume) bark in the Southern region of Sri Lanka

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## Abstract

The compound: *ortho*-anisaldehyde (2-Methoxybenzaldehyde or *o*-anisaldehyde) was first detected in trace amounts in the bark oil of *Cinnamomum zeylanicum* Blume (Ceylon cinnamon) in a very recent study conducted at Industrial Technology Institute (ITI), Sri Lanka. However, there is a maximum allowable level of *o*-anisaldehyde in *Cinnamomum zeylanicum* Blume bark oil according to international trade standards. Therefore, it is important to select the best maturity level of cinnamon bark that produces the minimum level of *o*-anisaldehyde. Ontogenetic fluctuation of *o*-anisaldehyde in Ceylon cinnamon bark was quantified at four maturity stages as Juvenile stems (M1), Yong stems (M2), Mature stems (M3), and Old stems (M4) using Gas Chromatography Flame Ionization Detector (GC-FID). Bark oil was obtained by hydro-distillation using a Clevenger apparatus, and the moisture content was determined using the Dean & Stark apparatus. The level of *o*-anisaldehyde exhibited a maturity-dependent increase from juvenile to old bark. Moisture content declined from 17.0±0.5 %w/w to 9.5±0.9% w/w with increasing maturity, while dry basis oil yield rose from 1.0±0.1% v/w to 2.0±0.3 v/w%. The thickness of the bark (juvenile bark=1.2±0.3 mm to old bark=3.4±0.5 mm) showed a positive correlation ($r = 0.982$, $p < 0.001$) with *o*-anisaldehyde level, validating its use as an indicator. Multivariate models confirmed that oil yield is the primary predictor of phytochemical abundance, while moisture exerts a secondary, inverse effect. These findings provide applicable guidance for cinnamon producers: targeting young to mature stems (bark thickness ≥ 2.3 mm) achieves optimal oil yield, but also achieves optimal *o*-anisaldehyde content with low moisture content. Young stems are showing minimum *o*-anisaldehyde level, alongside considerable oil yield with medium moisture level. In conclusion, considering the *o*-anisaldehyde level, it's better to harvest cinnamon bark with young stems (≤ 2.3 mm).

Acknowledgement: Financial assistance by International Finance Cooperation (IFC FP/136)

# Development and characterization of a synbiotic goat milk yoghurt with passion fruit (*Passiflora edulis f. flavicarpa*) and a commercial probiotic starter culture

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## Abstract

Goat milk is a nutrient-rich alternative to cow milk, commonly used to produce yoghurt, cheese, and other dairy products. Despite its potential, Sri Lanka primarily offers sterilized and pasteurized goat's milk, with limited value-added options. This study aimed to develop and characterize a novel synbiotic goat milk yoghurt with passion fruit (peel and pulp) using a commercial ABT-5 probiotic starter culture (*Bifidobacterium animalis subsp. lactis, Lactobacillus acidophilus, and Streptococcus thermophilus*). Passion fruit peel and seeds, typically discarded as waste, cannot only enhance the yoghurt's flavour but also contribute to its gut health-promoting properties. Various yoghurt formulations were prepared with differing concentrations of passion fruit peel (2%, 4%, 6%, and 8% v/v), alongside a probiotic control yoghurt formulation without passion fruit. Sensory evaluation by a trained panel revealed that the 8% peel formulation (F4) was most preferred, and its modified version showed no significant difference in acceptability compared to the control ($p>0.05$). The selected synbiotic yoghurt had 96 kcal energy, 3.4% protein, 3.4% fat, 13.0% carbohydrate, and 79.3% moisture with acceptable pH (4.14 to 3.99), titratable acidity (1.49 to 0.94), and Brix values (13.3 to 14.2) over 21 days of refrigerated storage (4 °C) without adding permitted preservatives. Colour analysis showed higher yellowness (b* 9.86 to 11.26) reflecting the retention of passion fruit pigment. Probiotic viability in the formulation remained above 6.5 log CFU/g, peaking at 7.19 log CFU/g (Day 17), while the control peaked at 8.48 log CFU/g (Day 5) but declined to 6.11 log CFU/g by Day 21, ensuring the delivery of live beneficial microorganisms to consumers. This product demonstrates potential for functional food development, valorization of fruit byproducts, and innovation in the Sri Lankan goat milk industry.

Acknowledgement: Financial assistance by Treasury Research Grant (TG 24/237)

# *Trichoderma harzianum* GenBank MZ423064.1: An emerging protein-synthesizing candidate for the sustainable food and feed industry

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## Abstract

The fungal protein food and feed industry is experiencing significant growth due to increasing demand for sustainable and nutritious protein sources. Fungal protein, often derived from mycoprotein, is gaining traction as a meat alternative and a component in various food products and animal feed. *Trichoderma harzianum* is a non-pathogenic filamentous fungus that has shown potential in converting low-cost agricultural substrates into high-value protein. The objective of this study was to investigate the optimum fermentation conditions of the newly isolated fungi *T. harzianum* GenBank MZ423064.1 to enhance fungal biomass protein production, for the potential application in food and feed industries. To optimize the fermentation conditions, liquid culture flasks were investigated for different carbon sources (glucose, maltose, sucrose, lactose, dextrose, galactose and soluble starch), nitrogen sources (peptone water, yeast extract, ammonium nitrate and sodium nitrate), pH (4,5,6), temperature (22, 25, 27 °C), with stirring/non- stirring and fermentation time (0-240 hours). The results exhibited that *Trichoderma harzianum* GenBank MZ423064.1 has an optimum growth and protein synthesis at pH 6, at 27 °C with a fermentation time of 168 hours without stirring. Maltose and peptone water were identified as the optimum carbon and nitrogen sources, respectively, thus providing preliminary optimum conditions for the growth of *T. harzianum* GenBank MZ423064.1. Facts contributing to safety aspects and regulatory acceptance such as digestibility, presence of anti-nutritional factors & off-flavors, if any and processing methods/purifying methods for synthesized protein need to be further investigated.

Acknowledgment: Financial assistance by Treasury Research Grant (TG 21/223)

# *Talaromyces albobiverticillius* GenBankPQ616019 - Emerging red pigment synthesizing fungi with bioactive properties for industrial applications

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## Abstract

*Talaromyces albobiverticillius* is recognized as an emerging pigment-producing fungus that synthesizes pigments similar to azaphilones and is generally recognized as safe, thus being increasingly investigated as a source of natural food color. The objective of this study was to optimize the pigment production conditions and to investigate the bioactive properties of *T. albobiverticillius* PQ616019 as a potential food colorant. Before growth optimization studies, its mycotoxin synthesis ability was investigated using Liquid Chromatography-Tandem Mass Spectrometry (Limit of Detection - 0.8 µg/kg). To optimize the fermentation conditions, liquid culture flasks were investigated for different carbon sources (glucose, maltose, sucrose, lactose, dextrose, galactose and soluble starch), nitrogen sources (peptone water, yeast extract, ammonium nitrate and sodium nitrate), pH (4,5,6), temperature (22, 25, 27 °C), with stirring/non- stirring and fermentation time (0-240 hours). The antioxidant properties were evaluated by DPPH free radical scavenging and ferric-reducing antioxidant power assays. The total phenolic content was determined by the Folin-Ciocalteu method. Antibacterial properties were evaluated using the agar well diffusion method. The results exhibited that *T. albobiverticillius* PQ616019.1 was an aflatoxin-free strain with optimum growth and pigment synthesis at 5 (pH), at 25 °C, with a fermentation time of 168 hours without stirring. Lactose and peptone water were identified as the optimum carbon and nitrogen sources, respectively, for red pigment synthesis. The extracellular pigment demonstrated moderate DPPH free radical scavenging activity (8.371±0.365 mg Trolox Eq/g of dye) and good ferric reducing activity (30.255±0.105 mg Trolox Eq/g of dye). The phenolic content was found to be highest in pigment extract (57.207±2.108 mg Gallic Acid Eq/g of dye). Antibacterial activity against *Escherichia coli* ATCC 8739 (9.96±0.50 mm) and *Bacillus subtilis* ATCC 6633 (10.84±0.71mm) was detected at the concentration of 0.05 mg $\mu L^{-1}$. Further investigations need to be carried out to elucidate the structure of the compound and its safety attributes prior to pilot-scale trials.

Acknowledgement: Financial assistance by Treasury Grant (TG 21/223)

# Colorimetric determination of 5-Hydroxymethylfurfural as a quality marker in Sri Lankan bee honey

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## Abstract

Bee honey is a natural product valued for its nutritional, medicinal, and commercial importance. However, its quality can decline due to thermal exposure and prolonged storage, both of which promote the formation of 5-hydroxymethylfurfural (5-HMF). This compound forms via the acid-catalyzed dehydration of hexose sugars, particularly fructose, which is the predominant sugar in bee honey. This study aimed to develop and validate a simple, rapid, and cost-effective UV-Visible spectrophotometric method to quantify 5-HMF in honey samples. The method is based on a colorimetric reaction in which 5-HMF reacts with barbituric acid under acidic conditions to form a yellow chromogen. A honey solution was prepared by dissolving 1.0 g of the sample in 5 mL of deionized water and then filtered. An aliquot of 40 µL of this honey solution was mixed with 80 µL deionized water, 20 µL HCl (1 M), and 40 µL barbituric acid solution. The mixture was incubated at room temperature for 10 min, and absorbance was measured at 395 nm against a reagent blank prepared identically but replacing the honey aliquot with deionized water. A calibration plot was prepared for HMF standard solutions (10–100 mg/L) following the same procedure as described for honey samples. The method's performance was evaluated through linearity, detection limit, and recovery analysis. Additionally, honey samples were subjected to gradual heat treatments at various temperatures and durations to observe 5-HMF accumulation and develop a color spectrum scale for visual assessment. The method demonstrated excellent linearity ($R^2 = 0.98$), a limit of detection of 2.5 mg/L, and recovery rates ranging from 94% to 102%. Heat-exposed honey samples exhibited a positive correlation between temperature/time and 5-HMF levels. Fresh honey samples had HMF concentrations below 25 mg/kg, while 40 commercial samples showed levels between 42 and 60 mg/kg. A color spectrum scale was successfully developed, visually correlating 5-HMF concentration with sample color intensity. The Codex Alimentarius guideline of 40 mg/kg for general honey and the SLS limit of 30 mg/kg were used as practical thresholds for quality classification and safety assessment. The validated UV-Vis spectrophotometric method offers a reliable, low-cost, and more effective alternative to the traditional Winkler method and HPLC for 5-HMF quantification in honey. This method provides a practical solution for monitoring honey quality and detecting heat-induced deterioration, especially in field, rural, or resource-limited settings. Development of a color-based visual evaluation tool will be addressed in the next step.

# Assessment of salt and sugar content in commercially available flour-based products in Sri Lanka: Implications for traffic light labelling and public health

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## Abstract

Non-Communicable Diseases (NCDs) are the leading cause of mortality in Sri Lanka, with excessive salt and sugar intake identified as key dietary risk factors. Processed and packaged foods significantly contribute to this issue. To support healthier food choices, Sri Lanka has introduced Front-Of-Pack (FOP) labelling regulations using a traffic light colour code system (red, amber, green) based on the fat, sugar, and salt content of foods. This study evaluated the total sugar and salt content in 35 commercially available flour-based food items, categorized as cereal-based flour (n=7), wheat flour-based bakery items (n=6), cakes (n=5), and biscuits (n=17). Sugar and salt levels were quantified using Lane and Eynon titration and flame photometric methods, respectively. Results were interpreted according to Sri Lanka's Food Act No. 26 of 1980, which classifies nutrient levels using traffic light colour thresholds per 100 g of product. The sugar content (g/100 g) in cereal-based flour, wheat flour-based bakery items, cakes, and biscuits was less than 2.0±0.0, 22.5±10.9, 33.6±11.9, and 24.2±12.4, respectively. On the other hand, corresponding salt levels (g/100 g) were 0.12±0.19, 0.72±0.48, 0.51±0.33, and 0.56±0.40, respectively, for cereal-based flour, wheat bakery items, cakes, and biscuits. Based on sugar content, 100% of cereal-based flour products qualified for a green label, while only 17%, 0%, and 6.3% of wheat bakery items, cakes, and biscuits, respectively, met this criterion. For salt content, green labels were applicable to 86%, 17%, 40%, and 6% of products in the respective categories. These findings indicate that a significant proportion of flour-based products, particularly bakery items and biscuits, contain high levels of sugar and/or salt. This underscores the need for stronger enforcement of FOP labelling regulations, enhanced consumer education, and reformulation by the food industry to promote healthier dietary habits and reduce the risk of NCDs in Sri Lanka.

# Quantitative analysis of fatty acids in dairy products available in the Sri Lankan market using Gas Chromatography - Flame Ionization Detection (GC-FID)

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## Abstract

Fatty Acids (FAs) are essential components of lipids that significantly influence the nutritional quality, flavor, texture, and shelf life of dairy products. The profile of these fatty acids includes Saturated Fatty Acids (SFAs), Monounsaturated Fatty Acids (MUFAs), and Polyunsaturated Fatty Acids (PUFAs), which serve as crucial parameters for assessing a product's authenticity, detecting adulteration, and evaluating processing methods. This study investigates the quantitative analysis of fatty acid profiles of commonly consumed dairy products in the Sri Lankan market. The fat was extracted by using the Rose-Gottlieb method and was converted to its corresponding Fatty Acid Methyl Esters (FAMEs) following a standard transesterification process. The extracted fat from a range of products, including liquid milk, yoghurt, butter, ice cream, and cheese, was analyzed using Gas Chromatography with Flame Ionization Detection (GC-FID). Quantitatively, Butter and cheese showed the highest total SFA content at 67.8% ±1.6% (64.51–69.51%), while yogurt and ice cream had lower levels at 63.7% ±1.0% (62.86–65.09%). Liquid milk contained 66.9% ±1.3% SFA (65.65–68.74%). MUFA were higher in yoghurt and ice cream (33.0% ±1.0%, 31.65–33.84%) than in butter and cheese (29.7% ±1.3%, 27.88–32.01%). PUFA levels averaged at 3.3% ±0.02% (3.25–3.29%) in yogurt and ice cream, with cheese showing the lowest at 2.2% ±0.4%. Trans-fat was also higher in yogurt and ice cream (4.9% ±0.2%, 4.62–5.21%) compared to butter and cheese (2.4% ±1.9%, 0.56–5.6%). It was observed that many products exceeded the recommended saturated fat level of 10%, which raises potential public health risks when compared to international dietary guidelines [(Food and Agriculture Organization (FAO)/World Health Organization (WHO) and Food and Drug Administration (FDA)]. The findings highlight the importance of nutritional labeling, dairy product reformulation, and consumer awareness to promote healthier dietary fat intake in Sri Lanka.

# Rapid quantitative determination of Vanillin content in commercial Vanilla extracts using High Performance Liquid Chromatography

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## Abstract

*Vanilla planifolia* Andrews (Vanilla) is one of the world's leading natural flavoring agents, with its characteristic aroma primarily attributed to 4-hydroxy-3-methoxybenzaldehyde, commonly known as *vanillin*. As global demand for natural and authentic vanilla products continues to rise, accurate and reliable quantification of vanillin is essential to ensure the quality of Ceylon vanilla, a rapidly growing industry in Sri Lanka. This study aimed to develop a simplified and rapid High-Performance Liquid Chromatography (HPLC) method for determining vanillin content in commercial vanilla extracts. Ten samples were obtained from various premium retail outlets. Each extract was homogenized and appropriately diluted (1:10) with the mobile phase, then filtered through 0.45 µm membrane filters prior to HPLC injection. Vanillin was quantified using a reverse-phase HPLC system equipped with Diode Array Detection (DAD) at 280 nm and a C18 column (250 mm × 4.6 mm × 5 µm). The mobile phase consisted of methanol and water (55:45, v/v), delivered under isocratic conditions at a flow rate of 1.5 mL/min. The vanillin peak was detected at a retention time of 3.1 minutes. Vanillin was present in all analyzed commercial ethanol-based vanilla extracts, with concentrations ranging from 51.1 to 137.1 mg/100 mL. Sample S10 contained the highest vanillin content (137.1±0.1 mg/100 mL), while Sample S5 had the lowest (51.1±0.2 mg/100 mL). The optimized HPLC method developed in this study enabled rapid quantification of vanillin, offering a significantly shorter analysis time compared to the conventional ISO 5565-2:1999 method, where vanillin elutes at approximately 9.8 minutes. Moreover, the ISO method, as noted in its scope, is not well-suited for the accurate quantification of vanillin in vanilla extracts. In conclusion, the optimized HPLC method is easily applicable for determining vanillin content in commercially available vanilla extracts. Further validation of this method, along with comparisons to the Ultraviolet (UV) spectroscopy approach described in ISO 5565-2:1999, is planned to assess its suitability for routine quality control and regulatory compliance within the Sri Lankan vanilla industry.

# Proficiency testing using consensus values for cement testing: selecting the best robust statistical method for limited participants

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## Abstract

Proficiency Testing (PT) is essential for laboratory accreditation under ISO/IEC 17025. However, implementing effective PT for materials like cement in Sri Lanka poses challenges due to the limited number of participants and the lack of Certified Reference Materials (CRMs). This study evaluated five robust statistical methodologies recommended by ISO 13528:2022 to identify the most suitable technique for cement proficiency testing with a small sample size (n=8). Cement PT results were obtained from eight Sri Lankan laboratories for four critical parameters: compressive strength (at 2 and 28 days), initial setting time, and soundness. In the absence of approved reference materials, median and standard deviation values provided by the manufacturer were used as performance benchmarks. Five statistical methods Qn, Q, Algorithm A, MADe, and nIQR were programmed in R Studio to calculate consensus values (x*) and robust standard deviations (s*). The biases in x* and s* were analyzed to assess accuracy, while z-scores were used to evaluate laboratory performance and identify outliers. To validate the findings, Monte Carlo simulations (1,000 iterations) were performed using synthetic datasets that replicated real PT conditions, including 5% contamination to simulate outliers. These simulations enabled a comparative assessment of the robustness of each method based on s* bias, Z_MSE (mean squared error of z-scores), and sensitivity to outliers. The Median + Qn approach demonstrated the lowest s* bias and the highest accuracy in outlier detection, with s* bias values of 1.60 for compressive strength at 28 days (C28), 0.63 for compressive strength at 2 days (C2), 5.96 for Initial Setting Time (IST), and 0.22 for soundness. Simulation results further supported the robustness of the Qn technique, showing minimal s* bias and favorable Z_MSE scores across all parameters. The reported efficacy of 78% for the Qn technique, as per ISO 13528, reinforces its suitability. The study recommends the adoption of the Median + Qn method to enhance the reliability and credibility of cement PT schemes. This approach is particularly advantageous in resource-limited settings and can be extended to other PT applications. However, the potential bias introduced by manufacturer-supplied data highlights the importance of incorporating CRMs in future studies.

# Isolation and characterization of *Xanthosoma sagittifolium* (L.) Schott starches as potential excipients for the formulation of pharmaceutical products

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## Abstract

Pharmaceutical products consist of an Active Pharmaceutical Ingredient (API) for therapeutic effect and excipients that support drug stability, solubility, and delivery. While synthetic excipients are commonly used, they pose drawbacks such as toxicity, allergic reactions, environmental impact, and high costs. As a result, natural excipients are increasingly favoured for their safety, biodegradability, multifunctionality, and alignment with sustainable pharmaceutical practices. Fresh *Xanthosoma sagittifolium* tubers were processed through sequential solvent extraction (hexane, acetone, ethanol), followed by washing, drying, grinding, and sieving to obtain *X. sagittifolium* dry powder (XSP), which was stored under controlled conditions. The material was characterized using Raman, FTIR, and XRD techniques, and its physicochemical properties, including flowability, pH, moisture content, solubility, presence of starch and reducing sugars. All tests were performed in triplicate, and results were reported as mean values with standard deviations where applicable. The XSP showed no presence of reducing sugars but tested positive for starch, indicating effective extraction and starch retention. It exhibited sparing solubility in polar and non-polar solvents, and remained suspended in water and ethanol, suggesting a mix of natural polymers and had a near-neutral pH (7.3±0.0), favourable for maintaining API stability. XSP demonstrated moderate moisture content (9.32±0.00 % w/w), good compressibility (Carr's Index: 14.0±0.1), and favourable flowability (Hausner ratio: 1.16±0.00), while XRD and IR spectroscopic analyses confirmed its predominantly amorphous nature with the presence of cellulose and polymeric sugar monomers. In conclusion, the absence of a crystalline structure and its overall physicochemical profile support XSP's potential as a natural pharmaceutical excipient, warranting further evaluation in tablet formulation with a crystalline API.

Acknowledgement: Financial assistance by Treasury Research Grant (TG 24/257)

# Development of a certified reference material for oils

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## Abstract

Certified Reference Materials (CRMs) are an essential component of quality assurance, consisting of materials with well-defined chemical properties. In Sri Lanka, the development of CRMs remains a significant gap in quality assurance practices. Therefore, an initiative was undertaken to develop a CRM for the oil industry. Coconut oil was selected as the matrix-based CRM due to the absence of CRMs or Quality Control (QC) activities for edible oils in the country. The chemical properties targeted for certification included iodine value, saponification value, unsaponifiable matter, and peroxide value. Bulk coconut oil was extracted from 80 coconuts aged 10–12 months, and prepared according to SLS 32:2017 standard. The processed oil was divided into 34 subsamples and stored under refrigerated conditions until analysis. Four subsamples were randomly selected to assess homogeneity, with five replicate analyses performed per test method. Twelve subsamples were selected for stability studies, conducted bimonthly over six months, yielding four analytical data points per month. Homogeneity and stability were assessed using the statistical methods outlined in ISO 17034:2016. The selected chemical parameters were measured according to the following ISO standards: iodine value (ISO 3961:2018), saponification value (ISO 3657:2013), unsaponifiable matter (ISO 3596:2000), and peroxide value (ISO 3960:2007). Results indicated that the CRM sample was homogeneous and stable over six months for unsaponifiable matter. While the saponification value demonstrated stability over six months, homogeneity was not achieved. For iodine value, neither homogeneity nor stability was attained. The peroxide value remained in the non-detectable range even in the room temperature reference sample, indicating that the coconut oil did not become rancid during the six-month period. In conclusion, the CRM is competent enough for unsaponifiable matter, while other parameters need to be improved by adding a stabilizer in the next oil preparation.

