# ICDA 2021

## 7TH INTERNATIONAL CONFERENCE ON DRY ZONE AGRICULTURE


# CONFERENCE PROCEEDINGS

## 3rd & 4th December 2021

Volume - 07

Faculty of Agriculture, University of Jaffna, Sri Lanka.

# 7TH INTERNATIONAL CONFERENCE ON DRY ZONE AGRICULTURE (ICDA 2021)

*"DYNAMIC AGRICULTURE TOWARDS SUSTAINABLE FUTURE"*

## CONFERENCE PROCEEDINGS

**3rd - 4th December 2021**

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

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# MESSAGES

# Message from the Chief Guest

**Prof. S. Srisatkunarajah**
**Vice-Chancellor**
**University of Jaffna**
**Sri Lanka**

It is with immense pleasure that I write this message for the 7th International Conference on Dry Zone Agriculture (ICDA 2021) hosted by the Faculty of Agriculture, University of Jaffna. In the past years, this annual conference provided a venue for local and international researchers who study the agrarian practices and agrarian economy of the dry zone of Sri Lanka to disseminate their scholarship and exchange ideas. I am hopeful this year's conference too will lead to productive conversations and future collaborations. Agriculture remains the livelihood of majority of the people in this country. In addition to the climate changes, the ongoing COVID 19 pandemic has impacted the agriculture sector of Sri Lanka's Dry Zone adversely. In this context, the theme of the conference, "Dynamic Agriculture Towards Sustainable Future" is timely significance. Located in Kilinochchi, which is considered the rice bowl or the granary of the Northern Province, the Faculty of Agriculture of the University of Jaffna plays an important role in re-fashioning and strengthening the agricultural activities of the North. Rebuilding an agrarian economy in the post-war contest is not an easy task. It involves not just the invention and implementation of sound, eco-friendly agricultural practices, but also addressing inequalities related to landownership and building self-sufficient agrarian communities. Furthermore, with the restrictions on the importation of artificial fertilizers, the Faculty is now focusing on the research to invent new methods to produce natural fertilizers in the form of compost to support the farming community. Addressing these issues is important to develop an agrarian economy that ensures both food security and livelihood security. Such a context calls for radically new scholarly and policy approaches. I am optimistic that this conference will be a step towards exploring solutions to the challenges faced by dry zone agriculture and the communities that are at the heart of this sector.

I congratulate the Dean of the Faculty of Agriculture and the organizing committee of the ICDA 2021 for organizing this landmark conference and wish the conference and its participants all success.

# Message from the Conference Chair

**Dr. S. Vasantharuba**
**Dean**
**Faculty of Agriculture**
**University of Jaffna**
**Sri Lanka**

It is an immense pleasure to deliver this message on the occasion of seventh International Conference on Dry Zone Agriculture (ICDA), 2021 of the Faculty of Agriculture, University of Jaffna which is scheduled to be held on 3rd and 4th December 2021. ICDA is an annual event in the academic calendar of the Faculty and has been a great success in the past seven years with high quality presentations and participation of local and international researchers and scientists from different institutions.

Our Faculty of Agriculture is addressing various challenges with which humanity is faced including the stable supply of safe high quality food with reduced environmental degradation and restoration of degraded environments. Accordingly, we undertake education and research across a wide variety of subjects related to life, food and environment. We aimed to improve productivity in agriculture, forestry, fisheries and livestock as well as to preserve the environment in which such activities are performed. The theme of this conference is "Dynamic agriculture towards sustainable future". It is vitally important that human beings are able to secure sufficient food via dynamic agriculture in order to live agreeable lives. But currently, there are a lot of negative factors that reduced agricultural production. Technologies has brought upon the environment such as chemical contamination, soil erosion, salt accumulation etc., all of which adversely affect stable food production. For mankind continue to thrive in the world, the food needs to be produced sustainably and efficiently while protecting the environment.

On behalf of Faculty of Agriculture, I wish to express my sincere gratitude to our Vice-chancellor, Professor. S. Srisatkunarajah for his generous support to the faculty. I also wish to thank all the guest speakers, chair of the sessions, presenters, reviewers, sponsors, members of the organizing committee and academic and academic supporting staff of the faculty for their support and assistance. While warmly welcoming all the participants to the ICDA 2021, I wish the conference would be a great success and contributes immensely towards the development of the dry zone agriculture of the whole nation.

# Message from the Convener

**Dr. N. Kannan**
**Department of Agricultural Engineering**
**Faculty of Agriculture**
**University of Jaffna**
**Sri Lanka**

It is with great pleasure that I write a message from the desk of the convener to the proceedings of the ICDA2021. The International Conference of Dry Zone Agriculture (ICDA) is an annual event organized by the Faculty of Agriculture University of Jaffna to make a platform for academics, researchers, policy makers and other interested people to share their productive ideas, views and options in order to solve the problems that are related to dry zone agriculture are of national importance. The ICDA 2021 has been set with the theme, dynamic agriculture for sustainable future, on the 3rd and 4th of December 2021. However, the proceedings of the ICDA 2021 comprises of 62 scientifically sound abstracts along with six keynote addresses from internationally renowned scientists from various countries.

Moreover, it is good note that around 75% of accepted papers is from outside experts. It clearly indicates strong influence of ICDA 2021 in the scientific community nationally and internationally in spite of the COVID19 pandemic situation. Furthermore, the ICDA 2021 would be an ideal platform to have productive discussion regarding strategies that are highly required to produce good quality compost as its production is badly needed to the country so as to maintain environmental sustainability. I do further assure that the future ICDA conferences will be strengthened more by widening the network of international collaboration to bring innovative ideas in order to solve weighty local problems related to dry zone agriculture.

To end with, I thank the ICDA 2021 team for their tireless work to organize ICDA 2021 successfully during this pandemic situation and wish all the best for the remarkable event of the ICDA 2021.

# Message from the Finance Chair

**Mr. M. Prabhaharan**
**Department of Agricultural Engineering**
**Faculty of Agriculture**
**University of Jaffna**
**Sri Lanka**

It is my pleasure to being as a committee member in the 7th International Conference on Dry Zone Agriculture (ICDA 2021). The ultimate aim of this conference is to foster communication among eminent scholars attached to different disciplines of agriculture, disseminate research findings and share scientific ideas and experiences to use the novel knowledge for successful practical outcomes in dry zone agriculture. This event is successfully achieved with the support of academic staffs, supporting staffs, stakeholders and shareholders. Although this event held virtually, the contribution from keynote speakers, reviewers and distinguished guests is highly appreciated.

Moreover, high number of good quality research papers were received from local and international level which interprets the dissemination of the conference. The ICDA has been getting more recognition and reputation among scholars. This achievement makes us more proud and pride. I would like to thank E.S.P.Nagaratnam for his contribution to the ICDA 2021.

# Message from the Joint Secretaries

**Mr. S. Anand Kumar**
**Department of Animal Science**
**Faculty of Agriculture**
**University of Jaffna**
**Sri Lanka**

**Ms. N. Aruchchunan**
**Department of Agricultural Biology**
**Faculty of Agriculture**
**University of Jaffna**
**Sri Lanka**

The Faculty of Agriculture, University of Jaffna, Sri Lanka has proudly hosting the 7th International Conference on Dry Zone Agriculture (ICDA) in this year 2021 under the theme of "**Dynamic Agriculture towards Sustainable Future**". This event provides an incredible platform to researchers to present and disseminate their research findings to research scholars who seeking for innovations and inventions. It is a great pleasure for being as a member in the organizing committee of ICDA 2021. The proceeding comprises a wide range of disciplines in terms of Agriculture Economics and Agribusiness Management, Livestock, Poultry and Aquaculture, Food Technology and Safety, Crop Production and Technologies, Plant Genetics and Biotechnology and Environmental Engineering. On the other hand, the proceeding enriched with valuable research findings from both local and international which helps scholars to explore new trends in order to sustain in future due to dynamic agriculture. In addition, these collective research outcomes would create platforms for researchers to generate novel innovations towards emerging trends and raising issues. On behalf of the organizing committee of 7th ICDA 2021, it is a great honor for us to forward our sincere gratitude to all the reviewers who gave their fullest support and dedicate their valuable time to review the papers within the due date. Therefore, the success of launching the proceeding of 7th ICDA 2021 on this prestigious day is because of them.

# KEYNOTE ADDRESSES

# Climate Change and Population Growth: Balancing Water Demand

**Professor. Ashantha Goonetilleke**
**Queensland University of Technology**
**Australia**

Water is essential for the survival of all living organisms. Freshwater is a finite resource which is facing unprecedented challenges due to escalating demands for household use, agriculture and industry. This in turn has resulted in unsustainable extraction of water from available sources and the pollution of water resources due to a range of anthropogenic activities. The dire situation facing the world's freshwater resources is being further exacerbated by climate change impacts.

Climate change is predicted to result in significant and permanent changes to weather patterns around the world. Changes in climate factors are projected to increase in severity into the future. These changes will encompass alterations to the average climate characteristics such as the increase in the average earth surface temperature, and increasing severity and frequency of extreme meteorological events such as cyclones, storms and droughts and also the rise sea levels.

Changes to climate characteristics is an ongoing process and can result from natural phenomena such as forest fires and volcanic eruptions. However, it has been proven that these changes are being accelerated due to specific anthropogenic activities, such as the combustion of fossil fuels, industrial activities, increasing use of fertilizer and deforestation, which results in rising greenhouse gas emissions to the atmosphere. This has led to a relentless rise in the global average surface temperature. Furthermore, human influence on the global climate is becoming increasingly evident and can be considered to be primarily responsible for the tangible changes in the earth's climate.