Acknowledgement: Financial assistance by Treasury Research Grant (TG 24/259)

# Investigation into the authenticity of commercial products labeled as virgin coconut oil

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## Abstract

According to 2024 statistics from the United States Department of Agriculture, 49% of South and Southeast Asian countries use coconut oil as their primary edible oil. Various types of coconut oil are available in the market, including Virgin Coconut Oil (VCO), Copra Coconut Oil (CCO), coconut oil extracted from Desiccated Coconut (DC oil), and Refined, Bleached, and Deodorized (RBD) coconut oil, which are differentiated by their manufacturing processes. Due to the recently recognized medical and cosmetic benefits of VCO, there is a growing market demand for it. Although the Sri Lanka Standard Specification (SLS) 32:2017 provides guidelines for VCO production, some vendors mislead consumers by marketing DC oil as VCO or by adulterating VCO with DC oil for unethical financial gain. Because VCO and DC oil are similar in appearance, distinguishing between them visually is difficult without chemical analysis. The Headspace Solid-Phase Microextraction Gas Chromatography coupled with Mass Spectrometry (HS-SPME-GC-MS) method can differentiate VCO based on its volatile compound profile. Using this method, several unique volatile marker compounds were identified. Among them, 2-heptanone was found to be the most suitable marker, with a significantly higher concentration (14.63±0.47 ppm) in authentic VCO, whereas other markers were present at levels below 3 ppm. Sri Lanka is a major producer and exporter of VCO, and many brands are available in the local market. However, no previous studies have investigated the authenticity of commercially available VCO. Therefore, the main objective of this study was to assess the authenticity of VCO available in the local market. To evaluate the current market status, 23 commercial coconut oil samples, including both local and export-oriented brands, were analyzed using the HS-SPME-GC-MS method. Out of the 23 locally manufactured samples labeled as VCO, only two were confirmed to be authentic. One of these was produced using the traditional "*Sekku*" cold-milling method, which does not involve heat. The rest were either adulterated or exposed to heat during processing, as indicated by significantly lower 2-heptanone levels compared to the authentic samples. In conclusion, most coconut oil products labeled as VCO in the local market cannot be guaranteed as genuine VCO. Therefore, it is essential to streamline and regulate the manufacturing processes of Sri Lankan VCO producers to ensure product authenticity.

Acknowledgement: Financial assistance by Treasury Research Grant (TG 19/259)

# Development of a Near-Infrared (NIR) spectroscopic method to detect adulteration of virgin and RBD (Refined, Bleached and Deodorized) coconut oils with lard fat

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## Abstract

Virgin Coconut Oil (VCO) and Refined, Bleached, and Deodorized (RBD) coconut oil are highly valued for their diverse applications. However, their susceptibility to adulteration with cheaper fats, such as lard, raises concerns regarding authenticity and halal regulatory compliance. This study aims to develop a rapid and non-destructive method using Near-Infrared (NIR) spectroscopy to detect lard adulteration. VCO and RBD coconut oil samples were obtained from a locally authenticated oil mill, while lard samples were sourced from local slaughterhouses. Adulterated sample series of VCO and RBD coconut oil with lard were prepared in triplicate, with concentration ranges of 0.2–50% (w/w) and 0.2–30% (w/w), respectively. NIR spectra were collected using a Thermo Scientific Antaris II FT-NIR Analyzer over the range of 10,000–4,000 $cm^{-1}$, with 32 scans at a resolution of 4 $cm^{-1}$. A partial least squares (PLS) regression model was developed to calibrate the NIR spectra and was cross-validated to verify the accuracy of the method. External validation was performed by quantifying adulterated oil samples. PLS models were constructed for multivariate calibration of the spectral data. Both VCO and RBD coconut oil models yielded a coefficient of determination ($R^2$) of 0.999. The models demonstrated low and acceptable Root Mean Square Error of Calibration (RMSEC) and Cross-Validation (RMSECV) values of 0.217 and 0.245 for VCO, and 0.323 and 0.531 for RBD coconut oil, respectively, indicating strong model performance. External validation showed that both models could detect lard adulteration at concentrations ≤ 1% (±0.1%). For the VCO model, the Root Mean Square Error of Prediction (RMSEP) and Ratio of Performance Deviation (RPD) were 0.407 and 4.584 in the 1–10% lard adulteration range, and 1.490 and 7.272 in the 10–50% range, respectively. For the RBD model, the RMSEP and RPD values were 1.034 and 7.435 across the full adulteration range of 1–30%, respectively. These results demonstrate strong predictive performance, with RPD values exceeding 3.0, confirming the accuracy of the models. In conclusion, the developed NIR-PLS models are effective in detecting and quantifying lard adulteration in VCO and RBD coconut oil within the ranges of 1%–50% and 1%–30%, respectively.

# Investigation of matrix effect and processing factors on the formation of aldehydes during the preparation of fried rice

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## Abstract

Frying oils, frequently reused or preheated, are subjected to thermally induced oxidation, forming harmful aldehydes that can be transferred to food matrices. This study investigates the formation of aldehydes in fried rice, a highly demanded ready-to-eat food, and evaluates the influence of preheating duration and characteristics of the rice variety. Rice varieties of polished CIC red fragment (R1), CIC super kernel (R2), and BG 360 (R3) were used, along with three oil types: Refined, Bleached and Deodorized (RBD) Coconut Oil (CO), Palm Olein (PO), and Sunflower Oil (SO), obtained from oil mills. Each rice sample was cooked under controlled conditions and fried with oil samples, which were preheated to 180 ± 5 °C for different time durations from zero to six hours. Each preheated oil sample and each fried rice sample were analysed for aldehyde compounds by a modified and validated method using an Ultra Performance Liquid Chromatography/Photo Diode Array-Mass Spectrometry (UPLC/PDA-MS). A Total of 11 aldehydes (propanal, acrolein, butenal, butanal, pentanal, hexanal, heptanal, 2-octenal, octanal, 2-nonenal, and decanal) were detected in all pre-oxidized oil systems and prepared fried rice samples. Total Aldehyde (TA) contents in all preheated oil types were increased with elevation of preheating time and the highest TA was detected in SO preheated for 6 h (556.1±8.2 µg/g) followed by the PO and CO. All fried rice samples, prepared using preheated oil types contained TA in the range of 19.8 to 52.1 µg/g and the highest detected in R3 prepared using SO preheated for six hours. The most prominent aldehyde was octanal in preheated SO and PO, and heptanal in CO. Notable variations in both quantity and composition of aldehyde profile were detected across the rice types. Hazardous aldehydes of acrolein were detected in all fried rice varieties that used SO preheated for ≥ 2 hours. Unsaturated aldehydes of both 2-octenal and 2-nonenal were detected in R3, fried in all three oil systems. The three-way ANOVA demonstrated significant effects of oil type ($p<0.001$), rice variety ($p<0.001$), and preheating time ($p<0.001$) on TA composition in fried rice. Among those factors, the rice matrix has the most significant influence, followed by preheating time and oil type, which contribute to the composition and quantity of total hazardous aldehydes in fried rice.

Acknowledgment: Financial assistance by Treasury Research Grant (TG 24/256)

# Impact of storage temperature and brine preservation on saponin content and related parameters of *Solanum torvum* Sw. berries

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## Abstract

The study was intended to determine the changes in the yield of saponin from *Solanum torvum* berries (TB) stored at different temperatures and preserved in acidified brine. TB were cleaned and packaged in sterile low-density polyethylene. They were stored under -18 °C, 5 °C, 10 °C and 30 °C for seven days. Raw and Stored TB (RSTB) were analyzed for moisture content (AOAC 920.151), pH (pH meter, MetrOhm 744), colour (Chromameter, Minolta), saponin and alkaloid contents. RSTB were preserved in 5% brine solution with 3.5 pH. TB processed after storage (PSTB), were analyzed for the same parameters. Data were analyzed via one-way ANOVA and Tukey's pairwise comparison (Minitab 17.1). RSTB showed a significant increase ($p<0.05$) in lightness values (L), moisture content and alkaloid content along with increasing storage temperature, while their yield of saponin reduced significantly ($p<0.05$). Saponin yield and pH values of PSTBs reduced significantly ($p<0.05$) along with increasing storage temperature, while their alkaloid contents, moisture contents and L values increased significantly ($p<0.05$). Brine preservation led to a reduction in saponin and alkaloid contents. Fresh TB showed the highest saponin (0.35±0.02%) and the lowest alkaloid (0.09±0.00%) contents. The values remained the highest (0.28±0.00%) and lowest (0.06±0.00%) even after brine preservation. Storage at 5 °C yielded 0.24±0.00% of total saponins, 0.09±0.01% total alkaloids, 5.60±0.00 pH and 8.73±0.13% moisture. Storage at 10°C resulted in similar values, only with lower L values compared to 5 °C storage. However, storage at 30°C yielded lower amounts of saponins (0.20±0.00%) and alkaloids (0.09 ±0.11%). In conclusion, the highest saponin yield can be obtained by processing freshly harvested TB. Storage and brine preservation will reduce the saponin content. Storage at -18 °C, 5 °C and 10 °C for seven days will result in better saponin yield compared to 30 °C. Storage at 5 °C and 10 °C is most suitable for storing TB intended for brine preservation, for the extraction of saponin later.

Acknowledgment: Financial assistance by Treasury Research Grant (TG/21/208)

# Development and validation of an analytical method for pesticide residue determination in wastewater using solid phase extraction coupled with liquid chromatography-tandem mass spectrometry

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## Abstract

Pesticides are extensively utilized in agriculture, industry, and public health sectors to manage pests and enhance productivity. However, their residues often enter aquatic environments through agricultural runoff, industrial effluents, and improper disposal practices. Pesticide contamination in wastewater poses significant environmental and public health risks. This study aimed to develop an accurate, reliable, and sensitive analytical method for detecting multiple pesticide residues in wastewater samples. Solid Phase Extraction (SPE) was optimized to extract target pesticides efficiently from wastewater. The extracted analytes were analyzed by Liquid Chromatography coupled with Tandem Mass Spectrometry (LC-MS/MS), employing electrospray ionization in Multiple Reaction Monitoring (MRM) mode to enhance sensitivity and selectivity. The method was validated in terms of accuracy, selectivity, precision, linearity, Limit of Detection (LOD), and Limit of Quantification (LOQ), adhering to international standards and guidelines. Calibration curves exhibited excellent linearity ($R^2$ >0.997) across the tested working range of 0.001–0.020 mg/L. The LOD and LOQ values were adequately low (1.1–1.9 and 1.1–2.6 µg/L, respectively) to detect trace levels of pesticides in environmental samples. Recovery studies yielded values ranging from 80 to 105% with the relative standard deviations below 15%, indicating the method's satisfactory accuracy and precision. The validated method was successfully applied to real wastewater samples, demonstrating its robustness and suitability for routine pesticide residue analysis. This approach supports environmental monitoring efforts and facilitates regulatory compliance.

# Evaluating the Efficiency of Biodegradation of Glyphosate by Bacteria Isolated from Contaminated Soils in Sri Lanka: Preliminary Study on Soil Remediation

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## Abstract

Herbicide Glyphosate is a broad-spectrum, cost-effective pesticide widely used to control weeds in perennial crops like tea. However, its strong adsorption to soil particles and subsequent plant uptake via roots, contaminates commercially important plant parts like leaves, stems, flowers, fruits, etc., posing a potential trade risk. The Biodegradation mechanism utilizes enzymatic pathways to break down glyphosate into metabolites: aminomethylphosphonic acid (AMPA) or sarcosine, and it is a sustainable remediation strategy. In this study, soil samples were collected from glyphosate-exposed tea estates and nearby uncontaminated control sites. Glyphosate-resistant native bacteria were isolated by the enrichment culturing method using the minimal salt media with glyphosate as the sole carbon and phosphate source. The degradation efficiency of the obtained bacterial isolates was evaluated in minimal salt media by spiking glyphosate at 10 mg/kg with control studies in triplicate. The residual glyphosate, AMPA, and sarcosine over 28 days were quantified by Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS), and the viable microbial count was also calculated. From the enrichment culturing, four bacterial isolates (Coded as A, D, E, and G) were obtained from soils, and isolates A and D, utilizing glyphosate as a carbon source, showed minimal degradation (1.2% and 3.0%) and declining viability, with no detectable metabolites. In contrast, isolates E and G, which used glyphosate as a phosphorus source, achieved high degradation efficiencies of 92.8% and 96.6%, respectively, with sarcosine formation confirming the involvement of the C–P lyase pathway. Thus, these findings concluded the potential applicability of native bacterial isolates for the bioremediation of glyphosate-contaminated soils in the plantation sector of Sri Lanka. Hence, the present study strongly suggests further investigations on these isolates identified from Glyphosate-contaminated soils in Sri Lanka.

Acknowledgement: Financial assistance by Treasury Research Grant (TG 21/212)

# Development of a quantitative real-time Polymerase Chain Reaction (PCR) method for the analysis of genetically modified content in transgenic maize

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## Abstract

Genetically Modified (GM) crops such as maize are widely cultivated and consequently present in food products worldwide. Due to concerns regarding their potential effects on human health and the environment, regulatory bodies across the globe enforce regulations on the use of GM plants. In Sri Lanka, the Food Act No. 26 of 1980 mandates a labeling threshold of 0.9% for GM content. However, compliance with this legislation remains unregulated due to the lack of available services for quantifying GM content in food samples. This study aimed to develop an in-house, reliable, and accurate method for quantifying the GM maize event Bt-176 in food products using real-time PCR. Certified Reference Material (CRM) containing the Bt-176 maize event was used as the Deoxyribonucleic Acid (DNA) source. DNA extraction was performed, followed by measurement of DNA concentration and purity. The real-time PCR assay employed sequence-specific primer/probe concentrations of 500 nM/200 nM for the endogenous *ssIIb-1* gene and 140 nM/100 nM for the transgenic *bar* gene. Amplification efficiencies for both genes were determined independently using a four-fold serial dilution of 100% CRM DNA. A calibration curve for the endogenous gene was generated using this serial dilution series. The calibration curve for the transgenic gene was constructed using DNA from CRMs with GM content levels of 0.1%, 0.5%, 1%, 5%, and 10%. To assess the calibration curves, an in-house test sample containing 0.9% GM content was prepared using standard CRMs. The calibration curves demonstrated amplification efficiencies of 98.7% and 90.37%, with $R^2$ values of 0.9975 and 0.9978 for the endogenous and transgenic targets, respectively. Quantification of the 0.9% test sample using these curves yielded a value of 0.93%. The method showed low bias (-2.22%) and a Coefficient of Variation (CV%) of 6.06%, confirming the accuracy and precision of the calibration curves. The favorable statistical parameters of both the calibration curves and the test sample indicate that this method is suitable for the quantitative analysis of the GM maize event Bt-176. Further evaluation using market food samples is recommended to confirm its applicability for routine testing.

# Optimization and establishment of a rapid detection method for White Spot Syndrome Virus (WSSV) using real-time Polymerase Chain Reaction (PCR)

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## Abstract

White Spot Syndrome Virus (WSSV) is a large double-stranded DNA virus that has become one of the most destructive viral pathogens affecting crustaceans. The virus causes White Spot Disease (WSD), a highly infectious disease that leads to mass mortalities and heavy economic losses across the aquaculture industry. Sri Lankan shrimp cultivators faced two major outbreaks in 1996 and 2005, resulting in a major economic loss. Hence, a reliable and accurate diagnostic method is needed to detect WSSV within a short period of time to safeguard the harvests. This study focuses on the development and optimization of a rapid and sensitive diagnostic method for WSSV detection using the Real-Time Polymerase Chain Reaction (RT-PCR) technique. Specific primers targeting the highly conserved regions of the WSSV genome were used and the real-time PCR assay conditions were optimized with different DNA concentrations. The amplification efficiency of the WSSV-specific gene was determined using a fourfold serial dilution. The calibration curve revealed a high amplification efficiency (99.98%) with strong linearity ($R^2$=0.9977). The Limit of Detection (LOD) was found to be 1.56 ng/µL of DNA. Repeatability was tested using 10 replicates of 1.56 ng/µL DNA and 2 replicates of 100 ng/µL DNA, demonstrating consistent performance, with standard deviation ≤ 0.5. A market basket assay of shrimp samples and crab samples showed negative results for WSSV, while the positive control amplified with a Cq value of 18.371, confirming assay performance. The optimized real-time PCR method is simple, reliable, and highly specific for WSSV detection, offering a valuable tool for routine monitoring and rapid disease diagnosis.

Acknowledgment: Financial assistance by Treasury Research Grant (TG 24/241)

# Development and optimization of amplifiable maternal DNA from chicken egg

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## Abstract

Rising concerns about the circulation of counterfeit eggs in the food market have highlighted the importance of accurate methods to verify egg authenticity. Developing an advanced but simple method for extracting maternal DNA from chicken eggs and detecting it is important in distinguishing artificial eggs from natural eggs. This study aims to develop and optimize a method for isolation, quantifying and amplifying maternal DNA from various raw and cooked parts of the egg. Components of the chicken egg such as eggshell, inner membrane, Whole Egg Liquid (WEL), yolk membrane, chalazae, Germinal Disc Region (GDR) and cooked whole egg were used as the samples in this study. Isolation of DNA was performed with 200mg small fragment protocol of DNeasy Mericon Food Kit by QIAGEN, (Cat.: 69514) with several modifications made in centrifugation speed, amount of chloroform ($CHCl_3$) and amount of Elution Buffer. The quality and quantity of DNA were assessed using a bio spectrophotometer. Conventional PCR amplification was performed using chicken species-specific oligonucleotide primers to produce a 212 bp product. A 2% agarose gel was used to run the amplified PCR products. According to the spectrometric data, all the samples showed DNA, while WEL (41.8 µg/mL and ratio of 1.57) and yolk membrane (10.5 µg/mL and ratio of 1.74) samples showed higher DNA yield and purity. Isolated DNA from each anatomical part of the egg, as well as the cooked egg, was successfully amplified along with the positive control. Clear negative control reported zero contamination in PCR amplification. However, the inner membrane of the egg shell presented with non-specific lower amplicon band along with primer dimers could be due to contamination while handling. This study describes a simple and improved method for collecting maternal DNA from six different anatomical parts of a chicken egg and demonstrates that the amplifiability of the isolated DNA can be used to distinguish natural eggs from synthetic eggs.

Acknowledgment: Financial assistance by Treasury Research Grant (TG 24/241)

# Fabrication and performance evaluation of a dry block temperature calibrator

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## Abstract

Accurate temperature calibration is essential for quality assurance in industries such as pharmaceuticals, aerospace, and metrology. Apart from high cost, dry-block temperature calibrators, though widely used, often suffer from spatial non-uniformity and limited sensor accuracy, which can affect the reliability of calibrations. This study presents the fabrication and evaluation of metrological characteristics of a low-cost, locally fabricated dry-block temperature calibrator intended for industrial temperature sensor calibration. The device consists of a T6 aluminum dry well (30 mm diameter x 120 mm length) with machined inserts along with 6.3 mm, 9.8 mm, and 12.9 mm diameters. The temperature of the dry-block temperature calibrator is controlled by a TCS4-series PID controller with heuristically tuned gains and a 4-wire PT100 reference sensor. A 60 W cartridge heater provides uniform heating, while a 120 mm cooling fan enables rapid thermal cycling. The device was tested in the range from 35 °C to 80 °C using a Fluke 5628 precision reference standard Platinum Resistance Thermometer (PRT) along with a precision temperature scanner. Spatial uniformity was assessed at 40 °C in axial (top, center, bottom) and radial directions using inserts of 9.8 mm and 12.9 mm diameters. Axial uniformity tests at 40 °C revealed a significant 0.64 °C thermal gradient from top to bottom and 0.37 °C radial uniformity with optimal stability at the center, 0.008 °C. Uncertainty analysis followed ISO/IEC Guide 98-3 (GUM) methodology, accounting for resolution uncertainty of PRT and PT100, calibration uncertainty, PRT accuracy uncertainty, and scatter uncertainties of both PRT and the dry-block calibrator, with a coverage factor $k$=2 (Corresponding to 95% confidence level), yielding expanded uncertainties of ±0.11 °C at 40°C, ±0.31 °C at 60 °C, and ±0.40 °C at 80 °C. Systematic errors were calculated, which require corrections of -0.26 °C at 40 °C, +0.24 °C at 60 °C, and -0.23 °C at 80 °C to align the calibrator's readings with the reference standard. The system validates metrological performance across its operational range, with expanded uncertainties meeting ±0.2 °C requirements for precision applications at lower temperatures (30-50 °C) and ±0.5 °C thresholds for general process calibration (50-80 °C), offering a cost-effective alternative for temperature sensor calibration

# Enhanced purification and structural characterization of graphite oxide via the stirred diffusion method

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## Abstract

Sri Lanka is addressing the global demand for graphite oxide production by focusing on the development of a cost-effective, eco-friendly diffusion method for mass production aimed at high-tech applications. Natural vein graphite from Sri Lanka was used to synthesize graphene oxide using a modified Hummer's method. The resulting product was purified using a lab-fabricated, simple diffusion apparatus and analyzed through X-ray Diffraction (XRD) and Fourier Transform Infrared Spectroscopy (FTIR). XRD analysis of Graphene Oxide (GO) samples collected after the 4th, 8th, 12th, and 16th diffusion steps revealed a prominent diffraction peak between 11.5° and 12° (2θ), confirming the successful synthesis and purification of GO via the diffusion method. As the diffusion steps progressed from the 4th to the 16th, a reduction in interlayer distance was observed, with d-spacing values decreasing from 7.790 Å to 7.232 Å. This indicates effective water removal, resulting in a more compact and purified GO structure. The absence of a graphite peak at 26° further confirms the successful removal of unoxidized graphite, demonstrating that the GO produced through diffusion is comparable in quality to that obtained via conventional centrifugation. FTIR analysis supported these findings, revealing characteristic absorption bands associated with oxygen-containing functional groups, such as hydroxyl, carbonyl, alkoxy, and $sp^2$ carbon, indicative of successful oxidation. In conclusion, graphite was effectively converted into high-quality graphene oxide, and the purity of the oxidized material was validated by FTIR. This study confirms the efficacy of the stirring-assisted diffusion method as a scalable and practical alternative to the expensive and complex centrifugation-based purification processes. The resulting high-quality graphene oxide holds strong potential for advanced applications, including battery technology and various industrial uses.

Acknowledgement: Financial assistance by Treasury Research Grant (TG 19/183)

# Determination of Gamma-Amino Butyric Acid (GABA) *contents* in some traditional and improved rice varieties using a modified UV-Visible spectroscopic method

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## Abstract

Rice (*Oryza sativa* L.) is the staple food for over half of the world's population. Brown rice, processed by removing only the husk, retains the nutrient-rich bran, endosperm, and germ. During germination, hydrolytic enzymes such as glutamate decarboxylase are activated, enhancing the synthesis of Gamma-Aminobutyric Acid (GABA). GABA acts as a major inhibitory neurotransmitter in the central nervous system, contributing to anxiety reduction, depression management, and improved sleep quality. This study aimed to determine the optimal germination time for GABA production and quantify GABA content in selected traditional and improved rice varieties. Thirteen rice varieties commonly cultivated in Sri Lanka (six traditional and seven improved) were selected. Grains were soaked in water for 12 h and 24 h, then germinated at room temperature (28–30 °C) for 12 h, 24 h, and 36 h. Modified extraction methods were employed. GABA quantification was performed using UV-Vis spectrophotometry after reacting water extracts with phenolic acid and sodium hypochlorite to form an intense blue-colored complex, measured at 630 nm. Statistical analysis was conducted using one-way ANOVA, and mean differences were compared using Tukey's test (n=3 per variety). Optimal GABA production was achieved with 24 h soaking followed by 24 h germination. Among traditional varieties, Pokkali exhibited the highest GABA content (221.01±8.24 mg/100 g), while Kalu Heenati had the lowest (33.79±0.83 mg/100 g). Among improved varieties, BW 357 had the highest GABA content (155.05±6.91 mg/100 g) while Bg 336 had the lowest (74.39±5.83 mg/100 g), respectively. Statistically significant differences ($p \leq 0.05$) were observed between both traditional and improved varieties. In conclusion, traditional rice varieties produced significantly higher GABA content than improved varieties under optimal germination conditions. Moreover, the UV-Vis spectroscopic method proved effective for GABA detection and can aid in identifying rice varieties suitable for functional food development with potential health benefits.

Acknowledgement: Financial assistance by Treasury Research Grant (TG 24/234)

# Potential usage of *Pentadesma butyracea* Sabine (African butter tree) seed cake after fat extraction

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## Abstract

*Pentadesma butyracea* seeds contain 30-45% fat with other nutrients. After fat extraction, the seed cake contains high oxalate and tannins as anti-nutrients, causing bitterness, which limits its direct food applications. The objective of this study was to evaluate the potential of moist heat treatments to reduce the bitterness of *P. butyracea* Seed Cake Powder (SCP) and to develop a cupcake using the treated SCP. SCP was subjected to two treatments, boiling and pressure cooking, followed by drying. The untreated, boiled and pressure-cooked SCP were evaluated for proximate composition, anti-nutrients and antioxidants. The cupcakes were prepared using SCP, and the best powder was selected using a ranking test for preference and it was used in different ratios (7.2%, 5.4% and 3.6%) to develop instant cupcake formulations and the best formula was selected using another ranking test for preference. The selected cupcake made using the selected instant mixture was compared with a chocolate cupcake using a hedonic test. Results showed that the proximate composition of moisture, ash, crude protein, crude fat, crude fibre and carbohydrate of untreated SCP as 4.9±0.0%, 3.8±0.1%, 7.8±0.0%, 27.6±0.1%, 8.5±0.0% and 47.4±0.1%; boiled SCP as 6.7±0.0%, 1.9±0.0%, 8.3±0.1%, 24.2±0.0%, 8.6±0.0% and 50.3±0.6%; and pressure-cooked SCP as 6.4±0.1%, 1.6±0.0%, 8.6±0.0%, 23.4±0.0%, 8.6±0.0% and 51.4±0.1% respectively. The oxalate and tannins content in boiled (2.2±0.0% & 1.3±0.3%) and pressure cooked (1.1±0.0% & 1.2±0.0%) SCP showed significant reduction compared to untreated (3.2±0.0% & 4.3±0.2%) SCP respectively. The Total Phenolic Content (TPC) of boiled (4.81±0.04%) and pressure-cooked (4.75±0.02%) SCP had a lower value than the untreated SCP (5.43±0.07%). Pressure-cooked SCP was found to be preferred significantly ($p<0.05$) and the instant cupcake mix with 5.4% of it was preferred mostly. On comparison of the chocolate cupcake, the cupcake made with 5.4% of pressure-cooked SCP was found to be acceptable with minimized anti-nutrients, which shows its potential to be used as an ingredient in food products.

Acknowledgment: Financial assistance by Treasury Research Grant (TG 24/230)

# Graphite-cerium intercalated-montmorillonite-cement-biochar composite electrode with a synergetic matrix for energy storage applications by incorporating cerium as an electroactive mediator

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## Abstract

The growing demand for high-performance energy storage systems has driven the development of novel supercapacitor electrodes with enhanced electrochemical properties. This study presents the fabrication and characterization of a graphite–cerium intercalated Montmorillonite (MMT)–cement–biochar composite electrode (G-(Ce-MMT)-Ce-Bc-CE), incorporating cerium (Ce) as an electroactive medium to improve charge storage capacity. The electrode was initially prepared by intercalating cerium into montmorillonite (MMT). The resulting composite was formulated using graphite, biochar, (Ce-MMT), and cement in a weight ratio of 12:4:3:1. The mixture was compacted using a hydraulic manual press and subsequently calcined at 550 °C. Cyclic Voltammetry (CV) revealed a high specific capacitance of 548 F $g^{-1}$ at a scan rate of 5 mV $s^{-1}$, demonstrating strong potential for supercapacitor applications. Scanning Electron Microscopy (SEM) showed a well-structured Polyaniline (PANI) nanofiber network that enhances conductivity and charge storage efficiency. The addition of biochar increased porosity, enabling better electrolyte penetration and ion transport. Electrochemical Impedance Spectroscopy (EIS) confirmed low charge transfer resistance, indicating efficient charge mobility. Furthermore, $Ce^{4+}$ ions catalyzed the electropolymerization of aniline, producing distinct and reversible redox peaks. In conclusion, the composite outperformed conventional electrodes in both electrochemical activity and mechanical integrity, highlighting its promise for commercial energy storage applications. Future work should focus on optimizing material composition to further improve conductivity while maintaining structural stability.

Acknowledgement: Financial assistance by Treasury Research Grant (TG 24/246)

# Aniline electropolymerization on a graphite, tin oxide, and montmorillonite composite electrode and an electrochemical analysis of its capacitive characteristics

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## Abstract

To meet global energy demands, Supercapacitors (SCs) play a significant role in energy storage systems. The fabrication of electrodes for energy storage applications remains a major challenge, as electrode properties critically determine SC performance. In this study, a ternary composite electrode was prepared by simply mixing graphite, $SnO_2$, and Montmorillonite (MMT) as raw materials, forming the G–$SnO_2$–MMT composite electrode (G–$SnO_2$–MMT–CE). This electrode successfully facilitated the electropolymerization of aniline in an acidic medium, resulting in the formation of an interwoven polyaniline (PANI) nanofiber network. $SnO_2$ acts as a crucial supporting mediator in the electropolymerization process, enhancing the migration of anilinium ions from the solution to the electrode surface due to its strong proton affinity. Consequently, a PANI network with improved conductivity and structural integrity was achieved. These characteristics were confirmed by Electrochemical Impedance Spectroscopy (EIS), where the Nyquist plot of the PANI–G–$SnO_2$–MMT–CE electrode displayed a very low charge transfer resistance of 4.25 Ω, indicating excellent conductivity. The flattened semicircle shape of the Nyquist plot reflects the pseudocapacitive behavior of the composite, while the high empirical constant value (0.97) for the constant phase element corresponds to an oblique line in the low-frequency region, suggesting nearly ideal capacitive performance. Cyclic Voltammetry (CV) was used to calculate the specific capacitance of a supercapacitor cell assembled from two PANI–G–$SnO_2$–MMT–CE electrodes, yielding a value of 881 F $g^{-1}$ at a scan rate of 5 mV $s^{-1}$. This relatively high capacitance is attributed to the unique nanofiber morphology of the PANI network. Compared to other PANI-coated graphite-based composite electrodes, the PANI–G–$SnO_2$–MMT–CE shows superior performance, demonstrating its promising potential for advanced energy storage applications.

Acknowledgement: Financial assistance by Treasury Research Grant (TG 24/246)

# Comparison of lead-acid battery capacitance upon addition of rGO and $BaCl_2$ to the positive electrode

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## Abstract

Lead-acid batteries have evolved significantly since their invention, but still face challenges such as limited cycle life and sulfation. Recent advancements show that incorporating reduced Graphene Oxide (rGO) as an additive in the negative electrode improves conductivity, suppresses sulfation, and enhances overall battery performance. The present study focuses on the addition of $BaCl_2$ and rGO to the positive electrode with a view to improving the electrochemical performance of the battery. Discharge capacity was measured by varying the composition of $BaCl_2$ and rGO in the positive electrode. The addition of 0.05 g rGO resulted in the highest capacity of approximately 729 mAh, though the performance was unstable, while the 0.075 g rGO-added cell showed more moderate but stable behavior, indicating improved conductivity and performance balance. Incorporating $BaCl_2$ alongside rGO had no significant benefit, except for steady cycling performance and higher discharge capacities compared to those without additives. This is likely due to the lower conductivity of $BaCl_2$, which may hinder electrochemical performance, and the comparative study suggests that optimizing rGO content is key to enhancing lead-acid battery efficiency.

# Development of a calibration system for infrared thermometers: Evaluating uncertainty via Sakuma-Hattori modeling

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## Abstract

Infrared (IR) thermometers are widely used for non-contact temperature measurements in the food, construction, and low-temperature processing industries. During the COVID-19 pandemic, IR thermometers were also commonly used to measure human body temperature by aiming at the forehead or hand, often without sufficient understanding of their accuracy. This study addresses this national concern by presenting the development of an advanced calibration system for IR thermometers with uncertainty, improving the reliability. The system employs the Sakuma-Hattori equation to enhance uncertainty evaluation and ensure accurate calibration. It incorporates precision flat-plate IR calibrators: Fluke 9133 and 9132 for industrial applications, and BL671 for medical applications, which are traceable to international standards via the National Institute of Metrology Thailand (NIMT) and the South China National Center of Metrology. These flat-plate blackbody sources feature low distance-to-size (D:S) ratios, ensuring the thermometer's field of view is filled during measurement and minimizing angular errors. A dedicated darkroom setup is used to manage light intensity effectively. Calibration points were selected based on the operational range of the thermometers: a single point for narrow-range devices in wavelength 600 to 680 nm in medical applications, and at least three points (minimum, midpoint, and maximum) for wider-range devices in wavelength 8 to 14 μm used in industrial applications. A comprehensive uncertainty budget was developed by evaluating all significant sources of uncertainty involved in the calibration process. Custom spreadsheets were created for uncertainty analysis and calibration report generation. The results demonstrate successful calibration with expanded uncertainties of 0.27 °C ($k$=2) for medical IR thermometers and 0.50 °C ($k$=2) for industrial IR thermometers. The system achieves calibration measurement capabilities of 0.21 °C for medical and 0.41 °C for industrial IR thermometers. The application of the Sakuma-Hattori equation effectively addresses emissivity mismatch uncertainties and allows precise modeling of the radiance-temperature relationship, including reflected radiation and ambient temperature contributions in the uncertainty analysis. This advancement enhances the reliability and international compliance of IR thermometer calibration in both medical and industrial contexts. An inter-laboratory comparison is currently in progress to benchmark this system against existing calibration methods.

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# Digital calibration certificate for steel measuring tapes with uncertainty evaluation

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## Abstract

This study presents a comprehensive calibration method for measuring tapes up to 30 meters, ensuring traceability to primary metrological standards. The method specifically targets dimensional measurement instruments using the Octagon MSTC 1000 Measuring Scale and Tape Calibrator, which is traceable to the laser interferometer of the Federal Institute of Metrology (METAS), Switzerland. The methodology includes a detailed visual inspection for damage, wear, or faded markings that could affect measurement accuracy. Proper tape positioning was ensured by applying a 50 N tension to steel tapes using a hanging weight system and an easy align system. Test points were selected following standard practice, with a minimum of five equidistant points across the entire tape length, with the comparison of digital images with 10X magnification. Each measurement was repeated five times to assess repeatability and support statistical analysis incorporating various sources of uncertainty, including reference standard calibration, environmental conditions, and measurement repeatability. Auto-generated calibration reports were created using raw data in Excel, producing digital calibration certificates for efficient calibration management. Results showed that a 7.5-meter steel measuring tape with 1 mm resolution exhibited a maximum expanded uncertainty of 0.048 mm, calculated using a coverage factor of $k$=2 at a 95% confidence level. The industrial metrology laboratory's Calibration and Measurement Capability (CMC) ranged from 0.009 mm at 1 meter to 0.048 mm at 7.5 meters. In conclusion, the developed method ensures reliable measurement traceability for measuring tapes, with well-established uncertainty evaluation and systematic quality assurance procedures. The defined CMC range of 0.009 mm to 0.048 mm can be extended up to 30 meters through cumulative measurements. The digital calibration certificate offers a robust framework for dimensional instrument calibration, and the methodology effectively integrates multiple uncertainty sources to achieve comprehensive uncertainty quantification at a 95% confidence level.

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# Predicting player churn in online multiplayer games using artificial neural network and explainable artificial intelligence: A dual approach for player retention analysis

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## Abstract

Player churn prediction poses a significant challenge in the online gaming industry. This research addresses the gap between prediction accuracy and interpretability by integrating Artificial Neural Networks (ANNs) with explainable Artificial Intelligence (AI) for player retention analysis in massively multiplayer online role-playing games (MMORPGs). A dataset of 37,354 World of Warcraft player records, containing 11 behavioral features and an 80% churn rate, was used. The ANN model comprised three hidden layers (64, 32, and 16 neurons) with ReLU activation functions and 50% dropout rates, and was trained using the Adam optimizer over 15 epochs. SHapley Additive exPlanations (SHAP) and Local Interpretable Model-Agnostic Explanations (LIME) were employed to provide model interpretability. A Gradio web application was developed to enable real-time predictions. The ANN model achieved 100% accuracy across training, validation, and test datasets. Key retention factors included guild membership, unique playing days (correlation: 0.59), and maximum character level (correlation: 0.52), while churn indicators included recent players (min_month correlation: -0.55) and later-joining players (Chair_id correlation: -0.50). SHAP analysis identified unique_days (+0.3959) and min_month (+0.3446) as the most influential features for player retention. In conclusion, this dual-method approach effectively combines predictive performance with interpretable insights, quantifies key behavioral factors for retention, and bridges the gap between academic research and practical application, laying the groundwork for explainable gaming analytics.

# Development of $SiO_2$-Based Anode Material from Sri Lankan Vein Quartz for Rechargeable Lithium-Ion Batteries

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## Abstract

The search for sustainable anode materials for rechargeable lithium-ion batteries has prompted the investigation of silicon oxide-based materials as promising alternatives. In this study, high-purity Sri Lankan Vein Quartz (SLVQ) was mechanically milled and combined with conductive additives and binders to fabricate an anode electrode. The milled samples were characterized using X-Ray Fluorescence (XRF), Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES), and X-Ray Diffraction (XRD). Electrochemical performance was evaluated through half-cell testing methods, including Cyclic Voltammetry (CV), Electrochemical Impedance Spectroscopy (EIS), and galvanostatic cycling. Characterization results confirmed the presence of high-purity quartz with minimal impurities. Electrochemical analyses revealed stable lithium insertion and extraction, with distinct redox peaks at 0.55 V and 2.10 V, respectively. Although the material exhibited relatively high charge transfer resistance, likely due to its inherently low electrical conductivity, it demonstrated excellent cycling stability and maintained consistent specific capacity with 99% Coulombic efficiency over multiple cycles. These findings highlight the potential of SLVQ, when properly processed, to serve as a cost-effective and environmentally friendly alternative to synthetic silicon oxide-based anode materials.

# Low-Frequency Noise Level Variations Around Wind Turbines

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## Abstract

Wind power is a leading renewable energy source that plays a vital role in reducing carbon emissions and enhancing energy security. It generates electricity by converting the kinetic energy of wind, with performance influenced by factors such as wind speed, turbine height, and blade design. A key advantage of wind power is its low operating cost due to the free availability of wind. However, wind turbines also pose environmental challenges, particularly noise emissions, mainly aerodynamic noise from blade-air interaction, along with some mechanical noise. A study was conducted to determine existing noise levels and to perform 1/3 octave acoustic analysis at eight different locations around a wind turbine. This study analyzed the variation in noise frequencies at equal distances, using both 'A' and 'Z' frequency-weighted scales with a Class 1 Sound Level Analyzer. Each measurement was considered individually, with both the noise levels and frequencies examined separately. During the measurements, noise levels were recorded and 1/3 octave band analysis was conducted at a distance of 150 meters from the turbine center in approximately eight directions, in accordance with the EN 61400-11 standard. Calibrated sound level meters were used, and the noise level descriptors LAeq and LZeq were recorded. Calibration was traceable to the primary standard maintained at Brüel & Kjær, The Calibration Laboratory, Denmark. The results showed that at 150 meters from the turbine, LAeqT values ranged from 54 to 60 dB(A), exhibiting minimal variation and remaining below the 60 dB(A) threshold. In contrast, LZeqT values ranged from 76 to 96 dB, displaying significant variation and substantially higher levels, indicating the presence of strong low-frequency noise. Additionally, the survey revealed noticeable differences in noise levels between upwind and downwind directions. In the low-frequency range (12.5–125 Hz), differences exceeded 2 dB, reaching up to 4–5 dB. In the high-frequency range (1–5 kHz), the differences were smaller (1–2 dB), while the mid-frequency range (125–800 Hz) showed no significant variation (less than 1 dB). In conclusion, the absence of dedicated noise regulations for wind power projects in Sri Lanka highlights the need for targeted standards, as this study emphasizes the importance of assessing wind turbine noise emissions and identifying the most impactful frequency ranges for effective noise management.

# Assessment of Public Awareness and Risk Perception of Radiofrequency Electromagnetic Field

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## Abstract

Non-ionizing radiation, particularly Radiofrequency (RF) radiation, is often considered low-risk because current exposure limits are primarily based on short-term heating effects. However, these limits largely overlook the potential risks associated with long-term, low-level exposure. As electronic devices become increasingly common in both workplaces and homes, it is essential to scrutinize their emissions and evaluate their long-term health impacts. In this study, measurements were conducted using a calibrated multi-field meter on commonly used workplace electronics, including mobile phones, Wi-Fi routers, laptops, power cables, and switches. Electromagnetic Field (EMF) levels were recorded at distances of 10 cm, 50 cm, and 1 m, with each reading repeated three times under normal operating conditions to ensure accuracy. Data were analyzed using SPSS software with both descriptive and inferential statistical methods to compare devices and distances. Distance-based EMF exposure curves were generated using Wolfram Mathematica to assess compliance with biological safety limits (IGNIR, BioInitiative). Additionally, a structured questionnaire was administered to 120 workers from various occupations to assess awareness, device usage patterns, and any reported health symptoms potentially linked to long-term RF-EMF exposure. While most devices complied with the short-term limits set by ICNIRP, approximately 60% exceeded the more stringent biological limits set by IGNIR, particularly when devices were used at close range or for extended periods. RF levels from mobile phones and Wi-Fi routers measured at 10 cm were 150–200% above these biological limits. Electric and magnetic field emissions from power cables and laptop chargers exceeded these limits by 80–120% at close distances. Survey results showed that 87.5% of participants were unaware of the health risks associated with RF-EMF exposure. Statistically significant associations ($p < 0.05$) were found between using devices for more than four hours daily at distances under 50 cm and symptoms such as fatigue (65%), headaches (58%), and decreased concentration (52%). The findings highlight significant shortcomings in current RF-EMF safety standards, which fail to adequately address the effects of prolonged exposure. The study underscores the urgent need for updated international regulations that consider biological effects, promote safer usage practices, and enhance public and occupational awareness. Future policies should establish exposure limits grounded in biological impact to better protect human health.

# Correlation of Wet Bulb Globe Temperature (WBGT) with meteorological variables in the workplace

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## Abstract

Occupational heat stress poses significant risks to worker health, safety, and productivity, particularly in outdoor environments exposed to high ambient temperatures and humidity. This study aims to examine the correlation between Wet Bulb Globe Temperature (WBGT) and meteorological variables, identifying key environmental factors that influence heat stress. The study was conducted at an outdoor workplace exposed to direct solar radiation to evaluate heat stress under realistic conditions. Data were collected on seven non-consecutive high-sunlight days between 10:00 AM and 3:30 PM, the typical peak heat exposure period for workers. The Heat Stress Tracker was used to measure environmental variables at 10-minute intervals, which were then averaged to 30-minute intervals. Measurements were taken at a height of 1.1 meters in accordance with ISO 7243 to calculate WBGT using natural wet-bulb temperature ($T_{nw}$), black globe temperature ($t_g$), and air temperature ($t_a$). Additional parameters such as relative humidity and wind speed were also recorded. The site was free from shading or airflow obstructions. Pearson correlation analysis was conducted to assess the relationships between WBGT and meteorological parameters. Results showed strong agreement between measured and calculated WBGT values, with differences ranging from 0.1 °C to 0.9 °C, supporting the accuracy and practical applicability of the Heat Stress Meter in field conditions. The analysis revealed that WBGT values consistently peaked between 12:30 PM and 1:30 PM, aligning with the highest ambient temperatures. Furthermore, WBGT demonstrated a positive correlation with air temperature and relative humidity, and a negative correlation with wind speed, emphasizing the influence of meteorological variables on heat stress intensity. By identifying periods of elevated WBGT, this study enables the implementation of targeted mitigation strategies to reduce heat stress risk. The findings underscore the importance of proactive heat stress management and continuous environmental monitoring to protect worker health and sustain productivity in outdoor occupational settings.

# Incorporation of Ce (IV) into graphite-clay composite matrix in electrodes to improve the performance of supercapacitor applications

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## Abstract

Graphite–clay composite electrodes have recently been developed using various composite matrices by altering raw materials and their proportions. The intercalation of Montmorillonite (MMT) with cerium (Ce) introduces a novel approach to electrode matrix engineering through raw material modification. A graphite and Ce-intercalated electrode (G(Ce-MMT)CE) was fabricated using a simple technological process involving mechanical compression ($2.2 \times 10^4$ N) and thermal activation at 550 °C. The applicability of G(Ce-MMT)CE for energy storage devices was evaluated through the development of supercapacitor cells constructed with polyaniline (PANI)-coated composite electrodes and a separator containing $H_2SO_4$ as the electrolyte. Aniline electropolymerization on the electrode surface was likely catalyzed by the electrode matrix, resulting in an interwoven PANI nanofiber network with villi-like projections. Scanning Electron Microscopy (SEM) revealed that the PANI network was uniformly distributed across the electrode surface, contributing to low series resistance (17.8 Ω) and charge transfer resistance (4.1 Ω). The performance of the PANI–G(Ce-MMT)CE supercapacitor was characterized by capacitance and charge–discharge behavior, indicating pseudocapacitive properties. It exhibited the highest specific capacitance recorded among previously developed graphite–clay composite electrodes—1308 F $g^{-1}$ by cyclic voltammetry and 1329 F $g^{-1}$ by charge–discharge analysis. The present study underscores the significant potential of G(Ce-MMT)CE for energy storage applications. G(Ce-MMT)CE, fabricated via metal ion intercalation into MMT, outperformed existing graphite–clay electrodes due to enhanced electropolymerization and improved energy storage capability. Further modifications to the PANI-coated G(Ce-MMT)CE are expected to further increase capacitance, which is essential for advancing high-performance energy storage devices.