The key findings by the UN's Intergovernmental Panel on Climate Change which is directly relevant to the water environment and the reliability of supply for various consumptive uses are as follows:

- Global warming observed over the past decades can be directly linked to changes to the hydrologic cycle;
- The projected increased rainfall intensity and variability will increase the risks of flooding and drought in many areas;
- Increased temperatures and changes to rainfall patterns such as annual rainfall, timing of the wet season and drought cycle and rainfall extremes is expected to affect water quality and exacerbate water pollution;

Therefore, from a water quantity perspective, climate change will have a critical impact on stream flow such as the increase or decrease in peak flow and the timing of the peak. In current water deficient areas, the severity of water scarcity will be further worsened due to greater withdrawal of water from existing sources during dry periods. The more frequent drought conditions will lead to reduced soil moisture and annual stream flow in some catchments. However, in contrast, higher intensity rainfall events and increased frequency of extreme rainfall will lead to a range of natural disasters including more frequent flooding. Essentially, water resources will become increasingly stressed.

Climate change impacts specific to Sri Lanka include:

- Sea level rise, coastal flooding, coastal erosion, changes to rainfall regimes and the rise in ambient temperature;
- As climate change is expected to change the pattern and quantity of rainfall, changes to evapo-transpiration, surface runoff and soil moisture storage, changes in water availability for irrigated agriculture and public use could well be anticipated.
- Sea level rise will cause saline intrusion which can seriously affect freshwater availability with salt water intrusion affecting coastal aquifers;
- The annual average rainfall over Sri Lanka has decreased in the last 57 years at the rate of about 7 mm per year.
- Possible shifts in the demarcation between the Dry and Wet Zones with a reduction in the latter;
- Reduced rainfall will affect seasonal flows of rivers;
- The highest levels of paddy sector vulnerability to sea level rise exposure will be concentrated in the North/Northeast of the island;

- The dry zone is more vulnerable to increasing number of consecutive dry days which will have a significant impact on the yields of crops.

Superimposing challenges arising from population growth with those posed by climate change, the key issues that arise are water and food security. To provide context:

- According to the UN World Water Development Report (2015), by 2050, it is necessary to produce 60% more food globally to meet the demands of an increased population and 100% more in developing countries because the increase in population is primarily in this region;
- The major constraint to food production is abiotic stress, which refers to the negative impact of non-living factors such as drought, excess moisture and a range of meteorological influences which are going to be severely affected by climate change;
- Among the water resources available in the world, only about 0.5-1% is suitable for human consumption with the remainder either in the oceans or locked away in glaciers;
- Globally, around 60–70% of freshwater resources are currently used for agriculture.

Consequently, the common question that arises is, how is it possible to achieve the increase in food production if already 60-70% of available water is used for agriculture? Studies have shown that even with aggressive mitigation efforts, the negative impacts of climate change will eventuate. Therefore, the challenge faced by humankind is increasing food production and at the same time coping with the uncertainties associated with the changes to weather patterns and water availability driven by climate change. There are no easy solutions to this conundrum.

The prudent approach is to adopt a range of adaptation measures to meet these identified challenges arising from climate change. Adaptation can be broadly defined as the adjustments in human or physical systems to adequately cope with the expected challenges. At a broad conceptual level, it is imperative that adaptation strategies are based on a sound economic foundation to gain broad acceptance.

Adaptation should not be merely viewed as a 'technological fix'. Rather, it requires the prioritization of vulnerabilities, a clear understanding of the areas requiring

adaptation measures based on local needs and to address the issue of achievable and affordable levels of service to provide certainty in the outcomes. Further, it is important to seek opportunities in adversity. Therefore, the challenges detailed above should be viewed as an opportunity to create a tangible sustainable development agenda.

Unfortunately, there is no 'magic bullet' or an instantaneous solution and the most prudent approach is to adopt a series of well formulated measures which are feasible either at the local, regional or national contexts. A 'one size fits all' approach is doomed to failure in the long-term. In other words, a strategy that is effective in one area may not necessarily be effective in another area. A key strategy to be considered should be to conserve water use and the use of alternative water resources based on the concept of 'use of water fit for purpose'. The alternative water resources are harvested storm water and treated wastewater which can be used for specific purposes where human health is not jeopardized.

The other approaches that can be implemented fall into three broad categories. Firstly, approaches that have proven successful in the past and can be further advanced. These include, the planting of high yield crops and resource efficient farming practices. Secondly, highly water efficient approaches such as hydroponics, vertical farms and protected cropping which are emerging and needs to be mainstreamed for large-scale adoption.

Thirdly, the other concepts that are currently being promoted include urban agriculture, reduction in food waste and the adoption of a circular economy. As more than half the world's population currently live in urban areas, the production of food in areas of habitation would contribute to resource savings such as water and land and include savings in costly infrastructure such as irrigation infrastructure.

The FAO has estimated that one third of all food produced, about 1.3 billion tons of food and half of all fruit and vegetables is lost or wasted each year. Any saving would in turn translate to savings in water and other resources. A circular economy refers to a circular model of production and consumption with reuse, recycling and refurbishment playing intermediate roles. This would translate to savings in water and other resources.

In summary, the impacts of climate change would be further exacerbated by population growth. These impacts would be very widespread and Sri Lanka is particularly vulnerable. In order to mitigate the predicted impacts and to protect community well-being, robust and well formulated strategies are needed to be implemented. A number of strategies have been discussed and their adoption should be based on feasibility either at the local, regional or national contexts.

# Building Global Knowledge Partnerships for Sustainable Food Systems

**Professor. Karim M. Maredia**
**Professor and Director of International Programs**
**Director of World Technology Access Program (WorldTAP)**
**College of Agriculture and Natural Resources**
**Michigan State University, Michigan, U.S.A**

Globally, food systems need to meet food security, nutrition, environmental and socio-economic goals, especially in an interconnected world with growing population and a changing climate. There is a broad consensus on the need to transform current food systems towards more resilient and sustainable models. The national governments, private sector, non-governmental organizations and development agencies across the globe are investing resources and putting concerted efforts for transforming agricultural and food systems to create sustainable and resilient systems that nourish the growing global population, enhance economic growth and livelihoods, and protect the environment while conserving natural resources. There is a greater recognition that the agricultural and food systems must produce healthy and nutritious food, reduce food waste and must be sustainable and resilient to climate change. In addition, there is a greater appreciation that the food system must benefit and be inclusive of smallholder farmers, women, youth, and other disadvantaged groups. During the past few decades, the global community has generated a large knowledge base, new technologies, and enhanced human and institutional capacities that needs to be harnessed to create sustainable and resilient food systems towards achieving the United Nations (UN) Sustainable Development Goals (SDGs) of reducing hunger, malnutrition, and poverty. These aspiring goals will require enhanced cooperation and collaboration among the global community to mobilize knowledge, information, and technologies through innovative partnerships. We live in an information and knowledge intensive interconnected world. With the advances in information and communication technologies (ICT), the world has become a global village with reduced distances and boundaries. The ICT and social media tools are now making classrooms global and have opened new doors to share information and knowledge widely in a very rapid and cost-effective way.

Digitalization in now offering agricultural sector a faster pathway to recovery from the COVID-19 crisis. Challenges such as lack of digital skills, poor connectivity, and lack of investment in relation to smallholders remain part of the barriers that need to be addressed. Rural and urban digital divides need to be addressed by connecting cities to rural villages.

**Michigan State University Building Global Knowledge Partnerships:** International cooperation and collaboration are hallmarks of Michigan State University (MSU) https://msu.edu/. As a Premier Land-Grant University in the U.S., MSU remains at the forefront of building global knowledge partnerships. As the founding college of MSU, the College of Agriculture and Natural Resources (CANR) has three core missions: Research, Education and Extension, which are implemented in collaboration with a diverse range of stakeholders and multiple levels of national and international partnerships. These programs aim to explore creativity in many forms, to enhance human and institutional capacity and build global knowledge networks. The faculty members and students are actively engaged internationally through collaborative research, education, training, outreach and technology transfer programs in more than 60 countries covering all geographic regions of the world. These programs encompass diverse areas of food, agriculture, and natural resources worldwide.

**World Knowledge and Technology Transfer Program (WorldTAP):** Prominent among various programs of MSU is the World Knowledge and Technology Access Program (WorldTAP) in the College of Agriculture and Natural Resources (https://www.canr.msu.edu/worldtap/) The WorldTAP is a training, capacity building and technology transfer program of the College of Agriculture and Natural Resources (CANR). The WorldTAP programs aim to share knowledge and experiences of MSU and harness knowledge and expertise from the national and international partners of MSU towards building global knowledge partnerships in diverse areas of agriculture.

The WorldTAP global platform has allowed MSU to share the wealth of knowledge, expertise and experiences in diverse agricultural research and development topics with academic and non-academic stakeholders internationally and has created a vast global knowledge network to address pressing global challenges. The WorldTAP offers a basket of educational programs in diverse areas of agricultural

higher education, harnessing expertise and experiences of MSU faculty members along with expertise from U.S. and international universities, private industry, government and non-governmental organizations.

The WorldTAP programs include international short courses, workshops, internships, study tours, webinars, etc., in cutting-edge areas of agroecology and sustainable agriculture, agricultural biotechnology, molecular plant breeding, integrated pest management, food processing and value addition, food safety, biosafety, intellectual property rights & technology transfer, animal agriculture, zoonotic diseases, bioenergy, science communication, among others. These educational and training programs are offered at MSU as well as internationally in various regions of the world in collaboration with global partners. The WorldTAP programs are supported by various international development agencies, foundations, public and private organizations, and non-governmental organizations.During the COVID-19 Pandemic, some of these programs have been offered virtually using social media and digital tools. These diverse sets of educational and learning programs have provided learning opportunities to students and scholars at MSU and to diverse stakeholders from international community including scientists, academicians, policy makers, regulators, lawyers as well as representatives from NGOs, media and private industry. The WorldTAP platform has also created numerous opportunities for MSU and the international community for collaborative research, extension, and technology transfer. During the past 25 years, more than 12,000 academic and non-academic stakeholders from the global community have benefitted from the WorldTAP Programs and have resulted in numerous joint publications.

## Innovative Regional and Global Platforms at Michigan State University:

The International Studies and Programs (ISP) (https://www.isp.msu.edu/) at MSU serve as an excellent university-wide unit for advancing international cooperation and collaboration. The area and thematic studies center of ISP connect MSU faculty members to specific geographic regions of the world (e.g., African Studies Center, Asian Studies Center, Latin American and Caribbean Studies Center). Among many programs of ISP, two regionally focused platforms that are actively promoting global knowledge partnerships include: The Alliance for African Partnership and AsiaNexus.