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# From waste to wealth: Transforming Sri Lanka's banana agribusiness through circular economy innovations

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## Abstract

Agriculture has long been a major contributor to Sri Lanka's economy, accounting for 7.5% of GDP and employing approximately 75% of the workforce as of 2019, prior to the economic crisis. Bananas are the most commercially cultivated fruit in the country, with high domestic consumption generating substantial but unutilized biowaste. This study examines the challenges and opportunities within the banana agribusiness sector through the lens of Porter's value chain and circular economy principles, focusing on smallholder farmers across five districts representing Sri Lanka's diverse ecological zones. Data collected from 350 stakeholders and six focus group discussions revealed a decline in banana cultivation in some areas due to high production costs, low profit margins, wildlife threats, and limited access to agricultural inputs. However, private sector-led commercial farming in Anuradhapura, Rathnapura, and Jaffna has shown increasing production and export potential. A productivity analysis covering the years 2001 to 2023, using a multiple linear regression model, indicated that Rathnapura has the highest efficiency, with a statistically significant coefficient of 14 ($p<0.05$), highlighting it as a priority area for future investment. The study also explores the potential of value-added products derived from banana waste to enhance economic sustainability and farmer livelihoods. Utilization of the banana pseudo-stem has reduced waste disposal costs and increased farmer income, while eliminating open burning helps reduce environmental pollution. Banana pith can be used to produce paper, offering an alternative to synthetic packaging, and vermicompost derived from biowaste can reduce reliance on chemical fertilizers. Additionally, organic banana products have a higher export value, and banana fiber-based goods offer eco-friendly revenue opportunities. The research underscores the need for policies that support smallholder farmers, improve supply chain efficiency, and promote value-added banana waste products for greater economic and environmental sustainability. A mixed-methods approach employing various sampling techniques was used. Case studies on banana fiber, paper, vermicompost, flour, and blossoms included analyses of production, market potential, and cost-benefit outcomes. The banana value chain was mapped to identify key stakeholder roles, operations, and enabling factors.

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# A study on the physicochemical analysis of baby soaps and bathing bars available in the Western Province, Sri Lanka

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## Abstract

Soaps are widely used surfactant-based cleaners composed of sodium or potassium salts of fatty acids. Baby Soap (BS) and Bathing Bars (BB) are two types of soap in high demand, with BB typically containing both synthetic and natural surfactants. Considering the increasing number of soap manufacturers in Sri Lanka, quality assessments, including physicochemical evaluations, are essential to ensure consumer safety and product authenticity. This study evaluated locally available BS and BB samples against the standards SLS 547:2009 and SLS 1220:2016, respectively. A total of 40 commercially available soap samples (20 BS and 20 BB) were purchased from the Western Province and analyzed for key physicochemical parameters. For BS, the parameters included Total Fatty Matter (TFM), freedom from rosin, Matter Insoluble in Ethanol (MIE), Free Caustic Alkali (FCA), Total Free Alkali (TFA), and Chlorides (Cl), while for BB, TFM, FCA, synthetic surface-active agents (SSA), mush content, and pH were assessed. All BS samples met the Recommended Limit (RL) for TFM (≥78.0% m/m), except for two samples (50.2% and 62.3%), with the remaining samples ranging from 78.4% to 84.3%. The RL for MIE in BS is ≤1.5%, and all samples complied except one non-branded sample (24.7%). FCA and TFA levels in all BS samples were below the maximum allowable limits of 0.04% and 0.1%, respectively, and all passed the test for freedom from rosin. The average Cl content in BS was 0.3% (±0.12), within the RL of ≤1.0%. Among the BB, 15% samples (all non-branded) had TFM values between 22.1% and 31.9%, below the required minimum of 40.0% m/m. FCA levels in all BB samples were below the maximum limit of 0.06%, SSA values ranged from 2.1% to 10.3% (RL ≥2.0%), and mush content varied widely (0.3 to 8 g/50 cm²). The mean pH of BB was 9.8 ± 0.3, which complied with the RL. Notably, 50% of non-branded samples from both BS and BB categories failed to meet at least one recommended specification. In conclusion, the results indicate the need for continuous monitoring and regulatory analysis, particularly of non-branded products, to ensure consumer safety and uphold product standards.

# Stakeholder evaluation of science and technology institutions using the Kano Model

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## Abstract

A performance review of service-providing science and technology (S&T) institutions in Sri Lanka is crucial. Evaluating stakeholder perceptions is essential for institutional sustainability. The Kano model consists of paired functional and dysfunctional questions that assess stakeholder opinions in both scenarios. Based on responses, each service aspect is categorized mainly as a "basic feature" ("must-be"), "one-dimensional", or "attractive". Failure to meet a "basic feature" leads to high dissatisfaction, while fulfilling an "attractive feature" creates customer delight. A structured Kano model questionnaire was developed, focusing on eight major service attributes: timely delivery of service, service pricing, reliable and competent service, cooperativeness of officials, focus on customer needs, effective communication, institutional responsibility, and flexibility in meeting customer requirements. The questionnaire was distributed to stakeholders of a leading S&T organization in Sri Lanka. A total of 35 participants returned completed questionnaires, of which 18 had successfully answered all eight Kano question pairs. The impact of each aspect was evaluated using the "Better" and "Worse" indices, with the "Worse/Better ratio" indicating the effect of non-fulfillment of the aspect. Regarding demographics, 53% of participants were over 45 years old, 44% held postgraduate qualifications, and the majority (64.7%) were from the private sector. Stakeholders were primarily concerned about the timeliness of service delivery, which was perceived as a basic feature. Reliability, competency, confidentiality, and transparency of institutional functions were generally rated as satisfactory. However, the lack of institutional focus on customer needs had a high negative impact on satisfaction, which was three times higher than dissatisfaction when the feature was unmet. On the other hand, flexibility in fulfilling customer requirements had minimal effect on stakeholder satisfaction. In general, charges for scientific services in Sri Lanka are considerably high. However, stakeholders did not express strong dissatisfaction, as they realized the complexity of S&T services and found the associated charges were reasonable. In conclusion, according to the Kano model analysis of stakeholder opinions, timely delivery, reliability, responsibility, and customer focus are key basic features that institutions must prioritize to maintain stakeholders' satisfaction. Flexibility and communication were identified as "attractive features". Therefore, investment in both "basic" and "attractive" features is vital for the long-term sustainability of service-providing S&T institutions in Sri Lanka.

# Marker-based High Performance Liquid Chromatography (HPLC) standardization of *Amurthashtaka Kwatha*: quantitative evaluation of phytomarkers in raw herbal extracts and the final polyherbal formulation

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## Abstract

*Amurthashtaka Kwatha* (AK) is a classical Ayurveda polyherbal formulation used for managing fever, inflammation, and digestive disorders. It is made up of eight plant materials. This study aimed to standardize AK using High-Performance Liquid Chromatography (HPLC) through quantitative evaluation of selected phytochemical markers in both the individual herbal extracts and the final polyherbal formulation. The constituent herbal plants were collected from five locations in Sri Lanka. Marker compounds: nimbolide, piceatannol, picroside-I, and berberine were selected based on their known abundance in *A. indica*, *C. rotundus*, *P. scrophulariiflora*, and *T. cordifolia*, respectively. HPLC analysis was performed on a Shimadzu UFLC system using C-18 reversed-phase columns with photodiode array detection. All methods were validated according to ICH guidelines and demonstrated linearity in the 5–100 mg/dm$^3$ range. Retention times were 6.1 min (nimbolide), 1.9 min (piceatannol), 11.1 min (picroside-I), and 3.6 min (berberine). Quantified concentrations in the raw extracts were: nimbolide (4.7–17.4 mg/dm$^3$), piceatannol (133.2–680.1 mg/dm$^3$), picroside-I (0.4–58.0 mg/dm$^3$), berberine (21.2–41.2 mg/dm$^3$) and corresponding concentrations in AK ranged from 0.4–1.5 mg/dm$^3$, 182.5–343.4 mg/dm$^3$, 1.74–23.2 mg/dm$^3$, and 10.4–19.3 mg/dm$^3$, respectively. In conclusion, HPLC-based marker quantification confirmed the consistent presence of key phytochemicals in both raw extracts and the AK formulation, supporting its phytochemical standardization and potential integration into quality-controlled Ayurvedic practice.

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# Facile synthesis of copper nanoparticles by gamma irradiation technology

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## Abstract

Exposure of aqueous solutions to gamma radiation induces water radiolysis, resulting in the formation of reactive species. Among these, the hydrated electron and hydrogen atom act as strong reducing agents, while the hydroxyl radical serves as an oxidizing agent. In the presence of a hydroxyl radical scavenger, copper ions in solution can be reduced by the radiolysis products, enabling the synthesis of copper nanoparticles (CuNPs). The particle size can be controlled at the nanoscale using a suitable stabilizing agent. In the present study, aqueous solutions of copper sulfate were prepared, and either Triton X-100 or Polyvinyl Alcohol (PVA) was added as the stabilizing agent. The solutions were purged with nitrogen gas to remove dissolved oxygen and sealed in double-capped High-density Polyethylene (HDPE) bottles without headspace. Irradiation was carried out at a $^{60}$Co multipurpose gamma irradiation facility, delivering a dose of 15 kGy at a dose rate of 0.35 kGy/h. The experiment was conducted both in the presence and absence of formate ions, used as the hydroxyl radical scavenger. The irradiated solutions were analyzed using Dynamic Light Scattering (DLS) to determine particle size distribution. Precipitates obtained by centrifugation were further characterized by Scanning Electron Microscopy (SEM), Fourier Transform Infrared Spectroscopy (FTIR), and Raman spectroscopy. A strong Raman peak at 221 $cm^{-1}$ was observed in samples with both stabilizing agents, corresponding to $Cu_2O$. Similarly, an infrared band at 609 $cm^{-1}$, attributed to Cu(I)–O stretching, was detected in both cases. These results are consistent with previously published literature and confirm the formation of $Cu_2O$. In the Triton X-100 stabilized sample, SEM images showed clusters of CuNPs, while DLS indicated a monodispersed particle size distribution with an average diameter of 14.6 nm. In contrast, SEM and DLS results for the PVA-stabilized sample suggested incomplete separation of the polymer from the copper particles. Based on these findings, the present study successfully demonstrates the synthesis of $Cu_2O$ nanoparticles via gamma irradiation in the presence of Triton X-100 as a stabilizing agent. Further complementary analysis, such as X-ray Diffraction (XRD), is planned for future work.

# Characterization of rGO-enhanced positive plates in lead-acid batteries

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## Abstract

Lead-acid batteries remain widely used due to their low cost, simple design, and reliability. However, they suffer from limitations such as a short lifespan, low energy density, heavy weight, and environmental hazards. In this study, reduced graphene oxide (rGO) was incorporated into the positive plate to enhance electrochemical performance. rGO was first synthesized from Sri Lankan vein graphite using a modified Hummer's method followed by thermal reduction. Various compositions of the synthesized rGO were added to the positive electrode containing PbO. The fabricated lead-acid battery cells underwent charge-discharge cycling and were characterized using X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), and Thermogravimetric Analysis (TGA). XRD patterns confirmed the presence of PbO and the formation of both α-$PbO_2$ and β-$PbO_2$, indicating successful development of the positive active material. SEM images revealed morphological changes across the positive plates with different rGO compositions. TGA further confirmed the successful incorporation of rGO into the positive active material. Among the tested compositions, the electrode containing 0.05 g of rGO exhibited the highest discharge capacity, which was several times greater than that of the bare electrode. However, increasing the rGO content beyond this optimal level resulted in decreased capacity, likely due to the reduced proportion of active material. This highlights the importance of maintaining an optimal balance between the active material and the conductive additive. This study provides valuable insights into the effects of rGO concentration on positive plate characteristics and battery performance, particularly in enhancing discharge capacity for future applications.

# Determination of adsorption and desorption of urea into activated carbon to evaluate the efficiency of nitrogen usage in plants and the impact on the environment

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## Abstract

The efficient use of nitrogen fertilizers presents a significant challenge for sustainable agriculture. Their application often leads to volatilization, leaching, or runoff, which not only pollutes environmental resources but also results in economic inefficiency. Urea, one of the most commonly used nitrogen fertilizers, is particularly affected by these issues. This research aimed to analyze the functionality of activated carbon as a carrier for urea to develop a slow-release fertilizer that minimizes losses and maximizes plant uptake. Activated Carbon (AC) is especially intriguing due to its highly porous structure. The pores formed during the carbonization and activation processes result in a remarkable surface area, which enhances the adsorption capacity of activated carbon. Using activated carbon as a matrix for urea fertilizer offers a promising strategy to improve nitrogen use efficiency and reduce the environmental impact associated with conventional urea application. Steam activation of coconut shell is a green and cost-effective method for producing high-quality activated carbon. In this study, the adsorption and desorption isotherms of urea on activated carbon were examined to assess its suitability for this application. Activated carbon was immersed in a known concentration of urea solution, and the amount adsorbed was measured at regular time intervals. The experiment was conducted at room temperature (25 °C) without exposure to sunlight. Results indicated that optimal urea adsorption occurred after 16 hours, reaching site saturation. After seven days, the maximum urea release was observed. These findings confirm that urea can be effectively loaded into activated carbon within a short period and retained for at least one week, with gradual release under controlled conditions (room temperature with no sunlight). This slow-release behavior reduces nitrogen loss as ammonia and enhances fertilizer efficiency.

Acknowledgement: Financial Assistance by Treasury Research Grant (TG 24/264)

# Optimization of solvent-free microwave extraction of essential oil from seed kernel of *Myristica Fragrans* (Ceylon Nutmeg) by response surface methodology

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## Abstract

*Myristica fragrans* (Ceylon nutmeg) is an economically important spice valued for its Essential Oils (EOs), which contain volatile bioactive compounds, particularly monoterpenes and phenylpropenes. Conventional EO distillation methods, such as Hydrodistillation (HD) and steam distillation, often require long extraction times, consume high amounts of energy, cause thermal degradation of heat-sensitive compounds, and result in low yields. The objective of this study was to evaluate and compare Solvent-Free Microwave Extraction (SFME) with HD for EO extraction from different parts of *M. fragrans*, optimize SFME parameters for seed kernel EO yield using Response Surface Methodology (RSM), and determine EO constituents. Air-dried seed kernel, mesocarp, leaves, and mace were subjected to HD using a Clevenger-type apparatus for 6 hours and to SFME using a NEOS-GR microwave extractor. A Box–Behnken design (3-factor, 3-level) was used to optimize SFME conditions for seed kernel by varying power (300–450 W), time (30–90 min), and water-to-material ratio (0–0.1 mL/g). All EOs were analyzed for their chemical profiles using Gas Chromatography–Mass Spectrometry (GC–MS). SFME yielded the highest EO content from seed kernel (1.62%) in 60 minutes, compared to 1.36% by HD in 360 minutes. SFME also extracted a higher EO yield from mesocarp (0.13%) compared to HD (0.06%). However, mace and leaf EOs could not be extracted by SFME due to dense tissue structure and limited material quantity. RSM optimization identified optimal SFME conditions as 434.88 W microwave power, 77.85 minutes extraction time, and a water-to-material ratio of 0.079 mL/g, predicting a yield of 1.35%. The model was statistically robust ($R^2$ =0.9978; p=0.2706), and validation plots confirmed normally distributed and independent residuals. The perturbation plot indicated that the optimal conditions were near the local maximum. GC–MS analysis identified Myristicin, Safrole, α- and β-Pinene, γ-Terpinene, Terpinen-4-ol, Linalool, and α-Terpineol as the main EO constituents. In conclusion, SFME proved to be a faster, more energy-efficient, and greener alternative to HD for extracting EOs from *M. fragrans* seed kernel and mesocarp.

Acknowledgement: Financial assistance by Treasury grants (TG 21/203 and TG 23/229)

# Substance-based treatment on used gear oil for revenue potential

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## Abstract

Used gear oil, which is normally contaminated with degraded additives, oxidation products, and contaminants, reduces the performance and creates environmental hazards. Wasted gear oil could be converted into a different value creation aimed at a different purpose. This study preliminarily investigates a treatment method for used gear oil using selected reagents to restore its properties. The treatment process involved chemicals such as potassium hydroxide (KOH), $H_2SO_4$ acid, or natural adsorbents/charcoal, followed by settling, filtration, and purification steps. Moreover, acidity and viscosity were analyzed both before and after the treatments. The oil quality indicates that chemical treatment is an effective method for regenerating used gear oil. Further heavy particles, water, and sludge in used gear oil were allowed to settle naturally for 24–48 hours, heated at 60-70 °C, and filtered. The initial pH value was in the acidic region. Then 10 g of KOH pellets were dissolved in 90 mL of water, and10% KOH solution was prepared, which was slowly added to the pre-heated sludge and stirred thoroughly for 60 minutes. The mixture was settled in a separatory funnel for 3 hours. The bottom layer was separated, and the top oil layer was filtered. 100 mL of heptane was slowly added to the filtered oil sample. It was stirred thoroughly for 60 minutes and mixed with 10 g of activated charcoal along with 250 mL of the sludge sample. It was stirred again for 50 minutes and was allowed to settle for 1 hour. After that, gently heated the purified sludge to 80 °C to remove the residual heptane. The changes in physical and chemical properties revealed that the appearance of the “Used Gear Oil” was dark and cloudy, while the “Purified Gear Oil” was amber colored and clear. The density of the used gear oil was 0.947, and the purified oil showed 0.843. The purification process significantly improved the quality of the used gear oil. The viscosity slightly decreased, indicating the removal of oxidized and polymerized components, yet it remained within acceptable limits for re-use. The appearance improved after filtration and adsorption, demonstrating the effective removal of sludge, particulates, and contaminants. The chemical and physical treatment of used gear oil effectively restores many of its properties close to those of fresh oil, enabling it to be used as a base oil for formulating grease or for non-critical applications such as industrial gearboxes, chains, or farming machinery, aiming at a lower carbon footprint.

# Surfactant-assisted (Tween 80) dispersion of graphene at low concentrations in lubricant oil

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## Abstract

Lubricant oils are vital in reducing friction, minimizing wear, and managing heat in mechanical systems. Traditional additives often fail to enhance performance without negatively affecting fluid properties or long-term stability. Incorporating graphene, an ultra-thin, two-dimensional carbon material, offers a promising approach due to its exceptional mechanical strength, thermal conductivity, and low shear forces, all of which contribute to friction reduction and wear resistance. However, graphene's inherent tendency to agglomerate in hydrocarbon media, driven by strong Van der Waals forces, limits its effectiveness unless it is uniformly dispersed. Achieving a stable, uniform dispersion within the lubricant medium is therefore essential for unlocking graphene's benefits while maintaining long-term shelf life and operational stability. This study investigates the surfactant-assisted dispersion of graphene at low concentrations (0.0025–0.01 wt%) in lubricant oil using Tween 80 and hexane as a delivery medium. Tween 80 acts as a non-ionic surfactant to functionalize graphene sheets, enabling stable dispersion through hydrophobic π–π interactions and steric hindrance from its polyethoxylate chains. Graphene was first dispersed in hexane with Tween 80, then introduced into the lubricant at varying weight fractions. X-ray Diffraction (XRD) and Fourier Transform Infrared Spectroscopy (FTIR) analyses were performed to characterize the Tween 80-modified graphene. Rheological behavior was evaluated through kinematic viscosity measurements at 40 °C and 100 °C. Results showed that the lubricant containing modified graphene remained Newtonian, with viscosity changes of only 0.4% at 40 °C and 2.6% at 100 °C. Dispersion stability, assessed via visual sedimentation, indicated minimal agglomeration over five days. The findings demonstrate the feasibility of incorporating Tween 80-modified graphene in trace amounts to enhance lubricant performance without compromising fluidity or chemical stability. This work provides a foundation for further tribological evaluations, such as friction and wear testing and thermal conductivity measurements, to assess practical applications in engine lubricants. Overall, it contributes to the growing body of research aimed at developing sustainable, high-performance additives for next-generation lubricants.

# Innovations in cold plasma technology for sustainability in food processing

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## Abstract

Non-thermal food processing technologies could be an alternative method for food preservation, minimizing the negative effect on the nutritional profile. Some of the non-thermal processing technologies are already employed in the food processing industries to extend the shelf life. Cold plasma is an emerging non-thermal, eco-friendly technology in food processing, operating at atmospheric pressure and ambient temperatures. It generates Reactive Oxygen and Nitrogen Species (RONS), enabling microbial decontamination and modification of food macromolecules without compromising quality. Mechanisms of microbial inactivation by cold plasma include etching, electroporation, and cell wall disruption. Cold plasma is also used to modify starches, proteins, and polysaccharides, and even to enhance seed germination. Plasma-Activated Water (PAW), a derivative of cold plasma, alters pH, redox potential, and conductivity, offering an additional tool for food preservation. Together, these innovations position cold plasma as a modern, sustainable alternative to traditional processing methods. Pin-to-plate plasma systems have been effective in decontaminating plant-based beverages like oat milk, achieving microbial safety without thermal degradation. Cold plasma is used for the sterilization of sensitive materials, and now it is being extended to food industries as a novel technology for numerous applications. This technology addresses increasing consumer demand for minimally processed, preservative-free foods with retained nutritional value. Cold plasma also modifies the physicochemical and rheological properties of biopolymers from finger millet, mango seed kernel, and arrowroot, enhancing their functionality in food structuring and stabilization.

# Investigation of the synergetic effect of catalysis and cold atmospheric pressure plasma advanced oxidation process on the degradation of textile wastewater

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## Abstract

In this work, the synergetic effects of Nano Particles (NPs) and Cold Atmospheric Pressure Plasma (CAP) treatment were systematically investigated on the degradation efficiency of textile dye in aqueous solution and direct textile effluent. Initially, NPs were produced by sol gel method and thereafter, morphology, structure and functionalities were examined via various advanced analytical methods. The degradation efficiency of the combined plasma/NPs catalysis treatment was investigated by Ultraviolet (UV)–Vis spectroscopy. An Optical Emission Spectrometry (OES) was used to investigate the generated reactive species such as OH• OH• radicals and $N_2$*, during the treatment. Furthermore, the deviation in the pH, electrical conductivity and Total Organic Carbon (TOC) was also examined. All collective results showed that plasma treatment processes, combined with the NPS catalytic performance, produced higher concentrations of various ROS and RNS, which in turn enhanced the efficiency of degrading complex dye compounds and inhibited the formation of harmful intermediates. This was further verified by the non-toxicity of the plasma-treated aqueous solutions when in contact with bacteria (*S. aureus* and *E. coli*). Overall, it can be concluded that the unique catalytic plasma-assisted treatment processes are ideally essential in various textile industries as a highly efficient treatment of effluents before discharging into water bodies.

# Glucocorticoid transcriptional responses in triple-negative breast cancer

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## Abstract

Dexamethasone (DEX), a synthetic Glucocorticoid (GC), binds exclusively to Glucocorticoid Receptors (GR). Poly-ADP ribose polymerase 1 (PARP1) catalyses poly-ADP ribosylation (PARylation) —a GC-sensitive post-translational modification. In BC cells with BRCA1/2 mutations, PARP1 recognises and repairs single-strand DNA breaks. Considering that PARylation is regulated by DEX and inhibited by the broad-spectrum PARP inhibitor PJ34, this study aims to identify differentially expressed genes (DEGs) in response to DEX and PJ34. RNA was extracted from treated MDA-MB-231 Triple-negative Breast Cancer (TNBC) cells and subjected to RNA-sequencing to identify Differentially Expressed Genes (DEGs), which were visualised using Volcano plots. DEX treatment significantly downregulated genes ($p<0.1$ and $>-1.5$-fold change) associated with BC cell proliferation, metastasis, and angiogenesis, while upregulated genes ($p<0.1$; fold change$>1.5$) were enriched for tumour-suppressive functions and markers of poor prognosis. PJ34 treatment downregulated genes linked to BC initiation, proliferation, and metastasis, and upregulated chromosomal instability suppressors and tumour suppressors. The DEX + PJ34 transcriptome closely mirrored DEX alone: 16 of the top 18 downregulated genes and 19 of the top 18 upregulated genes overlapped with DEX, with minimal overlap with PJ34. In conclusion, TNBC, DEX overwhelmingly dominated the transcriptomic response, even when combined with PJ34, driving strong tumour-suppressive and anti-metastatic gene signatures. PJ34 showed only modest effects, suggesting distinct, non-overlapping mechanisms. These findings could position DEX as a primary driver of transcriptomic reprogramming in TNBC.