**Alliance for African Partnership (AAP):** The AAP (https://aap.isp.msu.edu/) is a consortium of MSU, ten leading African universities, and a distinguished network for African research institutes. AAP takes a cooperative approach to addressing global challenges by building networks across all sectors- including universities, NGOs, government, and the private sector- to partner around core thematic areas including agri-food systems; water, energy, and the environment; culture; youth empowerment; education; and health and nutrition.

**AsiaNexus:** The AsiaNexus (https://asianexus.isp.msu.edu/about/) offers an enhanced platform at MSU for expanded faculty and student engagement in Asia by engaging key partners, exploring new strategies to co-fund and leverage investments, and facilitating collaborations to advance integrated research and novel academic programming. AsiaNexus partners and research teams are creating a synergistic network of networks within and across Asia region and the world in order to advance the frontiers of knowledge while building capacity among all partners to address global challenges, particularly within the context of food and agriculture, education, health and nutrition, energy, environment and natural resources.

**USAID Feed the Future (FfT) Innovation Labs:** MSU manages two of the USAID Feed the Future Innovation Labs:

1) **Food Security Policy, Research, Capacity and Influence (PRCI)** Innovation Lab https://www.canr.msu.edu/prci/ which is partnering to strengthen local and regional capacity for policy research and influence in pursuit of sustainable, inclusive, and healthy agrifood system transformation
2) **Legume Systems Research Innovation Lab** https://www.canr.msu.edu/legumelab/about_us/ which focusing on research capacity building development program on grain legumes in West and Southern Africa.

## Way Forward in Building Global Knowledge Partnerships:

The food systems are becoming global and knowledge intensive. Food systems challenges are multi-faceted and complex. No single institution alone can effectively address these challenges. The transformation of food systems will require a focus on creating enabling policies, acceptance of new technologies, enhanced

institutional capacities, human-centered approaches, and transformative leadership. As the global community moves forward, multiple levels of innovative partnerships and networks involving all the key stakeholders will be required so that knowledge, information, and technologies can flow and be exchanged at all levels using modern digital tools. Greater efforts will be required towards creating community-university-industry-government partnerships that can leverage policy and institutional changes to support stronger, sustainable, and resilient food systems in both rural and urban settings.

The role of the private sector in food systems is growing. The relationship between universities and industry needs a transformation to create new forms of strategic partnerships that go beyond the traditional exchange of research for funding to co-creation of knowledge, technologies, and human capital. The disruptions in food supply chains caused due to the COVID-19 Pandemic has strongly emphasized the need for developing local food systems. Scientific transformation of the food systems will need to ensure that the people have access to nutritious and healthy food that is produced in a more environmentally friendly way and safeguard a healthy planet for current and future generations.

To reduce hunger, malnutrition and poverty, the global community will need programs that utilize digital tools, social media and networks that link together national and international organizations so that stakeholders across disciplines can work together towards building effective global knowledge partnerships. Lessons learnt from MSU's long standing global engagement indicate that knowledge is critical to improve development effectiveness of all its partners engaged in the agricultural and food sector and this can happen when all stakeholders learn systematically and collectively from the partnership programs by sharing experiences which includes rural and urban people and local organizations to deliver high quality services to overcome poverty and influence policies. New knowledge sharing programs will continue to be important to address the rapidly changing environment in food systems. MSU's programs for the future will continue to strengthen its knowledge sharing and learning process along with its international partners by fostering partnerships for broader knowledge sharing and learning, and promoting a supportive knowledge sharing and learning culture globally.

# Predictions, Perceptions and Reflections of Dynamism in Agricultural Marketing and Trade

**Professor. N. Kumar**
**Vice-Chancellor**
**Tamil Nadu Agricultural University**
**Coimbatore India**

Agricultural Marketing and Trade has been well recognized as an institutional mechanism to achieve the developmental objectives such as higher agricultural growth, food security and sustainability. Markets facilitate commercialization and diversification in agricultural production and play crucial role in connecting producers and consumers across regions, and countries. Domestic markets could reduce the cost of food and stabilizes the food supply, which are the key to assure food security particularly in developing countries. Well established domestic markets also open up opportunities for value addition and employment. Over the past decade, international agricultural and food markets have witnessed a number of changes, which have brought domestic and international markets closer together. Since 2000, trade in agro-food products has grown strongly – more strongly than in the preceding decade at close to 8% in real terms annually between 2001 and 2014 compared to 2% between 1990 and 2000 – as world markets responded to a more rules-based trading environment, falling tariffs, and reductions in trade-distorting producer support. Global agricultural production has also continued to increase, driven by rapid growth in a number of developing regions, in particular those of Asia and South America.

Liberalization of the economy across countries and the process of globalization led to transformation in agricultural production in the form of "***production oriented marketing"*** to "***market oriented production"***. Farmers have to transform themselves from mere producers-sellers in the domestic markets to producer cum seller in a merging global market to increase farm income and profitability. The rapidly changing face of agriculture calls for a redefining of priorities and alternate management strategies. It is crucial that farmers have to become active participant in the marketing system in general and supply chain management and value chain in particular.

The stakeholders in agriculture should have market consciousness and a grasp of the intricacies of market oriented production techniques to be able to handle the new challenges.

In spite of different hurdles, the agricultural marketing sector still plays dominant role in both the developed and developing economies. There is need for integrated effort and regulations oriented towards the marginal and small holding farmers rather than general policies. In the present context of market oriented agriculture there is need of vibrant market information systems, new approaches in marketing such as, IoT in Agricultural Marketing (eg.AGMARKNET in India), e-Marketing, Supply chain, block chain, Artificial Intelligence, etc. My perceptions and predictions pertaining to the recent advent of above developments will make more dynamism in the area of agricultural marketing and trade across the globe. Further, the forward and futures market have the potential for national level market integration but it needs reforms to suit the Indian farmers. Mainstreaming these market models will definitely lead stable market and less price volatility and safeguard both producers and consumers.

## 2. Current Challenges

- ***International Trade***

The agricultural markets and trade is facing many challenges. The agricultural food trade is not only increasing but also becomes global today. A growing share of agro-food trade is taking place in global value chains (GVCs) – agricultural and food processing value chains that are spread over several countries – linking agro-food sectors and other sectors of the economy from across the world. On the one hand, the agro-food markets have evolved globally, however, on the other hand, many countries continue to extend support and impose trade barriers through measures that distort trade and limit the benefits that international agro-food markets can deliver for consumers. These measures continue to have significant and negative effects on the welfare, resilience and food security of consumers and producers, as well as on agricultural sustainability, and also reduce agricultural and food trade volumes. Hence, in order to increase agricultural production and trade across countries, there is a need for removing the distorting supports.

Globally, around 24% of agro-food export value comes from imported inputs: industrial inputs (machinery and fertilizer) and services, as well agriculture and

food. Trade policies that act as barriers to imports directly reduce the competitiveness of a country's own agro-food exports by raising input costs. Other measures that affect the flow of agro-food products across borders can also reduce trade include: (i) Non-tariff measures (NTMs) – those related to laws, regulations and requirements such as sanitary and phyto-sanitary measures (SPS), technical barriers to trade (TBT) and customs procedures – can increase trade costs. Since agro-food products in Global Value Chains (GVCs) may cross borders multiple times before reaching final consumers, those trade costs can have significant ripple effects and are most problematic for smaller businesses. While NTMs are in place to achieve legitimate regulatory goals, they can restrict trade depending on how they are designed and enforced.

- ***Domestic Agricultural Marketing***

Many researchers over the period in India found that the major challenges in marketing include fragmented markets, insufficient markets, marketing fees and charges, inadequate market infrastructure, post-harvest losses, restrictions in licencing, high intermediation costs, information asymmetry, and inadequate credit facilities. These challenges hinder the agricultural marketing in the country. Farmers face various problems right from their farm to terminal marketing points. Most of the farmers are small cultivators and their marketable surpluses are also small. The important problems in marketing farm produce are high transportation charges, loading and unloading expenses, market fees and commission apart from incorrect weights, and unwanted deductions. In addition, poor storage and cold storage facilities, superfluous middlemen, and unauthorized deductions also form major constraints. These problems led the farmers to get poor share in consumer's price. They get around only 50 per cent of the consumers' rupee particularly in the case of perishable commodities. The middlemen who perform various market services share large portions of the consumer's rupee.

In spite of creating orderly marketing facilities such as cooperative marketing societies, regulated markets and farmers' markets in the organized sector, a major chunk of the farming community still depends on private agencies for marketing their commodities. The gap between the farmers and marketing institutions still persist far and wide. It is reported that only about 12-14 per cent of the total agricultural produce traded goes through the institutional markets established with huge public investments.

- **Landscapes in Agricultural Marketing and Trade**

In order to achieve better marketing and increased farmers share in consumer's price and farmer's income, the governments in both developed and developing countries introduce various reforms and market models. The recent developments in agricultural marketing include (i) agricultural marketing information network (AGMARKNET), (ii) Information Technology in Agricultural Marketing, (iii) Electronic National Agricultural Market (e-NAM), (iv) Integrated Agri-supply chain management, (v) Block chain technology, (vi) FPOs in Agricultural Marketing, (vii) Artificial Intelligence in Agriculture Market and Trade, (viii) Agricultural Commodity Futures Market, (ix) Contract Farming, and (x) Marketing extension, Training and Research

**The Way forward**

The government policies play critical role in providing an enabling environment that can promote agricultural productivity growth and enhance the competitiveness of agro-food exports and participation in Global Value Chains (GVCs) through appropriate investments including transport infrastructure, education and research and development.

An alternative marketing systems need to be developed to promote direct marketing, smooth raw material supplies to agro–processing industries, competitive trading, organized retailing, information exchange and adoption of innovative marketing systems and technologies. The market models such as Contract farming, FPOs, Farmers markets, e-marketing, commodity futures, Artificial Intelligence in marketing and block chain technology should be considered for upscaling and mainstreaming so as to achieve many benefits in the marketing of agricultural produce both in developed and developing economies.

Credit flow to agricultural sector needs to be enormously increased to meet increasing demand for capital investments for developing marketing infrastructure and for pledge finance. Pledge financing enables the farmers to take advantage of favorable prices and improve their net margin.

Information Technology including Internet of Things (IoT) and Artificial Intelligence (AI) and Big Data analytics need to be extensively promoted in agricultural marketing to generate useful databases and information packages for

expanding marketing opportunities, especially for online information on demand and availability of different products; product specifications with regard to price, quality, pack size, packaging material, quantity and the time frame of supply.

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# Climate Change Adaptation in Agriculture: An Economic Perspective

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Climate change represents long-term modifications to the temperature, precipitation, wind patterns, and other meteorological parameters. Many physical effects of climate change are already being realized including altering the frequency and intensity of hot and cold days, extreme events, and sea-level rise. Sri Lanka being an island is often susceptible to climate-induced extreme weather events such as floods, landslides, and droughts. Mitigation and adaptation are the two approaches available to address the climate change impacts. Climate mitigation refers to actions taken to eliminate or reduce the risks and hazards of climate change whereas climate adaptation deals with adjustments to reduce potential damage and cope with the consequences. From the development nations' context, adaptation is the most feasible intervention. There are different types of adaptation strategies, local, national and regional, or sectoral.

Agriculture is a central issue in the climate change debate, mainly due to its direct links with land and water use, rural livelihoods, and food security. The climate change impacts on agricultural production depend on the combination of temperature, precipitation, and carbon dioxide concentration, accompanied by other related factors. It could influence agriculture in numerous ways including a reduction in productivity, changes in agricultural practices through changes in water use and agricultural inputs, and reduction of crop diversity (IPCC (2014). Such impacts of climate change on agriculture depend upon the variations in local climates rather than in global climate. Meantime, agriculture is also a culprit as it contributes to global warming by releasing greenhouse gases. Of the two main types of adaptations, autonomous adaptation includes the reaction to climate change such as changes in crops or varieties or planting dates. The other, the planned adaptation approaches are policy options that are mostly multi-sectoral aiming at enhancing the adaptive capacity of the institutions or people.

The adaptation measures can be supply-side measures (such as providing more water), demand-side measures (such as reuse of water), or combinations of both. Some of the important adaptation measures in agriculture include crop diversification, mixed crop-livestock farming systems, using different crop varieties, changing planting and harvesting dates, and mixing less productive, drought-resistant varieties and high-yield water-sensitive crops (Bradshaw et al. 2004). While some measures may be taken at the individual or farm level, others require collective action (rainwater harvesting) or investments at the agency or government level (for example, building dams, releasing new cultivars that are more water-efficient) (Jawahar and Msangi 2006). The assessment of farm-level adaptation is vital to formulate policies as a tool for managing a variety of risks associated with climate change in agriculture. Although climate change is one of the utmost challenges confronting humankind, the economics of climate change impacts and adaptation have received relatively inadequate attention. With the escalating climate change impacts, it is needed to make informed decisions on the long-term costs and benefits of investing in different adaptation projects and strategies. In this context, economic analysis plays a vital role in identifying adaptation needs, designing adaptation strategies, and evaluating their feasibilities. In other words, the economic analysis is helpful to decision-makers in developing countries to assess the climate change risks and design appropriate adaptation strategies. Simply, the economic analysis is useful in identifying and evaluating efficient adaptation measures and deciding the necessary actions and their timing, i.e. what, where, and when adaptations should practice. In agriculture, the analysis pays the way to screen the successful adaptation practices and their impacts on crop productivity. In the presence of anticipated climate change risks, such economic appraisal is supportive to make evidence-based decisions on the value, efficiency, and feasibility of adaptation projects and strategies.

The aim of any adaptation action, whether private or public, is to maximize the social net benefits. In practice, this objective is accomplished by using the cost-benefit analysis. However, the cost-benefit analysis for the evaluation of climate change adaptations is rather different from a normal economic appraisal, as it takes into account different time scales, dynamics, and multiple sources of uncertainties. This is because, there are various sources of uncertainties in adaptation such as lack or conflicting information, measurement errors, the subjectivity of opinions.

The analysis of the economics of adaptation supports a policy-orientated approach with a greater emphasis on mainstreaming adaptation into current policy and development. Realistic estimates of climate change impacts require the use of biophysical models, but these models are highly diverse in terms of assumption, data needs, and structure.

The challenges of economic analysis of adaptation include uncertainty about the future; unavailability of baselines; distributional impacts; discount rates and time horizons; mixing monetary and non-monetary evaluations. The other challenge in the analysis is the need for consideration of social aspects such as how vulnerability to climate change is socially differentiated, what elements are needed to strengthen the adaptive capacity of poor people and regions, and how governments can support adaptation that addresses the needs of the poorest and most vulnerable while maximizing co-benefits with development goals.

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# Abiotic Stress Management and Crop Diversification

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Abiotic stresses such as drought, high temperature, salinity, cold and frost reduce crop productivity. The challenge is not only to raise agricultural production for an expanding population, but also to achieve this under more adverse environmental conditions. Because of the larger impact these stresses have on crop yields, many plant biologists also target increased tolerance to stress as a major route to crop improvement. About 90 % of global agricultural land faces the distress of these abiotic stresses limiting crop production up to 70 %. These climate-induced challenges are intensifying, causing socio- economic insecurities as well as nutrition and health challenges, particularly in marginalized communities. Furthermore, climate-change impacts have put an additional pressure on already stressed natural resource base, reducing the resilience of agro-ecosystems that are, in part, providing food and nutritional security in rural communities.

There are two major strategies in management of abiotic stress i.e., crop improvement approach consisting of developing stress tolerant varieties and soil and crop management approach consisting of following soil and crop management practices (package of practices). Many abiotic stress-tolerant crop varieties have been developed by conventional breeding. However, conventional breeding is a time consuming and labor intensive approach. In the past few decades, the genetic engineering approach has attracted the interest of the research community for producing stress-tolerant elite crops. Genetic transformation with stress-inducible genes has been employed by the researchers to gain an understanding of their functional role in stress tolerance and ultimately to improve the traits in the target genotype. The genetic manipulation techniques including insertional mutagenesis have largely contributed to deciphering the function of genes and thereby identifying the suitable candidates for crop improvement.

However, though success has been achieved in introducing desired tolerance traits into various crop varieties from wild relatives like barley and tomato, only restricted success has been reported in achieving abiotic stress tolerance with elite germplasm. Moreover, the integration of transgenes into the host genome is sometimes non-specific and unstable. Similarly, QTLs identified for one background does not perform best under different other backgrounds. Similarly, issues are still present with the transgenic plants developed for combating with heat and drought stress. Most of the transgenic plants developed are not tested under field conditions therefore; their performance under the field conditions is yet a question mark. The use of conditional promoters driving gene expression at specific developmental stages, in specific tissues/organs and/or in response to specific environmental cues, circumvents this problem and will make possible the generation of transgenic crops able to grow under various abiotic stresses with minimal yield losses (Fahad *et al.,* 2017).

There are 400,000 plant species identified on the planet out of which 30,000 are known to be edible with only 6000 being used as food. Further only 150 crops are cultivated on significant scale worldwide, dominated by only three crops viz., maize, wheat and rice that supply nearly 60% of our daily protein and carbohydrate (FAO Commission on Genetic Resources for Food and Agriculture, 2019). A staggering 75% of crop diversity has been lost in the course of last century (an estimated 300,000 varieties). Just twelve crops together with five animal species provide 75% of the world's food, and of the 137 most important crops in the world, 20 are cultivated over 80% of the global agricultural area and the remaining 117 on a mere 20%. These trends are worsening every year. The lack of genetic diversity within the gene pools of these few crops leaves our agricultural systems vulnerable to pests and diseases, and to abiotic stress. Under such circumstances, apart from searching for wild relatives which will serve as donors for developing abiotic stress tolerant varieties, identifying suitable alternate crops (crop diversification) which will come up well under such disadvantaged conditions and also will give some yield and income to the resource-poor farmers is required. These alternative crops have great untapped potential to support smallholder farmers and rural communities by improving their income level and food and nutritional security while also sustaining the genetic resources needed to address present and future environmental challenges.

Alternative crops, also called orphan, abandoned, neglected, lost, underutilized, local, minor, traditional, niche, or underdeveloped crops, are part of a large portfolio of useful species which are marginalized, if not entirely ignored, by researchers and policy makers. They are non-commodity crops and belong to a large, biodiverse group of thousands of domesticated, semi-domesticated or wild species having great potential: hardy and highly nutritious, these cereals, millets, fruits and nuts, vegetables, pulses, roots and tubers, oil seeds, latex/rubber/gums, fibres, starch/sugar, and dye form a universe of tastes and flavors that have been shaping traditional systems everywhere. They may be a well-established major crop in one country and a neglected minor crop in another. However, these alternative crops differ from major staple crops in fundamental ways such as traditional method of cultivation, use of informal seed sources and involvement of strong gender element. These alternate crops are preferred because of their adaptability to harsh environment, multiple utility, high nutritional quality, low input requirement (eco-friendly) and high risk bearing capacity i.e. resilient nature.

The issue of climate change compels agricultural scientists to combine multiple abiotic traits into a single genotype (salinity and submergence, submergence and drought, salinity and drought, and salinity-submergence-drought) because these traits co-exist in a single cropping season. Combining such multiple abiotic stresses, using multi-parental populations, using genotyping platforms and incorporating molecular breeding and QTL effect will be the future direction in domesticated crops. Apart from these, identifying suitable alternate crops by crop diversification approach is the need of the hour.