# Microencapsulation of *Pistacia vera* 'Kalleh Ghouchi' (Pistachio) hull and *Citrus aurantium* L. (Sour Orange) peel essential oils by spray drying using whey protein isolate–maltodextrin matrix: Preparation, characterization, antimicrobial and antioxidant activities

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## Abstract

This study explored the microencapsulation of essential oils from discarded pistachio hulls (*Pistacia vera*) and sour orange peels (*Citrus aurantium*) from Shiraz, Iran, to enhance their stability and bioactivity for potential use as natural food preservatives. In this study, essential oils from pistachio hull and sour orange peel were extracted using 4-hour hydrodistillation and analyzed for composition using Gas Chromatography-Mass Spectrometry (GC-MS). Microencapsulation was performed using a combination of Whey Protein Isolate (WPI), Maltodextrin (MD), and sodium alginate. Emulsions of the oils were homogenized and spray-dried at 180 °C/90 °C, testing different MD:WPI ratios (1:1, 1.5:1, 2:1). Droplet size, uniformity (Span), and zeta potential were assessed using Dynamic Light Scattering (DLS). Encapsulation efficiency and surface oil content were measured gravimetrically. Microcapsules were further characterized using FTIR for functional group analysis and FE-SEM for morphology. Antioxidant activity was evaluated using the DPPH assay, while antimicrobial activity against *Staphylococcus aureus*, *Escherichia coli*, and *Salmonella spp.* was tested via the Disk Diffusion method. Results revealed that sour orange peel essential oil had a higher yield (1.2%) and was richer in limonene (~92%), while pistachio hull oil had a lower yield (0.6%) and was primarily composed of α-pinene (~76%). Sour orange peel oil formed smaller, more uniform droplets in emulsions and showed better encapsulation efficiency (84.3%) at a 2:1 maltodextrin-to-WPI ratio, while pistachio hull oil performed best at a 1:1 ratio (81.57%). Zeta potential values confirmed good emulsion stability, and FTIR analysis indicated that oils were physically entrapped within the matrix without chemical interaction. SEM images revealed that the microcapsules were mostly spherical, with sour orange capsules being smaller and smoother. Antioxidant tests showed high activity for both oils when encapsulated, while unencapsulated oils lost activity due to oxidation. Sour orange peel oil demonstrated stronger antimicrobial effects, producing larger inhibition zones against *S. aureus*, *E. coli*, and *Salmonella spp.*, with higher maltodextrin levels enhancing bioactive retention and sustained release. Overall, the optimized microencapsulation process successfully preserved the functional properties of these essential oils, offering a sustainable method for converting agricultural waste into value-added natural preservatives.

# Technical feasibility of using a mixture of biomass waste, municipal waste and discarded plastics in integrated biorefineries

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## Abstract

Official and reliable international statistics indicate that the demand for materials and energy is growing at the same time as population growth and related factors. The limitation of the use of fossil resources, along with the increase in waste production, has necessitated the use of mixed biomass waste, municipal waste, and discarded plastic. Main challenges in the use of waste are the difficulty of collecting, separating, and classifying it, due to the extreme fluctuations in different compositions. In this study, two main thermochemical conversion pathways, namely fast pyrolysis and gasification, were analyzed as key technologies due to their high speed, flexibility in accepting various feeds, and the ability to produce liquid and gaseous fuels. The processes were simulated using Aspen Plus software, and the mass and energy balances were calculated for each scenario. The results show that the optimal combination of 50% biomass, 30% municipal waste, and 20% discarded plastics increases energy efficiency by 78% and reduces greenhouse gas emissions by 45%. The results also show that the simultaneous combination of mixed biomass, municipal waste and discarded plastic leads to improved overall feed and final product properties. Further, it reduces costs and provides more sustainable access to higher feed volumes in biorefineries. The reason for this, is that biomass is high in oxygen and low in hydrogen, and when combined with plastics and dry wastes such as paper and cardboard, the moisture balance and hydrogen to carbon ratio in the feed improves. However, the presence of chlorine in plastics such as PVC and the presence of heavy metals in industrial sludge pose operational challenges such as equipment corrosion and the need for more complex gas treatment systems. This study provides a data-driven framework for developing strategies for using waste mixtures for energy and biomaterial production on an industrial scale.

# Sphingosides as emerging neuroprotective agents in Parkinson's disease: A biotechnological perspective

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## Abstract

Parkinson's Disease (PD) remains an incurable neurodegenerative disorder characterized by the progressive loss of dopaminergic neurons and debilitating motor symptoms. Recent biotechnological research has identified sphingosides, bioactive sphingolipid derivatives, as promising modulators of neuroinflammation and apoptosis in PD pathophysiology. Sphingosine-1-phosphate (S1P) receptors, which are widely expressed in the central nervous system, present a viable target for pharmacological intervention. This study reviews and contextualizes both *in vitro* and *in vivo* evidence supporting the potential of sphingoside analogs to attenuate microglial activation, reduce oxidative stress, and promote dopaminergic neuron survival. We also explore translational strategies for drug delivery across the blood–brain barrier and examine the potential of biotechnological synthesis of sphingoside analogs with optimized pharmacokinetic properties. This work underscores the value of innovative biotechnological approaches in addressing critical gaps in PD therapy and advocates for multidisciplinary collaboration to advance sphingoside-based interventions toward clinical application. By integrating molecular biology, pharmacology, and advanced biomanufacturing, sphingosides may represent a transformative direction in neurotherapeutics for Parkinson's disease.

# Mycoremediation in treatment wetlands: Enhancing pathogen removal using *Pleurotus ostreatus* mycelia in dynamic hydraulic systems

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## Abstract

Wastewater Treatment Wetlands (WWTWs) are utilized in the treatment of wastewater but are limited in pathogenic and Antibiotic-Resistant Bacteria (ARB) elimination, posing environmental and public health concerns. This study expands upon previous batch-mesocosm research demonstrating that active mycelial mats reduced *Escherichia coli* (*E. coli*) concentrations by up to 85.0%, meeting United States Environmental Protection Agency (USEPA) recreational water standards within 3.33 days. The research explores the use of fungal mycelia *Pleurotus ostreatus* (White Oyster Mushrooms) to enhance pathogen removal efficiency in WWTWs through a novel myco-augmented strategy. This research addresses limitations in static systems by configuring flow-through columns that more accurately represent wetland hydraulics and redox conditions. It mitigates stagnation and variability observed in previous systems by enhancing contact between fungal mycelia and target bacteria. In this study, the *E. coli* K12 strain acted as the indicator, and effluent concentrations were monitored as water passed through each treatment, with data collection being ongoing. With a Hydraulic Retention Time (HRT) of 6 hours, it offers a more scalable and operationally viable enhancement to conventional WWTWs. This eco-friendly, myco-augmented method presents a promising, low-energy, resilient solution for improving pathogen removal in WWTWs, promoting improved and more consistent remediation under dynamic hydraulic conditions.

# Investigating the improvement of amino acid, antioxidant, and volatile compounds of steamed bread with the addition of salted egg white

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## Abstract

The Salted Egg White (SEW), an ancient preserved food, is a by-product generated by salt-pickling fresh eggs over a period of time. It is well known in China and other Asian countries. However, SEW is often discarded as industrial waste due to the high cost of desalination, leading to environmental pollution and protein loss. In contrast, steamed bread has long been a staple of Chinese cuisine. This study investigated the effects of incorporating SEW at 5%, 10%, 15%, and 20% (w/w) on the amino acid composition, antioxidant activity, and volatile components of steamed bread. High Performance Liquid Chromatography (HPLC) was used to analyze the amino acid profiles. The results revealed a significant increase ($p<0.05$) in both essential and non-essential amino acid contents. Moreover, antioxidant activity, as well as total phenolic and flavonoid contents, increased with higher SEW concentrations. Analysis of volatile components using Headspace Solid-Phase Microextraction Gas Chromatography/Mass Spectrometry (HS-SPME-GC/MS) identified 54 volatile compounds. These included various chemical classes such as phenolic compounds, aldehydes, alcohols, benzenes, ketones, ethyl esters, and terpenes. In conclusion, the enhanced antioxidant activity suggests potential health benefits from consuming SEW-enriched steamed bread. Additionally, the analysis of volatile components provides insights into the aroma and taste characteristics of the bread, contributing to a better understanding of its sensory qualities.

# Method validation for the determination of selected elements in solid and liquid organic fertilizers using ICP-MS

Krishiga, R[1*]., Mubarak, M.N.A[2]., Chandrasiri, G.U[1]., Karunarathna, S[1]., Chathuranga, R[1]., Dias, W.K.N.D[1]. and Dewaraja, N.N[1]

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## Abstract

Heavy metals in organic fertilizers cause a risk to the agricultural ecosystem and, when they migrate into the soil-plant system, will harm human health throughout the food chain. Hence, an investigation on heavy metals in organic fertilizers is needed to avoid the adverse health and environmental effects. The objective of the proposed study is to develop and validate a method to determine the concentrations of heavy metals such as chromium (Cr), cobalt (Co), nickel (Ni), copper (Cu), arsenic (As), selenium (Se), cadmium (Cd), lead (Pb) and mercury (Hg) present in the solid and liquid organic fertilizer sample matrix. Fertilizer samples were digested with concentrated nitric acid and hydrogen peroxide using an appropriate temperature program in a closed vessel microwave digestion system. Then the digested samples were analyzed using Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). The applicability of the method was carried out by analyzing 20 commercially available solid fertilizer (compost) samples. During method validation, acceptable linearity was achieved for all calibration curves, with correlation coefficients ($R^2$) exceeding 0.998. The linear range was 1–250 µg/L for Cr, Co, Ni, Cu, As, Se, Cd, and Pb, and 1–25 µg/L for Hg respectively. The average recoveries recorded for the spiked samples with three spike concentration levels of standards (Low –2.5 mg/kg, Middle – 12.5 mg/kg, High – 20.0 mg/kg for the elements: Cr, Co, Ni, Cu, As, Se, Cd, and Pb and Low – 0.25 mg/kg, Middle – 1.25 mg/kg and High – 2.00 mg/kg for Hg respectively) were within the satisfactory range of 80 -116 %. The relative standard deviation was below 15% for the precision measured in terms of repeatability and reproducibility for all the elements. Limit of Determination (LOD) values of each metal were in the range between 0.056 mg/kg and 0.094 mg/kg, and Limit of Quantification (LOQ) values ranged from 0.065 mg/kg to 0.124 mg/kg respectively. The validated method demonstrated satisfactory performance parameters, confirming its accuracy and reliability. Market analysis showed that Hg concentrations exceeded the maximum permissible limits specified in Sri Lanka Standard: SLS 1635:2019 in 25% of the samples, while Cr and Ni each exceeded their respective limits in 5% of the samples. All other analyzed elements were below the regulatory limits.

# Method development and validation for the determination of selected heavy metals in cinnamon of Sri Lanka using Inductively Coupled Plasma–Mass Spectrometry (ICP-MS)

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## Abstract

Adulteration and contamination of cinnamon can occur during cultivation and processing, affecting the quality of Ceylon cinnamon. To ensure product integrity, it is essential to develop a reliable and accurate analytical method for the analysis of heavy metals. The aim of this study was to develop and validate a test method for the determination of arsenic (As), cadmium (Cd), lead (Pb), and mercury (Hg) in cinnamon and to confirm the applicability of the method by analyzing cinnamon samples available in Sri Lanka using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Homogenized and powdered cinnamon samples were digested with ultra-pure nitric acid using a microwave digester according to a preset temperature-time program. The digested samples were then analyzed for As, Cd, Pb, and Hg using ICP-MS. Method performance parameters were evaluated for the selected heavy metals in cinnamon samples. A total of 15 cinnamon samples were randomly collected from three provinces in Sri Lanka for analysis. During method validation, the correlation coefficient ($R^2$) for each analyzed element exceeded 0.998, confirming the acceptable linearity of the developed method. The working range was 0.02–10.0 mg/kg for As, Cd, and Pb, and 0.01–1.0 mg/kg for Hg, respectively. The recovery rates of spiked samples at three concentration levels ranged from 80% to 115% for all selected elements. The Relative Standard Deviations (RSDs) for both repeatability and reproducibility were below 11%. The Limit of Detection (LOD) and Limit of Quantification (LOQ) were 0.01 mg/kg for Hg and ranged from 0.02 mg/kg to 0.05 mg/kg for the other elements. Matrix effects were minimized using appropriate internal standards and applying the helium collision mode in ICP-MS. In conclusion, the method's performance parameters complied with the AOAC criteria. According to the test results, As and Hg levels in all analyzed samples were below the maximum permissible limits set by SLS 81:2021 and EU Regulation 2018/73 (2018). However, Cd levels exceeded the permissible limit in two samples, and Pb exceeded the limit in eight samples. Therefore, this method can be considered a reliable and accurate tool for the determination of the selected heavy metals in cinnamon.

# Optimization of microwave digestion reagents for accurate trace metal analysis in coal by Inductively Coupled Plasma-Mass Spectrometry (ICP-MS)

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## Abstract

Coal contains a wide range of hazardous heavy metals at trace levels, which can become mobilized during combustion for power generation. Therefore, it is important to accurately quantify these hazardous elements. However, the complex matrix of coal poses challenges for effective digestion using microwave-assisted techniques. Identifying a suitable reagent mixture is thus essential for efficient digestion. The objective of this study was to determine an appropriate reagent mixture for the microwave-assisted digestion of coal to accurately quantify arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), selenium (Se), lead (Pb), zinc (Zn), and mercury (Hg) using ICP-MS. Coal samples were collected from the Lakvijaya Power Station in Norochcholai, Sri Lanka. Approximately 0.1 g of each sample was accurately weighed and subjected to microwave digestion at 230 °C and 9 MPa using three different reagent mixtures: aqua regia, $HNO_3/H_2O_2$, and $HNO_3/H_2O_2$/HCl. Three replicates were conducted for each reagent mixture, and the digested samples were analyzed using ICP-MS. Among the tested mixtures, $HNO_3/H_2O_2$ provided the highest acceptable recoveries for all analyzed elements except Hg, whereas aqua regia yielded the lowest recoveries across all analytes. The $HNO_3/H_2O_2$/HCl mixture, however, achieved satisfactory recoveries, ranging from 74.79±8.07% to 99.53±7.43% for all elements. The findings of this study underscore the importance of selecting an appropriate digestion reagent based on the specific elements of interest. Aqua regia is not recommended for coal digestion due to its poor recovery rates. For the analysis of As, Cd, Cr, Cu, Se, Pb, and Zn, the $HNO_3/H_2O_2$ mixture was the most effective. When simultaneous determination including Hg is required, the $HNO_3/H_2O_2$/HCl mixture is the most suitable.

# Development and validation of a Liquid Chromatography–Tandem Mass Spectrometric (LC-MS/MS) method for the determination of Glyphosate in tea

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## Abstract

Glyphosate, a widely used broad-spectrum herbicide, is frequently applied in agriculture to control weed growth. Due to its extensive use, concerns have arisen regarding its potential residues in food products and their impact on human health and the environment. Tea is the most widely consumed beverage globally, and because of its complex matrix, accurate trace-level quantification of glyphosate requires a highly sensitive and selective analytical method. This study presents the development and validation of a robust Liquid Chromatography–Tandem Mass Spectrometric (LC-MS/MS) method for the determination of glyphosate in tea. Tea samples were extracted with aqueous 1% formic acid, followed by clean-up and dilution. Purified extracts were analyzed by LC-MS/MS. Method validation assessed accuracy, precision, linearity, Limit of Detection (LOD), Limit of Quantification (LOQ), and the potential matrix effects. The method demonstrated excellent linearity ($R^2$ >0.998) over a range of 0.025 to 5 mg/kg. The LOD and LOQ were found to be 0.015 and 0.025 mg/kg, respectively. Precision values expressed as percentage Relative Standard Deviation (RSD%) were below 10%, and recoveries ranged between 103 to 110% with RSD% below 4%. Matrix effects were minimized through matrix-matched calibration, using dilution, and with the Electrospray Ionization (ESI) in the negative ionization mode. The results of tea samples revealed varying glyphosate concentrations, with some samples below the LOQ, indicating either absence or minimal residue levels. In conclusion, the present study emphasizes the suitability of use of the method for monitoring glyphosate in tea, highlighting its effectiveness in routine analysis, regulatory compliance testing, and public health protection.

# Comparative analysis of batik industry wastewater characteristics and treatment using jackfruit peel-based natural coagulant

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## Abstract

Batik industries generate large volumes of wastewater containing high levels of heavy metals, dyes, and suspended solids, which contribute to environmental pollution and health issues. This study compared the physicochemical characteristics of wastewater from two batik industries (Industry A and Industry B) and evaluated the treatment potential of a jackfruit peel-based natural coagulant. Wastewater samples were collected and analyzed for characterization. Jackfruit peels were washed, oven-dried at 150 °C for 10 hours, ground, and sieved using a 0.5 mm sieve. Two grams of jackfruit peel powder were mixed with 100 mL of distilled water, stirred at 120 rpm for 1 hour at 25 °C, and filtered using muslin cloth to prepare a 2% extract. The optimum coagulant dose and coagulation pH were identified through jar tests, using turbidity removal percentage as the response. A comparative analysis of the physicochemical characteristics of batik wastewater from Industry A and Industry B revealed significant variability in pollutant levels due to the variations in production processes, materials used, and the scale of operation. The Industry B generally exhibited higher concentrations of heavy metals such as Cr (0.11 mg/L), Ni (0.06 mg/L), Cu (0.83 mg/L), and Co (0.009 mg/L), compared to relatively low or non-detectable levels in Industry A. The organic pollutant load, represented by Chemical Oxygen Demand (COD), was also markedly higher in Industry B (4338 mg$O_2$/L) than in Industry A (2628 mg$O_2$/L). The wastewater from both industries poses significant environmental risks due to high COD levels. The jackfruit peel-based coagulant was applied to real Batik wastewater obtained from industry B with the initial turbidity of 190 NTU and achieved a maximum turbidity removal of 27.4% at 25–30 °C and pH 8.76. The optimum coagulant dosage was 3 g/L. Therefore, further studies on the application of jackfruit peel coagulant for batik industry wastewater treatment at different pH levels should be conducted to enhance treatment efficiency. This study underscores the dual importance of characterizing industrial effluents and promoting low-cost, biodegradable treatment solutions for sustainable wastewater management in the batik industry.

# Development of a skin whitening serum from *Vateria copallifera* (Retz.) Alston

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## Abstract

Safety concerns associated with synthetic skin-whitening agents have increased interest in plant-based alternatives. *Vateria copallifera* (S. Hal), an endemic Sri Lankan plant, has not yet been studied for its skin-whitening applications. This study investigates its antioxidant and anti-tyrosinase properties with the aim of developing a natural skin-whitening serum. Ethanolic extracts were prepared from the leaves and bark of *V. copallifera*. Total Phenolic Content (TPC) and Total Flavonoid Content (TFC) were quantified using the Folin–Ciocalteu method and aluminum chloride colorimetric method, respectively. Antioxidant activity was evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay, Ferric Reducing Antioxidant Power (FRAP) assay, and Oxygen Radical Absorbance Capacity (ORAC) assay. Skin-whitening potential was assessed via a tyrosinase inhibitory assay. A skin-whitening serum was formulated using the leaf extract along with propylene glycol, sorbitol, shea butter, glyceryl monostearate, cetyl alcohol, stearyl alcohol, glycerine, xanthan gum, ascorbic acid, and phenoxyethanol. The serum was evaluated for its organoleptic properties, pH, peroxide value, and thermal stability. Statistical analyses were performed using SPSS Statistics software, version 27.0 (SPSS Inc., Chicago, USA). Differences in the measured parameters were analyzed using an independent samples *t*-test. The bark extract exhibited a higher TPC (502.27±1.40 mg GAE/g of extract), while the leaf extract showed higher TFC (19.23±1.11 mg QE/g of extract), FRAP (10.70±0.43 mg TE/g of extract), and ORAC (72.72±0.36 mg TE/g of extract) values. The bark extract also demonstrated stronger tyrosinase inhibitory activity ($IC_{50}$: 158.73±4.54 µg/mL) compared to the leaf extract ($IC_{50}$: 240.12±7.37 µg/mL). The formulated serum exhibited a creamy white color, pleasant odor, good spreadability, and high thermal stability, with a pH of 6.96±0.01 and a peroxide value of 7.06±0.04 mEq/kg. Moreover, *V. copallifera* shows promising potential as a natural skin-lightening agent. In conclusion, the formulated serum meets the tested cosmetic quality standards (SLS 743:2021) and offers a viable herbal alternative to synthetic products.

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# Evaluation of anti-inflammatory and antioxidant properties of *Ircinia fasciculata* crude extract

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## Abstract

Marine sponges are frequently screened for their bioactive properties. However, *Ircinia fasciculata* has been poorly studied in this regard. The present study aimed to evaluate the anti-inflammatory and antioxidant properties of the crude extract of *Ircinia fasciculata*. Samples were collected from Unawatuna, Sri Lanka (Department of Wildlife permit no: WL/3/2/76/2023), and identified as *Ircinia fasciculata* through comprehensive morphoanatomical analysis using light microscopy and scanning electron microscopy. The Sponge Crude Extract (SCE) was prepared via maceration using methanol, dichloromethane, and n-hexane as solvents. Anti-inflammatory activity was assessed using the Bovine Serum Albumin (BSA) denaturation assay, as well as heat- and salinity-induced hemolysis assays. Antioxidant activity was evaluated through 2,2-diphenyl-1-picrylhydrazyl (DPPH), peroxide radical, and Nitric Oxide (NO) radical scavenging assays. Diclofenac sodium and aspirin were used as reference drugs for the anti-inflammatory assays, while ascorbic acid served as the reference standard for antioxidant assays. All assays were performed in triplicate, and results were statistically analyzed using one-way ANOVA followed by Dunnett's test and Pearson correlation. The results indicated that the SCE exhibited potent activity against protein denaturation, with an $IC_{50}$ value of 18 µg/mL. The $IC_{50}$ values for heat- and salinity-induced hemolysis were 1172±20 µg/mL and 572±8 µg/mL, respectively, while those for the reference drugs were 184±1 µg/mL for the BSA assay, and 1396±6 µg/mL and 3294±10 µg/mL for heat- and salinity-induced hemolysis, respectively. The SCE also demonstrated moderate antioxidant activity, with $IC_{50}$ values of 904±2 µg/mL (DPPH), 68±2 µg/mL (peroxide radical), and 897±3 µg/mL (NO radical). In comparison, the $IC_{50}$ values for the reference compound (ascorbic acid) were 18±1 µg/mL, 11±1 µg/mL, and 220±2 µg/mL, respectively. The SCE exhibited potent anti-inflammatory activity, surpassing that of the reference drugs, particularly in the protein denaturation assay. However, its antioxidant activity was moderate, possibly due to antagonistic interactions among the compounds present in the crude mixture. Further studies are recommended to isolate and identify the specific compounds responsible for the observed biological effects through bioactivity-guided fractionation.