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# Improve Cattle Reproductive Performances in Hot and Humid Environment

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Thermal or direct climatic aspects of the environmental factors influence the cow's ability to eat, maintain heat balance, produce milk and reproduce. In a thermal environment the animal's heat production exceeds heat loss, an increasing amount of heat is stored in the animal's body, resulting in increased body temperature. Hyperthermia directly alters and impairs the cellular functions of various tissues of the reproductive system. Furthermore, exposure of cattle to thermal or heat stress elicits indirect responses, which may also have an impact on reproductive processes. Such responses include redistribution of blood flow among body organs, reduction in food intake, respiratory alkalosis, etc. Thermal or heat stress -induced reduction in reproductive performance is due to the accumulation of the effects of several factors. Thermal or heat stress alters the proper functioning of Hypothalamic–hypophyseal–Gonadal axis, and affects directly on individual reproductive organs, the uterus oviducts and ovaries. The effect on corpus luteum and follicles resulting the alteration of oocyte development and sex steroid production leads to compromise the uterine and oviduct environments for proper oocyte maturation, fertilization, early embryonic development and implantation. The reduction in sperm quality further contributes to infertility. Beside those direct actions of thermal or heat stress on reproductive performance, the indirect actions mediated through alterations in energy balance. In thermal or heat stress dairy cows there is a reduction in dry matter intake, which prolongs the period of negative energy balance. The negative energy balance-leads anovulation would further decrease fertility in dairy cows. The effects of heat stress can be minimized via adapting suitable scientific strategies comprising of physical modifications of the environment, nutritional management and use of breeds that are less sensitive to heat stress. In addition, adopting advanced reproductive technologies including hormonal treatments, timed artificial insemination and embryo transfer etc. may help to enhance the chances for establishing pregnancy.

# ABSTRACTS

# Agricultural Economics, Entrepreneurship and Agribusiness Management

# Perceived Social Identity based on Affiliation to Natural Commons within the Community: A Case study in a Tank Cascade System in Sri Lanka

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This study investigates how the farmers who are receiving environmental services from the Mahakanumulla Tank Cascade System (MTCS) in Anuradhapura district perceive their social identity based on their affinity to the natural commons (i.e., village tank and water channels) they are benefiting from. First, following a psychometric research paradigm, the study attempted to design a measurement scale to gauge the perceived social identity of the individuals in the study population. Second, with reference to the study population, the study attempted to investigate how the perceived social identity of the MTCS inhabitants varied with their demographic characteristics. Data were obtained from a cross-sectional survey of 463 randomly selected adult village respondents in 13 village communities of the MTCS. Structural Equation Modelling (SEM) was employed to evaluate the validity of the measurement model. The results confirmed the validity of the model. As depicted in the validated measurement model, perceived social identity had two dimensions; (1) consciousness of belonging to the group and (2) affection generated by belonging to the group. Construct means of the above 2 dimensions of the scale were moderately high in the study population. This indicates that the individuals of the MTCS communities maintain a high sense of identity as recipients of environmental services from the MTCS. Perceived social identity significantly ($p<0.05$) varied in terms of respondents' certain demographic characteristics. Fulltime farmers showed a higher social identity compared to the others who had engaged in off-farm income activities as their mainstay. Farmers who owned farmlands showed higher perceived social identity than the farmers without their own farmlands. Smallholder farmers reported a higher social identity than the farmers with relatively large-scale holdings. Older farmers (> 48 Y) showed higher social identity compared to the younger farmers. This study has implications for designing and restructuring participatory management strategies to ensure sustainability of natural commons such as village tanks.

**Keywords:** Natural commons, Mahakanumulla tank cascade system, Perceived social identity, Structural equation modelling

# Incorporating Stakeholder Preferences for Effective Management of Hikkaduwa Marine Protected Area: A Multicriteria Analysis

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Marine Protected Area (MPA) is considered a successful method for managing marine resources. There are four marine protected areas in Sri Lanka. It is widely understood that effective stakeholder participation is key for sustainable management of MPAs around the world. Thus, this study aims to explore the stakeholder preferences for better planning and effective management of the Hikkaduwa MPA. A Multicriteria decision analysis tool was employed to analyse the perceptions of different stakeholder groups. A purposively selected sample of respondents were surveyed using a structured questionnaire. The sample included five key stakeholder groups including local households, students, academics, fishermen and government officials. The expert respondents were posed with statements reflecting key dimensions pertaining to management; biological, environmental, socio-economic, institutional and psychological. Weighting and scoring of the responses were carried out using an analytical hierarchy process. Results revealed that the highest importance was given to biodiversity conservation by the respondents while the lowest importance was indicated for psychological factors related to MPA. Fishermen and other households in the surrounding, who are resource dependent placed a high importance on the socio-economic benefits, which signals that the accessibility and use values for the community are essential concerns in MPA planning. Therefore, promoting an active participation of all key stakeholders in the complete decision-making process considering their objectives and perceptions are crucial for sustainable marine resource planning and management.

**Keywords:** Analytical hierarchy process, MPA, Multi-criteria analysis, Stakeholder preference

# Small and Medium Enterprises' Impact on Achieving the Sustainability in Agricultural Sector for Rural Development

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In the journey towards the sustainable development, the agricultural sector plays a major role in socio economic context. Many successful governments have taken the necessary steps to develop the agricultural sector in the light of policy implications. Sustainable development in the agriculture sector ensure food security, creating employment opportunities, mitigating wastage, alleviating poverty, and improving living standards while achieving higher economic growth. This study scrutinized the challenges and prospects of the agricultural sector in reference to SME. The study aimed to promote SME as an effective tool for empowering agriculture in the rural sector along the journey of sustainable development by examining the current status, challenges, and prospects of SMEs to promote sustainable agriculture for rural development and direct policymakers towards effective and efficient policy implications for Agricultural SME in Nuwara Eliya and generalize it upon the success. Data were collected using convenient sampling method. Qualitative research methods such as in-depth analysis of literature, semi-structured questionnaire interviews, farm observations, focus group discussions, key informant interviews were employed to collect data from 40 respondents. The thematic analysis was performed and found that the small medium enterprises employers and employees commonly expressed the fact that their existing production practices are not at their highest level and that fact hinders the progress towards sustainable development in their production. The main reasons according to them were, fragmentation of land, high cost occurrence for inputs, lack of knowledge, inefficiency in production, distortion of markets, government, and market failure, lack of efficient infrastructure, misappropriation of fertilizer usage, lack of skills, and young energetic workers tend to leave farming and migration to the industrial sector. The empirical evidence of this study confirms that the relevant authorities should address the persisting government failures, market failures asymmetric information, the attraction of public-private investment, the introduction of novel technologies, and business development strategies. The findings further confirmed the urgency of sustainable policy planning and implication, a strong legal system to strengthen the economies of scale, development of infrastructure facilities in terms of logistics, communication, financial aspects, and encouragement of youth towards agricultural activities.

**Keywords:** Agricultural development, Policy Implications, Small Medium enterprises

# Coupling of Agriculture with the Tourism for the Sustainable Livelihood Development of Small – Scale Farmers (Special Reference to Southern Province)

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Agrotourism is which is also known as a type of rural tourism. Many parts of Sri Lanka are still didn't attained that much of urbanism therefore, those areas acting as preserving grounds for the rural agricultural characteristics. Couple agriculture with the tourism as an Agri - entrepreneurial sector, an alternative tourism sector which could be a strategical method to involve more women and youth in to agricultural area in the Southern province in order to improve their livelihood in a sustainable manner. This study carried out based on the grounded theory method since the research work was a social study which have been done thorough focused interviews with the 50 small-scale farmers and fishermen and 20 surrounding community people in Dikkubura weekend farm and paddy cultivation, Stilt fishing at Koggala and Home Gardening and fishing village at Kahandamodara. A questioner was performed by 20 local and foreign visitors to Sri Lanka. The feeding grounds of the research were selected for reason of practicing ecological agriculture. As the parameters View on community based agrotourism by farmers and fishermen, View on economic, social and environmental impacts of community based agrotourism by the community, Knowledge about the agrotourism, expectations from the agrotourism by tourists were measured. Participants were had positive perceptions regarding the impact of agrotourism on economy than its negative with higher difference where social and environmental impacts also showed positive but with minor difference than the negative. The interviews were coded and a theory was derived and it was concluded that there is a generation of conflict between government and community regarding agro tourism establishment though it had huge potentials.

**Keywords**: Agrotourism, Ecological agriculture, Small scale farming

# Impact of Gender on Consumers' Agreeableness on the Structural Ecological Cues in Environmentally Friendly Food Packaging

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The concept of environmentally friendly packaging is at its initial stage yet in the Sri Lankan context in particular. However, environmental sustainability is the main focus of the world in which the environment is deteriorating terribly at present mainly due to non- degradable packaging. Packaging structural ecological cues referred to the cues that relate to the structure of packaging mainly concerned the reduction of its structure, the quality of packaging materials (recycled, recyclable, from renewable sources), and reusability of the package itself. Since consumer behavior is highly attached to the gender of the consumer and gender is considered as the main demographic factor vital in purchase decision-making by individuals, the main objective of this study was to identify the impact of gender on consumers' agreeableness on the nature of packaging material used in food products packed in an environmentally friendly manner with special reference to dairy products. A pre-tested structured questionnaire was distributed among the consumers visiting the Cargills Food city outlet located at Galgamuwa facing Kurunegala-Anuradhapura main road, Sri Lanka by using a simple random sampling technique (time randomization). The sample size consisted of 104 consumers selected by randomizing time segments during shopping hours. An independent sample t-test was used as the main analyzing technique according to the results; the sample consisted of 82% females and 18% males. There was a significant difference ($t(102)=-2.453$, $p=0.016$) between males and females in agreeableness towards the usage of minimum packaging material for eco-friendly packages. Male respondents ($M=0.26$, $SD=0.991$) agreed with using minimum packaging material for food products more than their female counterparts' use ($M=-0.33$, $SD=0.944$). Therefore, when designing a package for dairy products targeting male consumers, a minimum amount of packaging material should be used as a means of attracting more male consumers towards the product. From the environmental perspective, minimum use of material for food packages leads to lower environmental deterioration and efficient utilization of limited resources. The present findings are important for product/package designers, policymakers, environmentalists in particular.

**Keywords:** Environmentally friendly, Gender, Packaging, Structural ecological cues

# The Impact of COVID-19 on Agribusiness Sector: Views of Selected Agribusiness Companies in Sri Lanka

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COVID-19 is an ongoing threat to all over the world and causes the worst economic tremor in recent years. Sri Lanka is one of the most vulnerable developing countries that can be observed a detrimental effect on the economy with a reduction of GDP growth rate in 2020. As agriculture is the backbone of the Sri Lankan economy, the study aims to identify the effects of COVID-19 on the agribusiness sector in Sri Lanka and to examine their coping strategies. The pre-tested questionnaire was sent to purposively selected 50 agribusiness companies in Sri Lanka and 32 responses were received within 7 days of data collection. Collected primary data were analyzed by using descriptive statistics and Chi-square test. According to the responses, COVID-19 has a negative impact on 59.4% industries and 56.3% of businesses' monthly revenue was badly affected. Chi-square test illustrates that the economic impact of COVID-19 has a significant association with the scale of the business ($p=0.043$), while no relationship is shown with the business type ($p=0.186$). A significant relationship was exhibited between the impact of COVID-19 on the business' monthly revenue and its scale ($p=0.013$). Majority (40.6%) have no significant changes in their business mind and mainly they have faced labor shortage problems (65.6%). Further, 46.9% industries were worried about the impact. The agribusiness sector implemented web advertising (71.9%), e-commerce platforms (53.1%), door-to-door delivery mechanism (31.3%) and explored alternatives/new markets for their products (25%) as the coping strategies during COVID-19. Moreover, they have implemented sanitation practices (81.3%) as the employee management strategy. Financial support (75%) helped them to mitigate the pandemic effect while they have gained the opportunities of repayment of capital by banks under refinance schemes (65.6%). At present, the majority of the agribusiness companies (25%) are facing transportation/shipping problems. The research findings have discovered that the novel pandemic has a negative impact on Sri Lankan agribusiness industries. Even though the agribusiness companies have taken immediate measures to withstand this sudden unexpected risky situation, the government assistance is further required for them to have continuous business operations and market access.

**Keywords:** Agribusiness companies, Coping strategies, COVID-19, Impact

# Farm Households' Willingness to Pay for Sustainable Soil Fertility Management in Vadamaradchy South West Division of Jaffna, Sri Lanka

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This study investigates the farm household's willingness to pay for sustainable soil fertility management attributes and find the socioeconomic and demographic factors that influence the soil fertility management in red onion farms in the Vadamaradchy south west division of the Jaffna district. Applying only chemical fertilizer excessively in agricultural farms for a longer period leads to soil fertility degradation and underground water pollution and thus becomes an obstacle to achieve sustainable development goals. Sustainable soil fertility management attributes considered in this study are increase in yield, micronutrients, water holding capacity, soil porosity, beneficial nematodes in the soil and cost of production. For this study, 170 farm households were randomly selected from Vadamaradchy south west division and data were collected by interviewing them using a structured questionnaire. Choice modeling was employed, and a conditional logit model was developed to estimate willingness to pay for sustainable soil fertility management attributes. This study shows that farm households are willing to pay more for a big increase in yield that is a significant benefit to the farmers in the short term. On average, farm households are willing to pay around 10, 800 rupees per lacham for a big increase in yield by practicing sustainable soil fertility management. Farm households are willing to pay less for the attributes that provide significant benefits in the long term. Farm households are willing to pay around 920 rupees and 1900 rupees per lacham for a small increase in micronutrients and a big increase in porosity respectively. Farmland ownership, farmer education level and farm extent positively influence the willingness to pay for sustainable soil fertility management. The findings of this study would be useful to policymakers to formulate programs that promote sustainable soil fertility management.

**Keywords:** Choice Modeling, Conditional Logit Model, Soil Fertility, Willingness to pay

# Tobacco Cultivation during European Period - A Historical Prospect Focused on Jaffna Peninsula

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Jaffna Peninsula is situated in the Northern part of Sri Lanka. This Peninsula had been under control of the colonialism of Portuguese in AD 1505. In this context, Dutch and British followed Portuguese and colonized Jaffna Peninsula. While the main purpose of the Europeans' arrival had been for the economy, they gave the second place to religion. They had not only utilised the economic resources of the natives, but also tried to gain extra income by cultivating the crops of their countries. In such situation, Portuguese introduced tobacco cultivation during European colonial period, particular in AD 1636. Yet, tobacco was not cultivated like other crops at estates such as tea, rubber and coffee which were brought during the European colonial period. However, they did not fail to use tobacco as an exporting media for the achievement of economy during the period of Europeans in Jaffna Peninsula. Particularly, there was abundance of response in Thiruvankoor for Jaffna tobacco since they were dried and soaked in salt water. Hence, the trade of tobacco had started to flourish between Jaffna and Thiruvankoor during the Europeans reign. Although tobacco had been exported in the periods of Portuguese and Dutch, no one can reject that the tobacco cultivation and export had reached its peak especially during the British period in the latter part of AD.18th century. The primary purpose of this study completely approached historically, clearly explains the importance of Jaffna tobacco cultivation achieved only for the Europeans income. In this study, the principal and secondary statuses of sources have been used considering the obligation of the study. Generally speaking, nevertheless the tobacco cultivation was introduced by Portuguese, it has reached its peak growth only during the English ruling. Further, no one can underestimate the importance of tobacco in Jaffna farmers' cultivation among their secondary crops even after the Europeans left Jaffna Peninsula three centuries ago.

**Keywords:** Export, Europeans, Jaffna Peninsula, Tobacco, Thiruvankoor

# Environmental Engineering, Irrigation and Water Management

# Spatial and Temporal Variation of Groundwater Quality at the Waste Management Site of Kotavila, Matara District

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Open dumping is the most common way of disposing of municipal solid wastes in developing countries. Municipal solid waste in Matara town is disposed of to an open dumping site in Kotavila waste management complex (WMC), threatening to ground water pollution. The study area lacks scientific studies to back claims of residents on environmental pollution by the WMC. The objectives of this study were to determine the water quality parameters in the groundwater (pH, Electric Conductivity, Hardness, Chloride, Sulphate, Nitrate, Dissolved Oxygen, Chemical Oxygen Demand) and the temporal variation of the above parameter and to prepare the groundwater quality maps to identify the possible groundwater pollution. Groundwater samples were collected from wells, natural ponds and paddy fields (12 sampling points) near WMC. These parameters were measured for 4 months (November 2019 - February 2020). Water quality maps were prepared using ArcGIS (10.6 version). The study revealed that the groundwater pH was ranged between 4.1 to 6.65 and nitrate was ranged between 51.06 mg $l^{-1}$ to 95 mg $l^{-1}$, which exceeded the WHO recommendations. Temporal variations of the parameters were noted in several months. The spatial distribution reveals that sampling point 7 showed the lowest groundwater level. Further, the water quality parameters recorded in sampling point 7 were also poor. According to the results of this study, the measured water quality parameters were within the recommended limit except for pH and nitrate and observed concentration gradients of chemical parameters towards the (sample point 7) north direction from the open dumping site. However, heavy metal contents of well water are essential to be measured to reach a firm conclusion about water pollution due to open dumping.

**Keywords:** GIS, Ground water quality, Open dumping

# Effect of Thermodynamics on Mancozeb Adsorption by Neem Chip Biochar

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Emerging contaminants (ECs) create threats to the well-being of all living organisms globally. Among ECs, fungicides could be easily leached into the water bodies to create water pollution. In Sri Lanka, the use of mancozeb in crop farming has climbed due to increased demand for food. There is a need for the effective removal of mancozeb from water using low-cost adsorbents. Therefore, an attempt was made to understand the thermodynamic effect to add new knowledge to the adsorptive mechanism of mancozeb adsorption by neem chip biochar. Biochar materials were prepared from neem chips at four different pyrolysis temperatures (300, 500, 700 and 900 ℃) using muffle furnace. An adsorptive experiment was done using pH of 5, initial concentration of 200 mg/L, dosage of 1 g/L and the temperature of 25 ℃. The biochar with best adsorptive performance (mg/g) was selected for detailed thermodynamic study at temperatures, 25, 30 and 40 ℃ using Van't Hoff equation. Results revealed that the biochar pyrolyzed at 900 ℃ (NBC 900) expressed the highest mancozeb removal percentage of 93.84 and the adsorptive performance 187. 68 mg/g compared to other biochars pyrolyzed at 300, 500 and 700 ℃. The change in Gibb's free energy (ΔG°) values at 25, 30 and 40 ℃ is -11.005 kJ/mol, -13.544 kJ/mol and -18.622 kJ/mol respectively. Based on this thermodynamic outcome, it can be concluded that the adsorption process of mancozeb by NBC 900 is spontaneous in nature. Positive enthalpy change (ΔH°) indicates that the adsorption process is endothermic and positive entropy change (ΔS°) indicates that the affinity of biochar on mancozeb adsorption is strong. Hence, this information is highly useful to study the effect of temperature on the removal of mancozeb by NBC 900 from the aqueous phase and helps understand affinity of biochar toward mancozeb adsorption for better design of adsorption systems.

**Keywords:** Biochar, Endothermic, Mancozeb, Pyrolysis, Thermodynamics

# Effect of Submerged Aeration on Soaking Water and Grain Characteristics of Paddy Parboiling Process

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Parboiling of paddy is an important industrial process. In general, paddy is immersed in stagnant cold water for 36 -72 hours with frequent water change at room temperature in order to obtain 30% wet basis (wb) moisture content. The effluent generated during the soaking process pollutes the environment severely because of its high Biological Oxygen Demand (BOD). Hence, an attempt was developed to test the novel submerged aerated soaking system with long paddy grains for reducing pollution effects and improving paddy grain characteristics. An automated water circulation was maintained in the submerged aerated soaking system using a motor and a timer. It was programmed with 70 minutes on-time and 20 minutes off-time. The water circulation was started after 12 hours of soaking based on Dissolved Oxygen (DO) concentration of soaking water and continued up to 30% (wb) grain moisture content. The control unit was set without aeration under similar scenarios. Long paddy grain was used in the experiment with 1:1.3 paddy: water ratio. Paddy characteristics, moisture absorption rate and elongation profile, were investigated during soaking. Changes in soaking water characteristics, DO, Total Solids (TS) and BOD of effluent, were also measured during the soaking. Results revealed that the submerged aeration yielded the grain moisture of 30% (wb) by 24 hours of soaking duration, whereas it took 48 hours for the soaking system without aeration. The DO in soaking water was reduced to 2.19 mg/L and 0.89 mg/L for submerged aeration system and a system with no aeration respectively at the end of soaking. The BOD value of submerged aeration and a system with no aeration was 600 mg/L and 1575 mg/L respectively. It is obvious that the submerged aerated soaking is very effective for paddy hydration and effluent strength reduction in terms of BOD. Therefore, this novel concept of submerged aeration is useful to reduce the effluent strength and minimize unnecessary environmental consequences in order to process paddy grains via parboiling process in an eco-friendly manner.