# Generative artificial intelligence applications in food, herbal, environmental, and industrial technologies: A multidisciplinary analysis

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## Abstract

The generative Artificial Intelligence (AI) is a prominent topic that targets plenty of sectors by creating novel solutions. It provides solutions in food technology, herbal technology, environmental technology and Industrial management in terms of industrial productivity, sustainability and innovation. By using deep learning architectures, including Generative Adversarial Networks (GANs) and Large Language Models (LLMs), generative AI provides the automatic generation of synthetic data, predictive models, and innovative design solutions. This ability is especially useful in places with limited resources, where a lack of data and time makes it hard to do research and development in the usual way. In developing countries like Sri Lanka, where the need for technological transformation is urgent across key industries, generative AI offers an opportunity to accelerate progress in food security, environmental protection, herbal medicine discovery, and industrial efficiency, aligning with national goals for economic resilience and sustainable development. This study presents a multidisciplinary review of generative AI applications in four critical sectors: food technology, herbal technology, environmental technology, and industrial technology. The methodology involved a systematic analysis of research articles, pilot studies, and real-world use cases. In food technology, generative AI has been deployed to optimize food formulation and sensory evaluation, using machine learning models to simulate flavour profiles and nutrient combinations. In herbal technology, AI-generated molecular synthesis and compound mapping have accelerated the identification of bioactive ingredients in traditional medicinal plants, aiding in the development of phytopharmaceuticals. Environmental technology has benefited from AI-based climate modelling, pollution source tracking, and simulation of waste-to-energy processes, allowing for improved policy planning and environmental monitoring. In industrial technology, generative design algorithms have led to optimized manufacturing layouts, predictive maintenance, and energy-efficient system architectures. Collectively, these advancements have demonstrated significant improvements in research speed, operational precision, and sustainability outcomes. In conclusion, generative AI is acting as an innovative accelerator across food, herbal, environmental, and industrial technology sectors by providing data-driven innovative solutions. Although the possibilities are great, each sector faces challenges like lack of data, ethical issues, and missing regulations that need to be solved. This study highlights the importance of establishing national guidelines and interdisciplinary research ecosystems to support responsible AI deployment in Sri Lanka's industrial landscape.

# Standardized Bael fruit extracts loaded alginate nanoparticles as a novel herbal drug lead against glycation and chronic inflammation

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## Abstract

The formation of glycated end products and chronic inflammation play a significant role in the pathogenesis and development of complications associated with diabetes. Loading Bael fruit (*Aegle marmelos* L.; Family: Rutaceae) extracts into an alginate matrix presents a promising strategy for developing a novel herbal nano-drug lead. The successful incorporation of Bael fruit extracts into the alginate matrix was previously confirmed by our research group using various characterization techniques. The present study aimed to standardize Bael fruit extracts and assess the impact of encapsulation on antiglycation and anti-hyaluronidase activities. An aqueous extract was prepared at an initial concentration of 0.06 mg/mL using ultrasonication followed by refluxing. Ethanol, 50% ethanol, and 50% acetone extracts (0.03 mg/mL) were obtained through ultrasonication and concentrated under vacuum using a rotary evaporator. Standardization of Bael fruit extracts was carried out following established protocols. Antiglycation and anti-hyaluronidase activities (to evaluate anti-inflammatory potential) were assessed using in vitro assays. Data were compared with free Bael fruit extracts and analyzed using one-way analysis of variance (ANOVA) followed by Tukey's post hoc test. Proximate analysis revealed moisture content, total ash, acid-insoluble ash, and water-soluble ash values in the ranges of 0.6–1.2%, 2.6–3.5%, 0.05–0.50%, and 0.03–0.85%, respectively. Phytochemical analysis indicated the presence of phenolics, flavonoids, tannins, alkaloids, saponins, steroids, and terpenoids in Bael fruit extracts. Heavy metals, including lead, arsenic, cadmium, and mercury, were not detected. Alginate nanoparticles loaded with aqueous Bael fruit extract demonstrated significantly enhanced antiglycation activity, with a lower $IC_{50}$ value of 0.89±0.14 mg/mL compared to the free extract. Furthermore, aqueous, ethanol, and 50% ethanol Bael fruit extract-loaded alginate nanoparticles significantly inhibited hyaluronidase activity ($p<0.05$) by 19.38%, 0.84%, and 4.07%, respectively. These findings suggest that the well-standardized aqueous extract of Bael fruit, when encapsulated in an alginate matrix, exhibits enhanced antiglycation and anti-hyaluronidase activities, underscoring its potential as a promising nano-herbal drug lead.

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# Activity-guided fractionation and antioxidant profiling of *Pleurotus ostreatus*

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## Abstract

*Pleurotus ostreatus* is a popular edible mushroom, commonly known as the oyster mushroom, found in temperate and subtropical forests around the world. Only a few scientific investigations have explored the antioxidant activity of *Pleurotus ostreatus* cultivated in Sri Lanka. Therefore, the present study evaluated the antioxidant activity, Total Phenolic Content (TPC), and Total Flavonoid Content (TFC) of different solvent fractions of the Acetone Extract (AE) of *Pleurotus ostreatus*. The AE was fractionated by solvent partitioning into four fractions: hexane, Dichloromethane (DCM), Ethyl Acetate (EA), and aqueous. The antioxidant potential of these fractions was assessed using 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) radical scavenging assays, with ascorbic acid and Trolox as respective standards. The TPC and TFC were determined using the Folin–Ciocalteu and aluminum chloride colorimetric methods, respectively. Statistical analysis was performed using one-way ANOVA. Among the four fractions, the aqueous fraction exhibited significantly higher antioxidant activity ($p < 0.05$) (DPPH $IC_{50}$: 142.4 µg/mL; ABTS $IC_{50}$: 226.2 µg/mL), followed by EA and DCM, while the hexane fraction showed the weakest activity (DPPH $IC_{50}$: 491.8 µg/mL; ABTS $IC_{50}$: 481.9 µg/mL). The aqueous fraction also had the highest TPC (42.19±0.48 mg GAE/g), whereas the hexane fraction showed the lowest (30.00±0.08 mg GAE/g) ($p < 0.05$). The highest TFC was observed in the DCM fraction (27.23±0.30 mg QE/g), followed by the aqueous (23.50±0.37 mg QE/g), EA (20.71±0.53 mg QE/g), and hexane (4.71±0.12 mg QE/g) fractions ($p < 0.05$). These findings demonstrate that the polar solvent fractions, particularly aqueous and ethyl acetate, are rich in phenolic compounds and exhibit strong antioxidant activity. This highlights the potential of *P. ostreatus* as a valuable source of natural antioxidants and supports its further investigation in functional food formulations and nutraceutical research.

# Development of a tablet dosage form from *Laghupanchamoola* decoction and evaluation of anti-inflammatory and antioxidant activity of the formulated tablet

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## Abstract

*Laghupanchamoola* decoction is a well-known Ayurveda preparation used for the treatment of asthma, fever, skin diseases, and urinary calculi. It comprises roots of five medicinal plants: *Desmodium gangeticum*, *Aerva lanata*, *Solanum melongena*, *Solanum xanthocarpum*, and *Tribulus terrestris*. This study aimed to develop a tablet dosage form of the decoction and evaluate its anti-inflammatory and antioxidant activities. Tablets were formulated using the dry granulation (slugging) method. Each tablet contained 522.5 mg of freeze-dried decoction powder, along with lactose (filler), carboxymethylcellulose (disintegrant), maize starch (binder), magnesium stearate (lubricant), and talc (anti-adherent). Anti-inflammatory activity was assessed using the protein denaturation inhibition assay and the heat-induced hemolysis assay, with diclofenac sodium serving as the reference standard. Antioxidant activity was evaluated using the DPPH assay, with ascorbic acid as the standard. A one-way ANOVA was used for statistical analysis. Standard tablet evaluation tests were conducted, including assessments of weight variation, hardness, friability, thickness, diameter, and disintegration time. In the protein denaturation inhibition assay, the $IC_{50}$ values were 744.8±0.3 µg/mL for diclofenac sodium, 882.8±0.8 µg/mL for the decoction, and 891.9±0.4 µg/mL for the formulated tablet. Statistical analysis indicated no significant difference between the anti-inflammatory potency of the decoction and the tablet compared to diclofenac sodium ($p>0.05$). In the heat-induced hemolysis assay, the $IC_{50}$ values were 937.2±0.7 µg/mL for diclofenac sodium, 1053.0±0.6 µg/mL for the decoction, and 1191.0±0.2 µg/mL for the tablet. While the decoction showed no significant difference in anti-inflammatory activity compared to diclofenac sodium ($p>0.05$), the tablet exhibited a statistically significant difference ($p<0.05$). In the antioxidant assay, the $IC_{50}$ values were 9.0±0.0 µg/mL for ascorbic acid, 665.1±0.5 µg/mL for the decoction, and 747.7±0.5 µg/mL for the tablet, with both the decoction and the tablet being significantly less potent than ascorbic acid ($p<0.05$). The physical evaluation of the formulated tablet revealed that it was dark brown in color, with uniform weight variation, a hardness of 42.6 N, a thickness of 6 mm, a diameter of 13.6 mm, friability of 0.748%, and a disintegration time of 31 minutes and 5 seconds. Overall, the *Laghupanchamoola* tablet formulation exhibited comparable anti-inflammatory and antioxidant activities to the original decoction, suggesting its potential as an effective and convenient alternative dosage form without compromising therapeutic efficacy.

# Investigation of the efficacy of *Lawsonia inermis* L. leaves decoction on diabetic neuritis management

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## Abstract

Diabetic neuropathy most often affects nerves in the lower rather than the upper extremities. Around 60–70% of individuals with Diabetes Mellitus (DM) have some form of nerve damage. In the Siddha system, diabetic neuropathy is referred to as *Azhal Vaatham*. A decoction of *L. inermis* leaves is traditionally used to manage diabetic neuropathic symptoms in both the upper and lower extremities. The objective of the present study was to investigate the efficacy of *L. inermis* leaf decoction in the management of diabetic neuritis. Forty-five patients were selected from the Outpatient Department and the Diabetic, Geriatric, and Locomotor Disease Clinics at the Rural Siddha Hospital, Thalvupadu, Mannar. Data were collected through patient interviews. For assessment, subjective parameters such as burning sensation and numbness were recorded for each patient after one month of treatment. At the end of the study, results showed improvement in both burning sensation (marked improvement: 15.4%, moderate improvement: 38.5%) and numbness (marked improvement: 7.7%, moderate improvement: 15.4%). Chromatographic spectrum analysis revealed the presence of lawsone, esculetin, and fraxetin in *L. inermis* leaves. Furthermore, the anti-inflammatory, dermatological illness-curing, anticoagulant, and analgesic properties of *L. inermis* leaves are likely to contribute to their effectiveness in the management of neuritis.

# Quality assessment of a traditional herbal decoction: *Rasnadvigunabhagasaya Kashaya* used for Knee Osteoarthritis

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## Abstract

*Rasnadvigunabhagasaya* (RDB) *Kashaya* is well known among Sri Lankan traditional medical practitioners in liquid form due to its vast benefits on joint-related disorders, and it is one of the popular internal medicaments in India and Sri Lanka for Knee Osteoarthritis (KOA). RDB *Kashaya* consists of 26 medicinal plants. To date, no scientific experiments have been carried out to assess the quality of RDB *Kashaya* according to the Sri Lankan Traditional Medical preparation method. Therefore, an attempt was made to evaluate the quality of the RDB *Kashaya* in terms of (a) phytochemical analysis, (b) microbial limits, (c) heavy metal limits, and (e) development of Thin Layer Chromatography (TLC) fingerprints using standard protocols. The TLC fingerprint profile was developed using dichloromethane, ethyl acetate, and cyclohexane in a ratio of 3:0.5:1.5 v/v. The plate was visualized under Ultraviolet (UV) radiation (both 254 nm and 366 nm), a TLC fingerprint pattern was observed, and the $R_f$ value for each spot was calculated. Results revealed that phenols, flavonoids, tannins, alkaloids, saponins, steroids, terpenoids, monoterpenes and sesquiterpenes were present in the RDB *Kashaya*. Micro-organisms (such as Mesophilic bacteria, *Staphylococcus aureus, Pseudomonas aeruginosa* and *Escherichia coli*) and heavy metals (such as Hg, As, Cd and Pb) were not detected in the RDB *Kashaya*. In conclusion, present data can be utilized as a quality control and quality assurance reference standard for the RDB *Kashaya* in the future.

# Development of a mushroom-based nutritious vegan food

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## Abstract

Commercially cultivated mushrooms and medicinal mushrooms such as Ganoderma (*Ganoderma lucidum)* offer rich nutrients and health benefits. The objective of this study was to develop button-shaped ready-to-cook mushroom products with enhanced texture and nutritional value using American Oyster (*Pleurotus ostreatus),* Abalone (*Pleurotus cystidiosus*) and Ganoderma (*Ganoderma lucidum*). Formulations were prepared by finely blending Oyster mushroom alone, Oyster and Abalone mushrooms, corn flour and a mixture of spices and button-shaped products were developed. Formulas of Oyster and Abalone mushrooms were optimized with three ratios of Ganoderma mushroom powder and a new button-shaped product was developed, which contained 0.75 g of Ganoderma mushroom powder. Products were packed in nylon LDP packages, sterilized and stored at -18˚C temperature. Samples were analyzed for their moisture content, water activity, and pH, ash fiber, fat and protein contents following AOAC methods (n=3). Results showed that the Oyster and Abalone combination showed the highest overall acceptability. Low hardness of Ganoderma mushroom powder incorporated product (2.59±0.27%) indicated enhanced textural quality. Protein content of the product developed by Oyster mushroom and Abalone mushroom was significantly ($P<0.05$) lower (4.58±0.99%) compared to Oyster, Abalone and Ganoderma mushroom (14.93±1.37%). Antioxidant activity analysis revealed comparable Total Phenolic Content (TPC) between the improved formulation (41.17±0.52 mg gallic acid equivalents/g) and the control (40.26±0.68 mg gallic acid equivalents/g), with no significant difference ($P>0.05$). Further, 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity showed no significant difference ($P>0.05$) between the best formulation (13.76±0.71 mg TE/g) and Oyster and Abalone Combination (13.44±0.76 mg TE/g). Moreover, Oyster, Abalone and Ganoderma combination showed high nutritional, functional, as well as sensory properties.

# Initiatives for food adhesives based on local natural materials

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## Abstract

Currently, Polyvinyl Alcohol and Polyvinyl Acetate (PVA) based adhesives, which are food-safe, biodegradable and synthetically produced, are dominating the adhesive market. The study aims to assess the potential of Cashew Exudate (CE) gum and Cassava Starch (CS) in developing organic-based, locally available alternatives for synthetic food adhesives. Under this, utilizing Borax as a bond strengthener, which improves the bond strengths and Zinc oxide as a stabilizer, which stabilizes the final formulation, and to comparatively analyze their characteristics with commercially available adhesives. The formulated adhesives were evaluated through physical testing for their viscosity, pH, shelf stability, drying time, tensile strength and bond permanency as the principal characteristics of an adhesive. Both developed adhesive samples exhibited an increasing trend for both pH and viscosity upon the increment of Borax content. Additionally, in the process of drying time adjustment of CE-based adhesive by the addition of different ratios of ethanol as solvent, considering both drying time and tackiness, 20% ethanol was used as the ideal ratio. Through the tensile strength analysis, it is of the CS-based adhesive: 0.12±0.03 N/mm$^2$ was significantly higher ($p<0.05$) than that of the CE-based adhesive, which is 0.10±0.02 N/mm$^2$, while material damage was observed in the PVA-based adhesive, indicating that it has comparatively better adhesive properties. Additionally, bond permanency is significantly higher ($p<0.05$) in CS-based adhesive, while it is significantly lower in CE-based adhesive. Solubility of CE-based adhesive was calculated to range between 0.59±0.08% and 0.49±0.06% according to the galactose content in the initial cashew exudate used. Though CS-based adhesive has a high tensile strength and high bond permanency, it was not shelf stable, exhibiting layer separation and aggregation due to starch retrogradation, while CE-based adhesive was shelf stable. Overall, the results indicate that both materials have the potential to be developed into food adhesives through chemical modifications by incorporating alternative bond-strengthening and humectants to improve the adhesive strength and stability of the adhesives, respectively.

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# Poster Presentations

# Rapid determination of free fatty acids in coconut oil using Fourier Transform Near Infrared Spectroscopy (FT-NIRS)

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## Abstract

The conventional method for determining Free Fatty Acids (FFAs) in coconut oil is time-consuming, requiring numerous chemicals and incurring high consumable costs. As an alternative, a Fourier Transform Near-Infrared Spectroscopic (FT-NIR) model was developed as a rapid and cost-effective method for FFA quantification. Thirty coconut oil samples were analyzed using the Thermo Scientific Antaris II FT-NIR Spectrophotometer, and spectra for each sample were obtained in the 4000–10,000 $cm^{-1}$ range using OMNIC software. A Partial Least Squares (PLS) model was developed using TQ Analyst software, incorporating FFA values obtained via the titrimetric reference method (SLS 313: Part 2/Section 6:2009) against the corresponding spectra. After model optimization, a graph of predicted versus actual FFA values was plotted. Cross-validation was performed using the leave-one-out method. The spectral region from 4923.38 $cm^{-1}$ to 4576.25 $cm^{-1}$ was selected for model development. The correlation coefficient ($R^2$) of the predicted versus actual values was 0.9990, with a Root Mean Square Error (RMSE) of 0.0511. The model results closely matched those obtained by the titration method, confirming its accuracy. The developed FT-NIR model can predict FFA content in unknown samples with an accuracy of ±0.03. As a secondary analytical method, it relies on the titrimetric reference method for calibration. Due to the typically low FFA levels in coconut oil, even minor discrepancies between actual and predicted values can significantly impact accuracy. In conclusion, this study successfully developed an FT-NIR model using the partial least squares method for the rapid determination of free fatty acids in coconut oil.

# Rapid determination of oil content in desiccated coconut using Fourier Transform Near Infrared Spectroscopy (FT-NIRS)

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## Abstract

Sri Lanka is the birthplace of the Desiccated Coconut (DC) industry, with a production potential of 60,000 tons per annum. Ensuring high-quality DC production requires robust quality control measures. The key quality parameters for DC include oil content, moisture content, and fat content. According to SLS 98:2021, oil content plays a critical role in quality assessment. The most commonly used method for determining oil content is the AOAC 948.22, a chemical-based technique involving Soxhlet solvent extraction. However, this method has several limitations, including being time-consuming, costly, and leaving chemical residues that may pose health risks. This study developed a method to quantify oil content in desiccated coconut using Fourier Transform Near Infrared (FT-NIR) Spectroscopy in combination with a Partial Least Squares (PLS) model. Ten samples were used to develop the NIR method. Spectra were obtained using a Thermo Scientific FT-NIR instrument in the 10,000 to 4,000 $cm^{-1}$ range at 4 $cm^{-1}$ resolution, utilizing an integrating sphere module. Each sample was analyzed in triplicate. The PLS model was built by correlating NIR spectra with corresponding wet chemical analysis results. The model was validated using leave-one-out cross-validation. Oil content in unknown samples was then quantified using the developed FT-NIR method, alongside simultaneous analysis using AOAC 948.22. The wet chemical results were used to assess the correlation with predicted values from the PLS model. Calibration was performed in the 7,400 to 4,200 $cm^{-1}$ spectral range, where significant spectral variations associated with combination and first overtones of CH, $CH_2$, and $CH_3$ groups were observed. The PLS model achieved a correlation coefficient ($R^2$) of 0.9555 and a Root Mean Square Error (RMSE) of 0.937. The model showed that oil content in unknown samples could be predicted with an error margin of ±0.89. The predicted oil content values for DC samples showed strong agreement with wet chemical analysis results. In conclusion, the FT-NIR spectroscopy-based method offers a rapid, cost-effective, and environmentally friendly alternative to traditional wet chemical methods for determining oil content in desiccated coconut.

# Challenges in establishing geo-indication for Sri Lankan black tea in terms of chemical characterization approach

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## Abstract

Tea is a highly demanded, internationally traded commodity that significantly contributes to the Sri Lankan economy. Ceylon tea, renowned for its distinctive organoleptic properties, commands a premium price in global markets. However, this high value also makes it highly susceptible to fraud, threatening the international reputation of the Ceylon tea brand. To ensure the sustainability of the Ceylon tea industry, the authentication of tea origin is essential. Geographical Indication (GI) is a globally recognized method for authenticating agro-products such as tea. Among the available methods, chemical characterization-based GI is a scientifically robust approach, as traditional sensory evaluation is more prone to subjectivity and bias. Key strategies in geographical origin determination include analyzing the chemical composition, elemental signatures, and stable isotope ratios. Ceylon black tea exhibits considerable diversity due to variations in geographical origin, agricultural practices, seasonal changes, and manufacturing processes. These factors complicate the sampling process and necessitate a larger number of samples and more frequent sampling to ensure accurate analysis. The compounds responsible for tea's aroma and flavor pose additional challenges, as they are highly sensitive to time, storage conditions, and delayed analysis. Therefore, advanced storage techniques are required to preserve these analytes, along with immediate access to high-tech analytical facilities for chemical composition, elemental, and isotopic analysis. Furthermore, interpreting the resulting data requires specialized knowledge and dedicated software, as multiple variables must be considered in these studies. These complexities contribute to the high cost of analysis, which remains a significant limitation. Due to the wide range of influencing factors, implementing GI through chemical characterization is inherently challenging. Nevertheless, efforts to authenticate Ceylon tea using chemical characterization are crucial for protecting its international reputation, ensuring the industry's long-term sustainability, and strengthening the Sri Lankan economy.