**Keywords:** Effluent strength, Paddy, Parboiling, Soaking, Submerged aeration

# Isotherm and Kinetic Analyses of Methylene Blue Adsorption by a Selected Biosorbent

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Industrial dye related water pollution is a growing concern nowadays as it influences environmental quality significantly. Adsorption of dye molecules onto various adsorbents is a popular dye removal method. This study was set to investigate the ability of selected biosorbents, Palmyrah sprout casing, coconut kernel after milk extraction, king coconut husk, lime peel and manioc peel for the removal of toxic organic dye, methylene blue (MB). Batch adsorptive experiments were conducted under a set of experimental conditions (pH - 6; dosage - 3 g/L; temperature - 303 K; initial concentration - 100 mg/L) to identify best biosorbent with higher adsorptive performances for the removal of MB from water. MB concentration was determined by measuring the maximum absorbance at 664.5 nm using UV-Vis spectrophotometer and two replicates were used for each experiment. Among the selected biosorbents, Palmyrah sprout casing was selected as best biosorbent with higher adsorptive performance of 27.67 mg/g. Isotherm and kinetic analyses were then performed for a better understanding of the adsorption process. From isotherm analysis of Palmyrah sprout casing, monolayer adsorption was observed during the association between Palmyrah sprout casing and MB. Adsorption kinetic analysis indicated that the pseudo second order model is well suited for kinetic analysis and to understand the involvement of chemisorption process in the removal process of MB by Palmyrah sprout casing. Since the use of Palmyrah sprout casing as a biosorbent for the removal of MB is a novel concept, it could be used for the production of activated carbon with high adsorptive performance for the better removal of MB in future.

**Keywords:** Adsorption, Biosorbents, Isotherm, Kinetics, Methylene blue

# Evaluation of Heavy Metals Concentrations in Surface Water Bodies in Selected Rice Fields in Trincomalee District

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Agrochemicals can pollute water bodies, posing a serious danger to aquatic ecosystems and drinking water resources. In Sri Lanka, the use of agrochemicals has risen dramatically in recent decades. Many agrochemicals have been shown to contain harmful trace elements. The objective of this study was to measure the occurrence of heavy metals in surface water sources in rice-growing areas in the Trincomalee District. The study was conducted in three Divisional Secretariat divisions, including both CKD-endemic (Padavi Sripura) and non-endemic (Kanthala, Seruvila) areas. Ninety-three (93) water samples were randomly collected from the surface water bodies related to the rice fields in the above DSDs before and after the application of agrochemicals during 2019/2020 *Maha* season. Flame Atomic Absorption Spectrometry was used to assess the concentrations of five heavy metals. Results showed that mean and standard deviation of Arsenic (As), Lead (Pb), Cadmium (Cd), Copper (Cu) and Zinc (Zn) concentrations (µg/L) before and after the application of the agrochemicals were {0.048±0.363 and 6.220±8.798}, {0.014±0.139 and 0.371±1.847}, {not detected and 4.4212±6.865}, {1.583±3.832 and 1.262±1.591} {not detected and 6.403±3.525}, and for pH was {7.13±0.34 and 7.19±0.35}, respectively. Findings revealed that concentrations of as, Cd, Pb and Zn were significant ($p<0.001$) between before and after the application of agrochemicals and not significant for Cu. However, the measured heavy metal concentrations were well below the permissible levels for irrigation water, ambient water and drinking water quality set by the Food and Agriculture Organization, Central Environmental Authority and Sri Lankan Standard Institute, respectively. Furthermore, the concentrations of heavy metals in surface water samples from CKD-endemic and non-endemic areas were significantly not differed ($p>0.05$). Continuous studies are needed to understand the distributional pattern of agrochemicals in the water bodies.

**Keywords**: Agriculture, Agrochemicals, Flame Atomic Absorption Spectroscopy

# Agricultural Standardized Precipitation Index (aSPI) in Drought Characterization: A Case Study in Jaffna Peninsula in Sri Lanka

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The agricultural activity highly influenced by the rainfall and related meteorological parameters. This study utilized the method introduced by Food and Agriculture Organization (FAO) to estimate the effective rainfall (Ep) of Jaffna for the period of 1985 to 2019 to explain the drought condition of Jaffna using aSPI at 1, 3, 6, 9 and 12 months' time scale (aSPI 1, aSPI 3 aSPI 6 aSPI 9 and aSPI 12 respectively) and to check its effectiveness. The performance of the aSPI was evaluated using correlation coefficient (r) with the yield of red onion and green chilli and standardized precipitation index (SPI) values. Analysis shows that the annual effective rainfall has no trend in long term but there were seasonal and short term variations found. Most of the years falls under below average value (862 mm) of Ep. The near normal condition was exceeding the normal distribution pattern (68.2%) in all time scales. The very wet condition was highly deviates from normal distribution value of 4.4% in aSPI 3 (6.8%) and aSPI 9 (5.1%). The October, November, December and January months can be recorded as rainy months. The number of wet event increases with years in *Maha* and vice versa during *Yala*. aSPI 9 shows less amount of moderately wet condition. Moderate drought and severe drought conditions were less in aSPI 1. Eight hydrological years 1987-88, 1991-92, 1992-93, 1995-96, 2000-01, 2006-07, 2013-14 and 2018-19 can be denoted as dry years. Around 60% of the years falls under wet condition. The effective rainfall has low degree of correlation with the yield of red onion (*Maha* (0.17) and *Yala* (0.15)) and moderate relation with green chilli (0.31 for both season). The r value of different time period is similar in SPI and aSPI except 6-month period where high correlation with the yield of both crops was observed. From these findings it can be said that in this study area the monthly rainfall event was highly fluctuating and the value is higher than the normal distribution probability of the rainfall. The wet and dry event during the period of 1985 to 2019 was showed cyclic pattern with different rate of change. That is there was some variation or shift in the onset of rainfall and considerable impact on agriculture and other sectors also can be noted. But there was enough water to the cultivation of Chilli and red onion if the cropping calendar is properly schedule by considering the shift or change in the onset of rainfall in this region and aSPI is suitable indices to explain the drought in this region.

**Keywords:** Drought, Effective rainfall, Agricultural standardized precipitation

# A Study on Factors Affecting Adoption of Drip and Fertigation for Horticultural Crops in Dharmapuri District of Tamil Nadu

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In Tamil Nadu, drip and fertigation for a horticultural crop was introduced through Tamil Nadu Precision Farming project was implemented by Tamil Nadu Agricultural University, Coimbatore in the Dharmapuri and Krishnagiri districts during 2004-07 as a turnkey project. The yield and income of the farmers increased by three fold, apart from increasing the area under irrigation. A survey was conducted in the Pennagaram block to analyse the factors affecting adoption of drip and fertigation. Fifty farmers were selected from the Pennagarm block farmers' database of Krishi Vigyan Kendra of Dharmapuri district who had adopted drip irrigation system. Drip adoption index was calculated and based on the drip adoption index the farmers were categorized under three groups. It was found that majority of the farmers fell under the medium category (66%) followed by high adopters (24%) and low adopters (10%). The crop wise and the adoption of fertigation wise grouping was done based on the drip adoption index. It was found that there was significant difference among the drip adoption index crop wise. The correlation effect of the various items under consideration on the drip adoption index showed that the drip adoption index was high among the flower growers. The difference in the interaction effect of the crop and adoption of fertigation showed that this should be critically taken into account that the benefits of fertigation should be further educated to the farmers.

**Keywords:** Drip irrigation, Fertigation, Drip adoption index, Dharmapuri District

# Agroforestry, Crop Production Technologies and Natural Resource Management

# Dry Zone Home Gardens as the Potential Agroforestry Units for Carbon Storage: Study in *Gomarankadawala* area, Trincomalee, Sri Lanka

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Dry zone home gardens could be considered as agroforestry units which have potential to mitigate and adapt climate changes. Carbon quantification in home gardens could give a picture of carbon stock of home gardens as agroforestry systems. Once the present carbon stock is quantified, strategies could be made for dry zone home gardens to further develop into better carbon storages. This study was conducted to quantify existing permanent aboveground carbon stock in *Gomarankadawela* area in the *Kumbukwewa* cascade in the Trincomalee district of Sri Lanka. A total of 44 home gardens were categorized according to the size (< = 0.2 ha small scale (n=13), 0.2< to < = 0.4 ha medium scale (n=13) and 0.4< to < 1 ha large scale (n=18) and data were collected. Diameter at breast height, height of 3338 trees and plants with their abundance were recorded. Allometric equation was used to calculate aboveground carbon stock. Pearson R correlation test and one-way ANOVA test were used to analyze the calculated carbon stock values. Mean above ground carbon stock was 30 mg C $ha^{-1}$ ranging from 0.005 mg C $ha^{-1}$ to 80.99 mg C $ha^{-1}$. The size of the home garden was not significantly ($p<0.05$) correlated with aboveground carbon stock, but it had significant differences among the scale of the home gardens. The small-scale home gardens had the highest carbon stock (40.16±22.5 mg C $ha^{-1}$) and medium scale had the lowest carbon stock (23. 54± 14.7 mg C $ha^{-1}$). The findings revealed that the dry zone home gardens are having lower carbon stock and there is still a possibility of strategizing to increase the capacity of carbon storage as a measure of climate change mitigation specially focusing on medium and large-scale home gardens. This could be done strategically by increasing the carbon stock using under-utilized land area on a sustainable basis by optimizing tree density with proper mixture in the dry zone home gardens.