# Optimization of drying conditions for selected green leaves and flowers using different drying technologies

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## Abstract

Understanding the drying kinetics of flowers and green leaves is crucial for Sri Lanka's export industry, as it ensures optimal quality preservation, extends shelf life, and enhances competitiveness in international markets. This study aimed to optimize three drying methods including Hot Air drying (HA), Heat Pump drying (HP), and Vacuum Drying (VD) for selected green leaves and flowers, providing valuable data to support investment decisions for start-up businesses and planning for the commercial export of dehydrated products. Gotukola (*Centella asiatica*, GT) and Katurumurunga (*Sesbania grandiflora*, KT) were selected as the green leaf samples, while blue pea (*Clitoria ternatea*, BP) and marigold (*Tagetes erecta* L., MG) were chosen as the flower samples. HA, HP, and VD were applied at temperatures ranging from 50 °C to 75 °C until the moisture content fell below 10%. Moisture reduction over time, color difference (ΔE), Rehydration Ratio (RR), Total Phenolic Content (TPC), and Total Flavonoid Content (TFC) were analyzed. VD achieved the shortest drying time across all temperatures, while HP required the longest. The lowest ΔE values were recorded in VD for both GT and KT leaves, retaining 2.89±0.02 and 6.09±0.61 respectively, at 75 °C. For BP flowers, the lowest ΔE was 13.34±0.52 (VD, 65 °C), while the best color retention for MG flowers (ΔE = 0.96±0.85) was observed in HP at 50 °C. The highest RR for GT leaves (9.28±0.34) was obtained using HP at 60 °C, whereas KT leaves showed the highest RR (5.85±0.78) in HA drying. VD at 75 °C produced the highest RR for both BP and MG flowers. In green leaves, the highest TPC retention for GT (41.10±1.20) was achieved with VD at 70 °C, while for flowers, the highest TPC retention (133.11±0.42) was also found in VD at 75 °C. The highest TFC retention was recorded in GT leaves and MG flowers. In conclusion, the drying rate depends on both the method and the commodity. Increasing the drying temperature reduced the drying time. Overall, VD yielded the lowest ΔE values, while HP achieved the highest RR. Retention of TPC and TFC varied according to the drying temperature and the product type.

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# Blended coffee formulas with mushroom waste

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## Abstract

Mushroom blended coffee combines roasted coffee with medicinal mushrooms such as Reishi or Lion's Mane to enhance flavor, reduce caffeine content, and provide additional health benefits. The present study aimed to develop a novel functional beverage using roasted coffee with *Agaricus bisporus* (Button mushroom), *Pleurotus ostreatus* (Oyster mushroom), and *P. ostreatus* stems (considered agricultural waste sourced from commercial mushroom farms). Samples were prepared by mixing coffee and mushrooms at a 1:1 (w/w) ratio. Three formulations were developed with Button Mushroom (BUTM), Oyster Mushroom (OYSM), and Oyster Mushroom Stem (OYSTM), which were extracted with 70% ethanol at a 1:10 (w/v) ratio. Antioxidant properties, including Total Polyphenolic Content (TPC), Total Flavonoid Content (TFC), and antioxidant activities (DPPH, ABTS, and FRAP) were evaluated using a 96-well microplate-based (n=4) technique. Statistical analysis was conducted using ANOVA and the Minitab software. The coffee brew [22.90±0.29 mg Gallic acid equivalent (GE)/g of sample for TPC, 0.67±0.02 mg Quercetin equivalent (QE)/g of sample for TFC, 47.32±0.16 mg Trolox equivalent (TE)/g of sample for DPPH, 77.46±0.19 mg TE/g of sample for ABTS, 28.59±0.67 mg TE/g of sample for FRAP], which serve as the control also exhibited antioxidant activity. However, the three coffee mixtures made by BUTM, OYSM and OYSTM showed significant ($p<0.05$) differences compared to the coffee brew. Moreover, significant differences were not observed ($p\geq0.05$) between Oyster Mushroom and Oyster Mushroom Stem in terms of antioxidant activities. In conclusion, the present study suggests there is a possibility of formulating functional beverages using waste products in the mushroom industry.

Acknowledgement: Financial assistance by Treasury Research Grant (TG 24/228)

# Method Validation of ISO 10727:2002 for Caffeine Determination in Ceylon Black Tea (*Camellia sinensis* (L.) O. Kuntze) in Sri Lanka

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## Abstract

Caffeine, denoting a major methylxanthine alkaloid compound in tea brew, contributes to the major flavor attribute and a critical quality indicator of tea liquor. The current study has focused on validating the method of ISO 10727:2002 to guarantee method linearity, working range, precision, accuracy, Limit of Detection (LOD), and Limit of Quantification (LOQ). The selected method emphasizes an approach for the quantification of caffeine content in caffeinated and decaffeinated black tea by High Performance Liquid Chromatography (HPLC) with a Diode Array Detector (DAD). The analysis was performed on a C18 column with detection at 272 nm under the mobile phase: methanol and water in isocratic elution of 1.0 mL/min. Major results of the method validation parameters: linearity accounting for a coefficient of determination ($R^2$) of 0.9996, showing an excellent linearity while working across the range of 2-500 mg/kg concentration for the caffeine standard. Precision was calculated on repeatability (intra-day) and reproducibility (inter-day), expressed as Relative Standard Deviation (RSD). Analysis was performed at three concentration levels: 10, 200, and 500 mg/kg by covering low, medium, and high points of the working range. The repeatability results (%RSD) were 3.01, 1.55, and 1.85, and the corresponding reproducibility (%RSDR) values were 2.01, 2.23, and 1.81, respectively, for 10, 200, and 500 mg/kg. Recovery levels were recorded as 99.6%, 97.8%, and 99.6% respectively, for 10, 200, and 500 mg/kg, within the acceptable accuracy range. Both LOD and LOQ values were recorded as 300 mg/kg, establishing method sensitivity. In conclusion, the validated HPLC method offers a simple, reliable, and cost-effective approach for accurately determining caffeine content in black tea with minimal variability, making it suitable for industrial use in the Ceylon tea market. A future comparative study is planned to evaluate this method against the existing ISO 14502-2:2005 method for both caffeinated and decaffeinated black tea.

# *In vitro* Cholinesterase Inhibition Activity of Selected Chili Varieties Grown in Sri Lanka and Qualitative Evaluation of Capsaicin by High Performance Liquid Chromatography (HPLC)

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## Abstract

Chili peppers are widely consumed for their pungency, as used in flavoring food, and have many pharmaceutical and medicinal properties. Chili pepper is an important source of bioactive compounds with antioxidant activity, such as vitamin C, vitamin E, carotenoids, phenolic compounds, and alkaloids. The aim of the present study is to determine the *in vitro* cholinesterase inhibitory activity of seven selected chili varieties, including green chili (*C. annuum*), Bird pepper (*C. frutescens*), Capsicum hot pepper (*C. frutescens L.*), Purple chili pepper (*C. annuum*), White chili pepper (*C. annuum*), White small chili pepper (*C. annuum*), and Hot pepper (*C. chinense*), grown in Sri Lanka. The ethanol extracts of *Capsicum annuum, Capsicum chinense,* and *Capsicum frutescens* were subjected to determine the capsaicin content. Cholinesterase inhibition was evaluated by modified Ellman's assay, using the enzymes acetylcholinesterase (AChE) and butyrylcholinesterase (BChE). Extracts were tested at a concentration of 5000 µg/mL spectrophotometrically at 412 nm wavelength using a microplate reader. HPLC analysis was performed to compare capsaicin content in ethanol extracts of chili fruits at the concentration of 500 µg/mL, using a C18 column (250 mm × 4.6 mm × 5 µm) at 280 nm wavelength. Among the tested varieties, the highest AChE inhibition (51.26±1.42%) was recorded for *Capsicum frutescens* L, while *Capsicum annuum* exhibited the lowest (6.05±0.87 %) inhibition activity. *Capsicum annuum* showed the highest BChE inhibition, with the percentage inhibition 16.73±1.45%, where *Capsicum chinense* demonstrated the lowest inhibition (0.51±0.21%). Both AChE and BChE inhibitory activities were in a dose-dependent manner. With the recorded literature, a consistent peak between 3.05–3.35 minutes was identified as the putative capsaicin peak. The results of the present study prove that bioactive compounds such as capsaicin in chili pepper might function as anti-cholinesterase agents, since these compounds have been previously reported to be capable of effectively inhibiting cholinesterase enzymes *in vitro*.

# Assessment of vacuum and tray drying methods of *Moringa oleifera* Lam. leaves

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## Abstract

Tray dryers and vacuum dryers are two of the most popular drying technologies because of their adaptability and capacity to process a variety of materials. *M. oleifera* is a highly valuable plant that has both nutritional and therapeutic benefits. Choosing an appropriate drying technique has significant effects on energy consumption, operational effectiveness and product quality. Fresh and healthy *M. oleifera* leaves were dried using a vacuum dryer and tray dryer at 40 ˚C and the moisture content of the dried samples was analyzed using the oven drying method and the results were subjected to statistical analysis of mean, standard deviation and analysis of variance using Minitab 18. Values were considered significant at $p<0.05$. A sensory evaluation was conducted to compare the properties of the two leaf samples according to the simple difference version of the paired comparison test (ISO 5495:2005/Amd1:2016). The test parameters were appearance, colour, odour, texture, taste and overall acceptability. Results were tabulated and statistically analyzed according to the methods provided in ISO 5495. The efficiency of the equipment was determined by calculating the total power consumption of the equipment for the drying process. Moringa leaves were identified as dried after 5 hours, while the vacuum drier took 8 hours. Moisture content of vacuum-dried and tray-dried samples was 3.7±0.6% and 6.8±0.6% respectively. No significant difference between the two leaf samples according to the moisture content analysis and parameters tested at the sensory evaluation. Power consumption for vacuum drying was 146 kWh and for tray drying was 50 kWh. There was no significant difference between drying methods, but tray drying can be identified as the most effective method in terms of efficiency. Nutritional analysis of dried samples will be done in further studies.

# Assessment of physicochemical characteristics of extracted Ceylon Vetiver root essential oil from different locations of Sri Lanka and development of a perfume

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## Abstract

Vetiver (*Chrysopogon zizanioides* L.) is a highly valued aromatic grass renowned for its essential oil, widely used in the perfumery industry for its distinctive woody, earthy, and long-lasting aroma. This study evaluates the physicochemical properties of Vetiver essential oil extracted from roots collected from three regions in Sri Lanka: Awissawella, Galle, and Mahaoya. The oils were extracted via hydro-distillation using a Clevenger apparatus. Physical properties such as moisture content, specific gravity, refractive index, and pH were analyzed. The chemical composition was determined using Gas Chromatography-Mass Spectrometry (GC-MS). The best Vetiver oil was selected for perfume formulation, incorporating top, middle, and Vetiver base notes. Quality control parameters, including pH, allergy testing, and stability testing, were conducted following standard procedures. The highest oil yield (1.9%) was obtained from Galle, followed by Mahaoya (1.2%) and Awissawella (1.1%). Moisture content and oil profiles varied among the three locations. Major constituents identified in the oil included Khusimol, Khusimone, Vetiselinenol, Isovalencenol, and α-Vetivone. Specific gravity ranged from 1.52±0.00 to 1.50±0.01, while refractive index values ranged from 0.94±0.00 to 1.02±0.00, aligning with standard parameters for high-quality Vetiver oil. Vetiver essential oil from Galle was selected as the most suitable for future perfume development. In conclusion, 108 volatile compounds were identified in Ceylon Vetiver, with both chemical and physical profiles differing according to the geographical origin of the roots.

# *Anisomeles indica* L.: Medicinal role in indigenous healing practices of Sri Lanka

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## Abstract

*Anisomeles indica* L. (AI), locally known as *Yakawanassa*, belongs to the family Lamiaceae and is native to Sri Lanka. Medicinal plants hold a vital place in the country's Indigenous health system. *Thalpathe Piliyam* (TP) is a 22-volume series of Sri Lankan Indigenous Medical texts. This study aimed to compile literary evidence supporting the use of AI in Sri Lankan Indigenous Medicine, addressing the limited documentation on its therapeutic applications. Such knowledge is a crucial foundation for further scientific evaluation and promoting the wider use of indigenous medicinal plants in Sri Lanka. The study employed the Qualitative Document Analysis Method to review 21 volumes of TP (the 22nd volume, written in Tamil, was excluded). A coding scheme was developed to identify formulas containing the keywords "*Yakawanassa*" and its synonyms "*Wanassa*," "*Yakwanasu*," and "*Yakuhanassa*." The dosage forms and associated diseases mentioned in these formulas were then analyzed to determine the therapeutic uses of AI. A total of 360 formulas containing AI were identified: 121 for external use, 174 for internal use, 44 for both, 13 unspecified, and 8 for veterinary applications. External dosage forms included *taila*, *lēpa*, *mellum*, *guli*, *vedu*, *roti*, medicated water, *Anjana*, *purawaliyam*, *swarasa*, and *pottani*. Internal dosage forms included *kenda*, *kaşāya*, *kāyama*, *guli*, *taila*, *anupāna*, *kalka*, *arakku*, *yuşa*, and *basna*. Commonly treated conditions were *sanni*, *kōla*, *rata*, *sarpa vişa*, *gadu*, *odu*, *yaksha roga*, and *una*, recorded in all 21 volumes. In conclusion, AI is a widely used medicinal plant in Sri Lankan Indigenous Medicine for managing a variety of human and animal diseases affecting multiple body systems. Its inclusion in numerous internal and external dosage forms highlights its versatility and significance in traditional healing practices.

# A Literature Review of *Pandu* (Anemia) in Siddha Medicine

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## Abstract

Siddha medicine is one of the traditional medicinal systems in Sri Lanka, particularly popular in the Northern and Eastern Provinces. Literature on Siddha medicine describes 4,448 diseases that can affect humans. *Vath*a, *Pitha*, and *Kapham* are the three fundamental doshas in Ayurveda and traditional medicine, with each person having a unique balance of these elements; health is defined by maintaining this equilibrium. In a healthy body, the ideal ratio of *Vatha*, *Pitha* and *Kapham* is considered to be 1:1/2:1/4, respectively. This balance can be disrupted by unhealthy food habits and behaviors, leading to diseases. *Pandu* is identified as a distinct disease in Siddha medicine, and the present literature review aims to compile scattered information regarding its synonyms, causes, symptoms, and types. The review was conducted using resources from the Faculty of Siddha Medicine, University of Jaffna, and the main library of the Jaffna Municipal Council, identifying nine relevant texts. Of these, five (55.5%) mentioned the causes of *Pandu*, and all nine categorized its types based on doshas. Two books (22.2%) mentioned synonyms for *Pandu*, and five (55.5%) identified improper habits and behaviors as key causes. Additionally, five books noted fatigue as a primary symptom. In addition, eight (88.8%) books described five types of *Pandu*. Moreover, *Thanvandhiri Vaithiyam* listed seven types of *Pandu.* In conclusion, the review identified 13 types of *Pandu* and 15 causes for *Pandu.* In conclusion, the main cause of *Pandu* is improper behaviors and unhealthy dietary habits.

# Development and *in vitro* characterization of salbutamol sulphate loaded resealed erythrocytes

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## Abstract

Erythrocytes can be employed as biocompatible, non-pathogenic natural drug carriers and represent a novel drug delivery system with the potential for extended drug release. This study aimed to introduce salbutamol sulphate into intact human erythrocytes and to characterize these cells in vitro. Whole blood was collected from healthy human participants under aseptic conditions and centrifuged to separate the red blood cells. The separated erythrocytes were washed three times with normal saline. Pharmaceutical-grade salbutamol sulphate (99.56%) was loaded into the cells using a modified hypotonic pre-swelling method, and in vitro characterization of the loaded cells was performed in comparison to normal erythrocytes. The drug loading efficiency of the method was assessed by Ultraviolet (UV) spectrophotometry at the wavelength of 276 nm, revealing a loading efficiency of 35%. Optical microscopy of the loaded cells showed moderate morphological changes, including mild swelling and slightly roughened surfaces. The drug-loaded erythrocytes were slightly more fragile than the normal cells. Additionally, the loaded cells exhibited a higher Erythrocyte Sedimentation Rate (ESR: 22 mm/hour) compared to normal erythrocytes (15 mm/hour). These observations are consistent with previously reported data on resealed erythrocytes. The present study demonstrates that resealed erythrocytes can serve as promising carriers for salbutamol sulphate, with moderate alterations to their properties. Their increased fragility may facilitate targeted delivery to the reticuloendothelial system organs. Furthermore, stabilization techniques such as coating with polyethylene glycol or cholesterol enrichment may improve longevity and sustained drug release of loaded erythrocytes.

# Exploring the Antimicrobial Potential and their mechanisms in *Berberis aristata* DC and *Coscinium fenestratum (Gaertn.) Colebr.*: A Comparative Systematic Review

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## Abstract

In Ayurveda, *Berberis aristata* and *Coscinium fenestratum* are pharmacologically recognized as sources of Dāru Haridrā, a revered antimicrobial herb. While *B. aristata* is predominant in Indian traditions, *C. fenestratum* is widely used in Sri Lanka due to its ecological adaptability. Both species contain berberine and other bioactive alkaloids with broad-spectrum antimicrobial potential. This systematic review aimed to compare their antimicrobial efficacy and elucidate their molecular mechanisms against pathogenic bacteria. A comprehensive literature search was conducted in PubMed, Scopus, Web of Science, and Google Scholar for articles published between 2000 and 2025. Search terms included "berberine," "*Berberis aristata*," "*Coscinium fenestratum*," and "antimicrobial mechanisms." Following PRISMA guidelines, 1,695 articles were screened, and 1,380 remained after deduplication. A total of 69 studies were included after full-text assessment. Only original research focusing on bacterial models and mechanistic insights was considered. Berberine, isolated from both plants, demonstrated multi-target antimicrobial activity. In 86% of the studies, significant inhibition of efflux pumps (NorA, MepA, AcrAB-TolC) was observed, resulting in increased intracellular antibiotic retention. Several studies also confirmed membrane destabilization, evidenced by lipid peroxidation markers and Scanning Electron Microscopy (SEM) analysis. Approximately 61% of the studies reported enzyme-level disruptions, particularly in the shikimate pathway, folate biosynthesis (via DHFR inhibition), and DNA gyrase activity. In silico docking studies revealed high binding affinities for berberine and palmatine (–9.2 to –11.5 kcal/mol) with bacterial enzyme targets. Notably, *B. aristata* showed a higher berberine concentration (1.8–2.4%) compared to *C. fenestratum* (1.2–1.6%), although both exhibited comparable minimum inhibitory concentration values (6.25–50 µg/mL) against *S. aureus*, *E. coli*, and *P.aeruginosa*. Synergistic effects were reported in 47% of the studies when berberine was combined with β-lactams or fluoroquinolones. Despite chemotypic differences, both herbs share similar pharmacodynamic profiles, supporting their interchangeable use in Ayurvedic practice. This review affirms the strong, multimodal antimicrobial potential of *B. aristata* and *C. fenestratum*. Their comparable efficacy and diverse molecular targets highlight their promise as phytopharmaceutical leads against multidrug-resistant bacteria. However, the review is limited by heterogeneity in extraction methods and the lack of standardized protocols. Further clinical trials are needed to scientifically validate their efficacy.

# Makandawa and Sinharaja Forest Reserves of Sri Lanka: A natural habitat for industrially important novel fungal strains

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## Abstract

Sri Lanka is rich in biological diversity, but its fungal diversity is not adequately studied and documented. Recent fungal diversity estimations have predicted that the tropical regions would harbor a large number of novel fungal species. Filamentous fungi are highly efficient microorganisms widely used in industry due to their versatility in producing enzymes, proteins, pigments, and other valuable compounds. The application of filamentous fungi in food production is one of the sustainable approaches. This study focused on isolating and identifying novel strains of filamentous fungi from selected forest reserves of Sri Lanka, Makandawa and Sinharaja, based on environmental and soil temperature. Soil samples were collected from pre-determined locations, followed by the dilution plate technique and purification process, which was done to isolate soil fungi from their existing soil habitats. Morphological identification was carried out through extensive microscopic study, and isolates with distinct morphologies were subjected to molecular-level identification. Out of the 146 total isolates, 41 morphologically unique isolates were subjected to their gene sequencing using ITS 5 (TCCGTAGGTGAACCTGCGG) and ITS 4 (TCCTCCGCTTATTGATATGC) forward and reverse primers, respectively. The Basic Local Alignment Search Tool provided aligned homologous sequences of fungi from GenBank databases through the National Center for Biotechnology Information. Deoxyribonucleic Acid (DNA) sequences of novel fungal strains were deposited in GenBank accession numbers were received, and their phylogenetic relationship was established. Out of 43 newly isolated fungal strains, *Talaromyces albobiverticillius* PQ616019, *Trichoderma harzianum* PQ665276, *Trichoderma reesei* OW985639.1, *Aspergillus aculeatinus* OR600167.1, and *Aspergillus japonicus* KY199566.1 are the organisms with applications in the food industry isolated during this study. The rest of the strains were found to be important as biopesticides and biofertilizers, thereby elucidating the biodiversity of selected sample locations. In Sri Lanka, currently, a national culture collection for fungi does not exist. Findings of this study contributed to the ongoing industrially important fungal culture collection development at ITI and highlighted the availability of native microbiota in forest reserves of Sri Lanka and their potential industrial applications.

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# Soil Organic Carbon (SOC) in Sri Lankan mangroves: A key driver of carbon sequestration in coastal blue carbon systems

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## Abstract

Mangrove Ecosystems (MEs) are primarily found in coastal environments characterized by estuaries and lagoons. These ecosystems play a key role in the global carbon cycle by acting as powerful carbon sinks through the accumulation of Soil Organic Carbon (SOC). In Sri Lanka, the carbon sequestration potential of major MEs in the Southern and South-Western regions has been studied. However, the MEs in the Northern and North-Eastern regions remain largely unexplored. This study evaluates SOC levels in mangroves from Jaffna, Batticaloa, Lanka Patuna, Pulmudai, and Kokilai. The organic carbon content of the soil samples (0–15 cm depth) was analyzed using the dry combustion method. Total SOC stocks and equivalent amount of carbon dioxide content of Jaffna, Batticaloa, Lanka Patuna, Pulmudai, and Kokilai were 634.8±56.0, 504.9±105.5, 102.3±6.6, 170.5±8.2, 177.5±76.9 Mg C $ha^{-1}$ and 2329.9, 1852.8, 375.5, 625.6, 651.6 Mg $CO_2$ $ha^{-1}$ respectively. Jaffna recorded the highest SOC stock (634.8 Mg C $ha^{-1}$), exceeding the previously known maximum from Rekawa (580.84 Mg C $ha^{-1}$), while Lanka Patuna had the lowest (102.3 Mg C $ha^{-1}$). Some North-Eastern sites showed SOC values below the reported values in 2019. SOC variation is influenced by factors such as plant species, geomorphology, hydrology, salinity, tidal patterns, and human activities. Sri Lankan mangrove soils store nearly double the carbon found in tropical savanna forests of the Pacific Islands. The findings underscore the role of mangroves in climate change mitigation, the importance of targeted restoration and blue carbon research supported by ecological understanding.

# Comparison of the loss on ignition method and the Walkley and Black method for the determination of organic carbon in soil

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## Abstract

Soil is one of the most vital resources on Earth, and one of the key indicators of soil health is its organic carbon content. Soil Organic Carbon (SOC) consists of decomposed, partially decomposed, and undecomposed organic materials of plant or animal origin. Two commonly used methods for determining SOC are the Loss on Ignition method (SLS 645 Part 10) and the Walkley and Black method (SLS 1634 & SLS 1635). In the Loss on Ignition method, the sample is dried, incinerated, and the organic matter content is calculated based on the weight loss. In contrast, the Walkley and Black method involves the oxidation of organic carbon with potassium dichromate in sulfuric acid, followed by the titration of the remaining dichromate with ferrous sulfate to determine the carbon content. To verify these methods, analyses were conducted on sand, compost, and mixtures of 80% compost with 20% sand and 80% sand with 20% compost. A paired t-test at a 95% confidence level was performed to compare the results of the two methods. The p-values were $7.87 \times 10^{-12}$ for compost, 0.401 for sand, $4.22 \times 10^{-9}$ for the 80% compost mixture, and $1.6 \times 10^{-9}$ for the 80% sand mixture. A p-value less than 0.05 indicates a significant difference between the two methods. Discrepancies may arise due to the overestimation of SOC by the Loss on Ignition method, which can result from the oxidation of carbonates along with organic carbon at high temperatures. Conversely, the Walkley and Black method may underestimate SOC due to incomplete oxidation of organic matter by dichromate in the presence of sulfuric acid. These findings suggest that the method used to estimate SOC significantly affects the results; therefore, the choice of analytical method is critical and must be carefully considered to ensure accuracy and consistency in soil carbon assessments.

# Development of controlled-release fertilizer using urea and poly lactic acid

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## Abstract

Nitrogen, the most limiting nutrient in agroecosystems, is an essential macronutrient required for plants to perform fundamental functions such as chlorophyll synthesis, protein formation, and enzymatic processes. Regular application of nitrogenous fertilizers is vital to achieve economic crop yields, with urea serving as the primary and most cost-effective source. Urea enhances soil fertility and promotes plant growth efficiently; however, its inefficient use can significantly reduce crop yield and pose threats to food security and ecosystem stability. The development of a Controlled-Release Fertilizer (CRF) offers a promising alternative. This study aimed to develop a CRF using Polylactic Acid (PLA) as a biodegradable coating material for urea. Urea was converted into a slow-release form by applying a PLA coating through a dissolution process followed by solvent casting. The urea-release performance was evaluated using two distinct forms of the coated urea: the intact film (unmilled) and the powdered form. A colorimetric analysis method was developed using p-dimethylaminobenzaldehyde (DMAB) to quantify the amount of urea released into an aqueous medium at regular time intervals. The method demonstrated strong linearity ($R^2$=0.9971), precision (Relative Standard Deviation=5.30%), and repeatability (at 95% Confidence Interval). Results revealed cumulative urea release of 55.1%, 82.4%, 90%, and 99.49% at 1, 2, 4, and 24 hours, respectively. Fourier Transform Infrared (FTIR) spectral analysis confirmed successful encapsulation of urea in the film-coated sample, while the spectrum of the ground sample showed exposure of urea due to mechanical disruption of the PLA matrix. In conclusion, the present study successfully developed a PLA-coated urea formulation in its intact film form. Controlled release was effectively demonstrated through the gradual release profile. The intact film maintained encapsulation, whereas mechanical grinding compromised the coating and exposed the urea. Future studies will investigate alternative drying and granulation techniques to improve the efficacy of urea-release.

# Development and characterization of a clay-zeolite composite material for hardness removal from water

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## Abstract

Water hardness, primarily caused by divalent calcium ($Ca^{2+}$) and magnesium ($Mg^{2+}$) ions, poses significant challenges in both domestic and industrial water systems, including scaling, reduced equipment efficiency, and increased operational costs. While clays and zeolites are commonly used for hardness removal, their individual use is limited due to the rapid saturation of clays and the fine particle dissolution of zeolites. This study presents the development of a clay zeolite Composite Material (CM) that combines the mechanical strength of Locally Available Clay (LAC) with the ion-exchange capacity of synthetic Zeolite 4A (ZA). The CM was formulated by blending ZA and LAC in a 50:35 weight ratio with 15% water (w/w), followed by air drying, oven drying, and sintering at 650 °C for 16 hours. Performance testing using Ground Water (GW) samples from Polpithigama, North Western Province, Sri Lanka, revealed a 56% reduction in hardness (from an initial value of 301 ppm to 134 ppm) after circulating 1 L of GW through 250 g of CM for 10 minutes. Minimal changes were observed in pH (from 7.80 to 7.66) and Total Dissolved Solids (TDS) (from 1168 ppm to 1080 ppm), indicating the chemical stability of the material. X-ray Diffraction (XRD) analysis of the CM confirmed the retention of crystalline phases in both LAC and ZA. Fourier Transform Infrared (FTIR) spectroscopy demonstrated the preservation of key functional groups such as Si–O–Al, Al–OH, and O–H. Scanning Electron Microscopy (SEM) images revealed a cohesive microstructure, with ZA particles uniformly embedded within the clay matrix, contributing to both mechanical integrity and efficient ion exchange. In conclusion, the developed CM addresses the limitations of the standalone materials and offers a low-cost, effective solution for water hardness removal, particularly well-suited for decentralized treatment in rural or resource-constrained areas. Future enhancements to the CM, such as surface activation or functionalization, are expected to significantly improve its ion-exchange capacity, making it a more efficient and sustainable material for advanced water treatment applications.

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# Characterization of purified graphite oxide obtained from Sri Lankan vein graphite using a filtering-based purification method

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## Abstract

Graphite plays a significant role among the main export minerals of Sri Lanka due to its high purity, ranging from 95% to 99%. Compared to raw graphite, the export of graphite oxide and graphene can increase revenue by up to 1000 times, owing to their diverse and innovative applications in modern science, driven by their exceptional electronic, thermal, mechanical, and optical properties. Graphite oxide can be synthesized using the well-known Hummers method and its modifications, followed by chemical or thermal reduction to produce reduced graphite oxide. After synthesizing Graphite Oxide (GO), it is essential to remove impurities before direct use or conversion to reduced GO. However, the intensive use of hazardous chemicals in traditional methods poses a major bottleneck for large-scale GO production, primarily due to the complexity of the purification process. In this study, a multi-step filtration-based purification method was employed as a simple, cost-effective, and low-energy approach suitable for bulk purification at an industrial scale. The formation of purified GO was characterized using X-ray Diffraction (XRD), Fourier Transform Infrared spectroscopy (FTIR), and Inductively Coupled Plasma Mass Spectrometry (ICP-MS). XRD spectra confirmed that the GO obtained through multiple filtration steps exhibited high phase purity, with no detectable secondary phases. The FTIR spectrum revealed successful oxidation while indicating characteristic peaks corresponding to oxygen-containing functional groups such as C–O, C=O, C–OH, and C–O–C. Moreover, ICP-MS analysis confirmed that sulfate and manganese impurities were reduced to trace levels. In conclusion, this filtration-based method offers a cost-effective and scalable alternative for GO purification, effectively addressing the high energy demands associated with conventional centrifugation techniques commonly used in the industry.

Acknowledgment: Financial assistance by Treasury Research Grant (TG 19/183)

# Fabrication of different types of supercapacitors using graphite-kaolinite-based electrodes

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## Abstract

The novel supercapacitors were developed using polyaniline-coated graphite–kaolinite (PANI-GKCE) and graphite–kaolinite–cement (PANI-GKCeCE) composite electrodes. This study aims to understand the synergistic electrode effect when kaolinite is present alone and with cement towards aniline electropolymerization and its subsequent energy storage capacity. Electrodes are fabricated via standard composite pressing methods and electropolymerized with aniline in 1 mol $dm^{-3}$ HCl. Scanning Electron Microscopy (SEM) analysis revealed well-structured PANI nanofiber networks, particularly in PANI-GKCE, resulting in improved ion diffusion and porosity. The specific capacitance values achieved for PANI-GKCE and PANI-GKCeCE were 482 F $g^{-1}$ and 416 F $g^{-1}$, respectively, at 5 mV $s^{-1}$, indicating higher energy storage capability in the binary system. Cyclic voltammetry and galvanostatic charge-discharge analyses showed high cyclic stability and consistent charge storage behavior, with PANI-GKCE reaching 548 F $g^{-1}$ and PANI-GKCeCE achieving 1143 F $g^{-1}$ under GCD conditions. Electrochemical impedance spectroscopy confirmed lower charge transfer resistance in PANI-GKCeCE, attributed to improved matrix interactions, while X-ray Diffraction (XRD) analysis indicated enhanced crystallinity and reduced lattice strain in both electrodes. The energy density of PANI-GKCeCE was 635 W h $kg^{-1}$, while PANI-GKCE demonstrated superior power performance, reaching 304 W $kg^{-1}$. These results confirm the suitability of both composites for energy storage, with PANI-GKCE showing greater promise for high-power applications and PANI-GKCeCE excelling in energy density.

Acknowledgement: Financial assistance by Treasury Research Grant (TG/24/246)

# Facile and sustainable reduction of graphene oxide via *Euphorbia hirta* L. phytoconstituents

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## Abstract

Graphene and its derivatives have recently gained significant attention due to their exceptional physical and chemical properties. However, conventional methods for reducing Graphene Oxide (GO) often involve hazardous chemicals, energy-intensive processes, and poor environmental sustainability. To address these challenges, this study proposes a green and eco-friendly approach for synthesizing reduced graphene oxide (rGO) using *Euphorbia hirta* shoot extract. Rich in polyphenolic compounds and various phytoconstituents, the extract effectively acts as a reducing agent, facilitating the removal of oxygen-containing functional groups from GO. The synthesized materials were characterized using X-ray Diffraction (XRD), Ultraviolet-Visible (UV–Vis) spectroscopy, Scanning Electron Microscopy (SEM), and Fourier Transform Infrared Spectroscopy (FTIR). The reduction of GO to rGO was initially indicated by a visible color change from brown to black, suggesting the removal of oxygen-containing functional groups. XRD analysis further confirmed this transformation, showing a shift in the characteristic 2θ peak from around 10°, typical of GO, to approximately 26°, corresponding to the (002) plane of graphitic carbon. FTIR spectroscopy also confirmed the reduction process, as the intensity of GO's prominent oxygen-related peaks significantly decreased. Notably, the peak at 1720 $cm^{-1}$, attributed to C=O stretching vibration, disappeared after reduction, indicating successful deoxygenation. UV–Vis spectrophotometry further validated the reduction by showing a shift in the absorption spectrum, indicating the restoration of the conjugated π-network in rGO. In conclusion, this study presents an eco-friendly and sustainable method for synthesizing rGO using *Euphorbia hirta* extract, offering significant potential for a wide range of applications across various scientific and technological fields.

# An integrated treatment solution for batik industry wastewater in Sri Lanka: An overview of the present wastewater treatment status in batik industries in Sri Lanka

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## Abstract

Batik is a time-honored Sri Lankan art form with significant cultural and economic value. The State Ministry of Batik, Handloom, and Local Apparel Products aspires to advance the Batik industry by increasing the market to attract tourists by 50% in 2025. Despite these economic goals, Batik industries generate a large volume of wastewater containing high levels of dyes, imposing environmental pollution and health issues. The Industrial Technology Institute (ITI) has identified the need for a proper wastewater treatment solution for Batik industries in Sri Lanka. Several site inspections of selected Batik industries were conducted during July-September to study the Batik-making process and available wastewater treatment technologies in these industries. The reactive, vat, and naphthol dyes are used as dyes, and the mean daily wastewater generation in small & medium sector Batik industries is approximately 1.5-3 $m^3$/day, while in large-scale Batik industries it averages 5 $m^3$/day. Sri Lankan Batik industry operates mostly on a small & medium scale and discharges effluents into the environment without proper treatment. However, some Batik industries occupy collection tanks for their wastewater and dispose via bowsers. Several small-scale industries have applied the sand filtration with gravel and sand layers as a traditional treatment solution. In an established large-scale industry, a proper wastewater treatment facility was available, comprising chemical coagulation, a clarifier, an aeration unit and carbon filters, in which the sludge disposal had become a major issue. Therefore, the wastewater treatment has become a problem for both small & medium-scale and large-scale Batik industries in Sri Lanka. Future green approaches with integrated natural and chemical coagulants with low sludge production, phytoremediation technology, or application of membrane technology in a centralized treatment plant are suggested for future research and scaling up for Batik Industry wastewater treatment in Sri Lanka.

# Utilizing raw rice Husk as a partial sand replacement in low-cost lightweight cement blocks for sustainable construction

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## Abstract

The construction industry heavily relies on river sand, resulting in the depletion of natural sand resources, rising material costs, and significant environmental degradation. At the same time, Sri Lanka produces approximately 0.64 million tons of rice husk annually as a byproduct of rice cultivation. This agricultural waste is often burned or discarded, further contributing to environmental pollution. This study investigates the feasibility of using raw rice husk as a partial replacement for sand in the production of low-cost, lightweight building blocks. The research aims to develop an appropriate production process and mold designs tailored to the unique properties of rice husk mortar, which differs significantly from conventional sand-based mortar. Various mix proportions will be evaluated to determine optimal performance in terms of compressive strength, density, thermal and acoustic insulation, water absorption, fire resistance, plaster adhesion, and long-term durability. The blocks will also be assessed for their suitability in both load-bearing and non-load-bearing wall applications. In the preliminary phase, cement blocks with different rice husk compositions were produced and tested for compressive strength and density. Initial results indicate that rice husk blends effectively with cement, achieving compressive strengths ranging from 2 to 6 MPa. The blocks are also up to 40% lighter than traditional cement-sand blocks, demonstrating significant potential as a low-cost, eco-friendly construction material. Ongoing investigations aim to further enhance mechanical properties and evaluate performance across the aforementioned parameters. Therefore, the present study offers a promising approach to repurposing agricultural waste and promotes sustainable construction practices by reducing dependence on natural sand. Moreover, it introduces simple, low-tech building methods, provides valuable fire and insulation testing data, and supports knowledge transfer to farming communities, particularly in rural areas, contributing to environmental protection and affordable housing development.

Acknowledgment: Financial assistance by Treasury Research Grant (TG 24/260)

# Waste to energy: Fabrication and development of cost-effective leftover food briquettes using organic garden wastes as additives

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## Abstract

The present research project addresses the dual challenges of food waste management and domestic energy scarcity by fabricating briquettes using leftover food and garden waste. The aim was to transform household organic waste into valuable, eco-friendly fuel alternatives. The study focused on identifying suitable types of garden waste and binders, optimizing the production process, and evaluating the performance of the briquettes for both domestic and industrial applications. Organic waste, including food scraps and various garden residues, was collected from local urban sources. Initial trials explored both wet and dry fabrication techniques, with the dry method proving more effective in achieving the consistency required for high-quality briquettes. A lab-scale compression mold was developed to shape the briquettes, followed by sun drying to remove residual moisture. Eight types of briquettes were formulated using combinations of food waste mixed with garden waste, sawdust, jackfruit leaves, and rubber leaves, along with two different binders: paper pulp and starch. Each variant was tested for calorific value, moisture content, ash content, and texture. Briquettes made with jackfruit leaves and starch emerged as the most promising, offering a high calorific value (up to 4938 kcal/kg), low moisture content, and favorable handling texture. Further testing involved varying the ratio of food waste to jackfruit leaves while keeping the binder proportion constant. The optimal formulation: 50% food waste, 35% jackfruit leaves, and 15% starch, achieved the highest energy output. A combustion test using the optimal briquette mixture confirmed its practical utility: 200 g of briquettes successfully boiled 1 kg of water in 20 minutes using a coconut shell stove. These findings affirm the potential of food waste briquettes as a low-cost, renewable fuel source for low-income urban households in Sri Lanka, providing an effective alternative to traditional fuels such as firewood and liquefied petroleum gas.

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# Research on the mechanical and thermal properties of 3D printed samples using recycled polyethylene terephthalate (rPET) filament

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## Abstract

The growing concern over plastic waste has driven research into sustainable alternatives for additive manufacturing. Recycled Polyethylene terephthalate (rPET), derived from post-consumer PET bottles, is considered a promising material for 3D printing applications. In this study, rPET and virgin PETG filaments (1.75 mm) were used to fabricate ASTM D638 Type V tensile specimens using a Creality Ender 3 FDM printer under standard conditions (nozzle temperature: 240 °C, bed temperature: 80 °C, layer height: 0.2 mm). Mechanical properties were evaluated using a Universal Testing Machine (UTM), while thermal characteristics were analyzed via Differential Scanning Calorimetry (DSC) and Thermogravimetric Analysis (TGA). Surface morphology and interlayer quality were examined using Scanning Electron Microscopy (SEM). The rPET specimens exhibited slightly lower tensile strength (42.5±1.3 MPa) and Young's modulus (1.82±0.05 GPa) compared to virgin PETG (48.1±1.1 MPa and 2.05±0.04 GPa, respectively). Elongation at break was also reduced in rPET (8.6±0.4%). DSC analysis showed a glass transition temperature of approximately 76 °C and a melting point of around 245 °C. SEM images revealed reduced interlayer bonding strength in rPET prints and rougher surfaces, with occasional nozzle clogging observed during extended printing. rPET filament can be used as an eco-friendly alternative for low-load 3D printing applications. While its mechanical and surface properties are slightly inferior to those of virgin PETG, performance can be enhanced through optimized printer settings and improved filament processing. In conclusion, the present findings support the feasibility of incorporating recycled plastics into sustainable manufacturing practices, contributing to waste reduction and circular economy goals.

Acknowledgement: Financial assistance by Treasury Research Grant (TG 18/2024)

# Study of bentonite–zeolite–EDTA mixtures for efficient heavy metal adsorption in landfill leachate treatment

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## Abstract

Leachate from heavy metal–rich landfills is a major environmental concern today. Mainly, this is formed when water flows through waste which are there in landfills, enabling extractions to dissolve in water as well as containing suspended substances such as heavy metals. These contaminants can subsequently pollute soil and groundwater, which can accelerate toxicity risks to aquatic life and human health through bioaccumulation and carcinogenic effects. This study aims to optimize bentonite–zeolite–EDTA mixtures for efficient adsorption of heavy metals from landfill leachate, thereby leveraging the environmental safety and effectiveness of engineered landfilling systems. The adsorption efficiency of a mixture of bentonite, zeolite, and Ethylenediaminetetraacetic Acid magnesium disodium complex (EDTA) in the leachate treatment process was evaluated. The bentonite–zeolite combination improves cation exchange and adsorption, while the addition of EDTA further enhanced the removal efficiency by forming stable metal complexes. The adsorption process was highly dependent on pH, with the optimal value determined to be pH 5. Two bentonite–zeolite ratios (85:15 and 60:40) were prepared, both with and without EDTA. One set of mixtures was combined with water, while the other used EDTA as the preparation medium. The samples were characterized using Fourier Transform Infrared (FTIR) and X-ray Diffraction (XRD) techniques. FTIR analysis revealed more pronounced surface-level interactions in the 60:40 blend, while XRD analysis indicated significant structural changes, such as peak broadening and amorphization, particularly in the zeolite-enriched composition. The 85:15 blend maintained high crystallinity, whereas the 60:40 blend exhibited greater surface reactivity following EDTA treatment. These results indicate that the 60:40 bentonite–zeolite mixture, when modified with EDTA, achieves superior heavy metal adsorption due to its increased surface interactions and structural adaptability. This formulation is therefore worth to be well-suited for further investigation and could hold strong potential for practical applications in the efficient removal of heavy metals from landfill leachate.

# Effects of essential oils on increasing the flashpoint of Diesel

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## Abstract

Flash point of commercial liquid fuel, especially diesel, is critical when it comes to safety factor, especially in storing at vivid environmental conditions as well as in safe handling. On the other hand, refineries adjust fuel volatility to ensure efficient combustion while keeping flash points safely above ambient temperatures. Extreme conditions may still pose fire risks, making flash point an important quality control measure in fuel production. Higher flash point improves safety at a permissible limit. The present study was carried out to investigate and compare the characteristics of diesel embedded with commercially occurring cinnamon leaf oil, clove oil, and citronella oil. Tests were conducted for unaltered diesel and the following binary mixtures were developed: cinnamon oil (5%) with diesel (95%), clove oil (5%) with diesel (95%), and citronella oil (5%) with diesel (95%). Density, kinematic viscosity at 40 $^0$C, flash point, and corrosiveness of copper were tested according to ASTM standards. Compared with the flash point of diesel (64 °C) the results indicated that the flash point of binary mixtures had increased, out of which the highest flash point value obtained was for the binary mixture of citronella oil with diesel (74 °C), followed by cinnamon oil mix with diesel (68 °C), and clove oil with diesel (65 °C). Sample with cinnamon oil (5%) + diesel (95%) gave 68 $^0$C, while sample clove oil (5%) + diesel (95%) resulted in a flash point of 65 °C. The corrosiveness of copper is the same as diesel fuel (1a) in all three samples. Kinematic viscosity at 40 °C and density of the three binary mixtures were, although a little bit higher than the control diesel sample, which this improvement in flash point can be used without altering the common rail injection system of a diesel engine. This study identifies that essential oils can be used in altering existing diesel properties, especially increasing the flashpoint levels within a permissible range.

# Phytochemical and physico-chemical evaluation of *Cardiospermum halicacabum* L.

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## Abstract

*Cardiospermum halicacabum* L. (commonly known as Balloon Vine or "Wel Penela") is a medicinal plant traditionally used in Ayurveda and folk medicine for the treatment of rheumatism, skin disorders, respiratory ailments, and inflammatory conditions. Phytochemical standardization is essential to ensure the safety, efficacy, and quality of herbal formulations derived from this plant. The present study focuses on investigating selected physicochemical parameters and the quantification of saponins in dried leaf powder of *C. halicacabum*. Plants of C. *halicacabum* were collected from the Western Province of Sri Lanka. The leaves were separated, thoroughly washed, dried at 40 °C for three days, and subjected to analysis for the presence of secondary metabolites, ash values (total ash, water-soluble ash, and acid-insoluble ash), development of a Thin Layer Chromatography (TLC) fingerprint profile, and quantification of saponins using a gravimetric method. Preliminary phytochemical screening revealed the presence of saponins, alkaloids, flavonoids, steroid glycosides, terpenoids, and phenols, which are associated with the therapeutic activities of *C. halicacabum*. The total ash, water-soluble ash, and acid-insoluble ash values were 2.3±0.2%, 1.5±0.1%, and ≤0.1%, respectively. A TLC fingerprint profile was developed, and the $R_f$ values of each spot were determined. The saponin content in dried leaves of *C. halicacabum* was found to be 6.7±0.8%. Establishing phytochemical markers and quality control parameters contributes to the safe integration of this plant into modern phytopharmaceutical products. This study highlights the importance of comprehensive standardization protocols for ensuring the consistency and therapeutic potential of herbal medicines.

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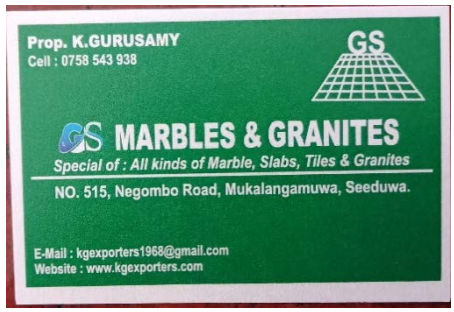






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