**Keywords**: Above ground carbon stock, Agroforestry system, Allometric equation, Climate change, Dry zone home gardens

# Socio-Economic and Livelihood Status of Inland Fisher Communities in Five Selected Reservoirs of Kilinochchi District, Northern Province, Sri Lanka

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Kilinochchi district is well known for its abundance of multi-purpose reservoirs used for agricultural activities and freshwater aquaculture. Despite their abundance, no study has been conducted for the crucial information required for the aquaculture development. Therefore, the current study focuses on the socio-economic and livelihood status of fishermen which acts as the baseline information for future development. Fishing communities were selected from the five major reservoirs, namely Akkarayan, Vannery, Murippu, Premanthanaru, and Iranaimadu in the Kilinochchi district using a structured questionnaire survey (184) to obtain general and fish production related information. The study revealed that the majority of fishermen (62.2–93.3%) were Hindus while Christians were recorded at the range between 6.7–37.8% were from five reservoirs. 31–60% of the fishermen belong to the age group between 35–45 years in all the reservoirs except Iranaimadu, however younger fishermen (25–35 years) community (26%) has been reported from Iranaimadu. About 83-100% of the fishermen from all reservoirs were married, obtained at least primary or secondary education, constructed fairly proper housing with sanitary facilities. Majority of the fishermen (39–85%) has engaged with this sector after the year, 2010 except the Vannery reservoir due to the civil conflict. In all reservoirs, 92.3–100% of fishermen has directly engaged with the inland fishery as their major livelihood. Further, gillnet (93.3–100%) is predominantly used for harvesting Indian carp and Tilapia and, production is up to 100 kg and less than 5 kg per attempt during high yield season (dry period) and off-season (rainy period) respectively. In Akkarayan, more than 86% of fishermen earn less than 10,000 LKR monthly while nearly 40,000 LKR per month is the income of 60 % of fishermen in Premanthanaru. Inland fish production shows relatively lower production due to the past civil war although inland fishery plays a major role in rural employment in Kilinochchi. Sustainable fishery management policies, effective stocking, technical, financial and, social support may improve the livelihood of the fishers by, ultimately increasing the overall inland fishery productivity in Kilinochchi District.

**Keywords:** Inland fishery, Structured questionnaire, Multi-purpose reservoirs

# Toxic Effect of Aqueous Leaf Extract of Milky Mangrove (*Excoecaria agallocha* L.) on Larvae of Mosquito (*Aedes aegypti*) and Brackish Fish (*Etroplus suratensis*)

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Climate changes including global warming make the world a safer breeding place for mosquitoes. Application of larvicide is a successful precaution method to reduce mosquitoes before emerging into adults. Identifying phytochemical properties is a cheap and environmentally safe technique. In this view, the study attempts to find out the toxic effect of aqueous leaf extract of *E. agallocha* on brackish fish (*E. suratensis)* and mosquito larvae (*Aedes aegypti*) under laboratory conditions. Mosquito larvae and brackish fish from the lagoon were reared separately at 25-27°C and 75-85% relative humidity. Five replicates with ten mosquito larvae and five replicates with six brackish fish in each were maintained. Aqueous leaf extract of *E. agallocha* at four concentrations 0.0625 g/ml, 0.125 g/ml, 0.25 g/ml, and 0.5 g/ml with lagoon water (control) were tested against fourth instar larvae and brackish fish separately. After 24 hrs of treatments, the number of dead larvae and fish were counted. All concentrations of the leaf extracts applied were able to cause significant ($p<0.0001$) mortality on the larva of mosquito and brackish fish. The highest larval mortality (80%) and brackish fish mortality (100%) were recorded from 0.5 g/ml while the least (48%) for larvae and (16.67%) for fish mortality were obtained by 0.0625 g/ml. Concentrations less than 0.0625 g/ml of leaf extracts were suitable for selective fish harvest by making them daze and mortality increases with the increase of concentration of leaf extract. *Excoecaria agallocha* leaf extract founds to be an effective replacement for synthetic larvicides while it is toxic for brackish fish.

**Keyword:** Bioassay, Brackish fish, Milky mangrove, Mosquito larvae

# Film Properties of Prevulcanized Natural Rubber Latex Films Produced from Creamed Latex

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Pre-vulcanization of latex yields latex that is agglomerated and disseminated in an aqueous media with intra cross-linked rubber molecules. The nature of pre-vulcanized latex offers many advantages such as improved stability, simplicity in use, long shelf life, low toxicity and energy efficiency in industrial applications. With ever increasing interest on green products, creamed latex could be considered as a potential raw material than centrifuged latex as the manufacturing process involves no power requirement. Despite numerous works reported on pre-vulcanization of centrifuged latex, not much research work reported on the pre-vulcanization of creamed latex. In this research study, pre-vulcanized natural rubber creamed latex was investigated using three different types of accelerator systems. Tetramethylthiuramdisulphide, Zincdiethyldithiocarbamate and N-tert-butyl-2-benzothiazolesulfenamide were utilized as fast, ultrafast and delayed-action accelerators, respectively. For the purpose of comparison, corresponding counterparts using centrifuged latex were also prepared. Properties of the prepared pre-vulcanized latex films such as tensile properties, swell index, tear properties, acetone extract and extractable protein content were investigated and compared. This research study clearly indicates that latex films made out of pre-vulcanized creamed latex exhibit higher crosslink density as evidenced by the lower swelling index and higher tensile strength compared to the corresponding films prepared using pre-vulcanized centrifuged latex. As evidenced by the acetone extraction studies, the pre-vulcanized creamed latex equivalent has a lower level of curing agent residuals than the pre-vulcanized centrifuged latex equivalent. Further pre-vulcanized creamed latex possesses low leachable protein content. Among the candidate accelerators, Zincdiethyldithiocarbamate (ultrafast accelerator) revealed the best overall performance while the least performance was shown by N-*tert*-butyl-2-benzothiazolesulfenamide. As a result, it could be inferred that pre-vulcanized creamed latex with ultra-fast accelerator is suitable for small sized manufacturing industries, to ensure and energy efficient and less toxic process, hence encouraging greener rubber products.

**Keywords:** Accelerator, Centrifuged, Creamed latex, Pre-vulcanized

# Appraising Surface Water Pollution due to Personal Protective Equipment (PPE) during the COVID 19 Pandemic in Sri Lanka

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The rapid spread of the COVID 19 virus made people wear personal protective equipment (PPE) to protect themselves during the pandemic. As a result, significant changes in PPE accumulation in water bodies were observed in Sri Lanka. Therefore, this study intended to explore the immediate impacts of COVID-19 safety processes on surface water bodies and water quality in Sri Lanka. An online cross-sectional survey was accompanied from the 1st of April to 1st of May 2021 using Google forms. The questionnaire with socio-demographics and surface water quality changes related questions were circulated over social media platforms. Purposive sampling was done and the analysis was done by descriptive statistics using Minitab software. A total of 466 respondents were included in the analysis (63.38% females). The majority of them was employed and resided in urbanized areas (66.67%). According to the findings of the study, 44% of respondents has been noticed water quality fluctuations and 50.32% of them mentioned that the water pollution was increased due to PPE during pandemic. The amount of PPE in water bodies increased more than usual as stated by 49% of respondents. The most polluted water source due to accumulation of PPE were rivers (27%), reservoirs (26%) culverts (26%) and streams (14%). The 79% of the respondents used face masks daily for their protection. Preventing PPE release to the environment has the potential of mitigating micro plastics and ecologically harmful substances into the aquatic bodies to evade the deterioration of the water quality. Overall, significant water pollution due to increase usage of PPE by general public ($p<0.001$) was observed and proper disposal methods should be implemented while making public community aware.

**Keywords:** COVID 19, Lockdown period, Environment, PPE, Water pollution

# Effect of Fertilizer Application with Fish Tonic on the Growth and Yield Performance of Tomato (*Solanum lycopersicon*)

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Fish tonic is a product of fermented fish wastage, and can be used as an organic fertilizer, to enhance the growth and yield of crops Moreover, fish tonic can serve as a solution for eco-friendly waste management. Hence, a pot experiment was conducted at the District Agriculture Training Center, Thirunelveli, Jaffna, during November 2020 to March 2021 to evaluate the effect of fertilizer application with fish tonic on the growth and yield performance of tomato. Padma F1 Hybrid variety of tomato was selected for this experiment as the test crop. Five treatments were designed by using different concentration of fish tonic as soil application with different percentages of recommended urea fertilizer namely, T1 – 100% fish tonic, T2 - 0% fish tonic + 100% urea, T3 – 75% fish tonic + 25% urea, T4 – 50 % urea + 50% fish tonic and T5- control. These treatments were laid out in a completely randomized design with three replicates. Nutrient contents (NPK) of fish tonic were analyzed. Several vegetative and reproductive growth parameters were measured. The data were analyzed in ANOVA test using SAS software. Nitrogen, phosphorus and potassium content of the fish tonic were 4077 ppm, 567 ppm and 521 ppm, respectively. According to the results, plants treated with fish tonic performed better than other treatments. The results revealed that applying 100% of fish tonic (T1) was significantly ($p$<0.05) showed better performance in the plant height (128.3 cm), number of leaves per plant (94), leaf width (10.2 cm), leaf length (5.3 cm), number of flowers per plant (25), number of fruits per plant (19), fruit weight (49.5 g/fruit), fruit circumference (13.3 cm) and yield (794 g/plant) than other treatments. Therefore, this study revealed that tomato plants were well performed under 100% fish tonic as soil application. Further studies can be conducted to evaluate the nutrient uptake and nutrient use efficiencies as affected by the application of fish tonic in tomato.

**Keywords**: Fish tonic, Organic fertilizer, Soil application, Tomato, Yield

# Effect of Chemical Treatments and Cold Stratification on Dormancy Breaking in Israel Blue Grapes (*Vitis vinifera* L.) Variety

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Grapes are propagated through seeds to produce new varieties. Seed dormancy in grapes reduces the germination percentage (%) and delays germination, resulting in the low efficiency of breeding programs. The present research evaluated the impact of pretreatment with different chemicals and cold stratification on the dormancy breakage of grape seeds, variety Israel blue. Two factor factorial experiment was conducted under Complete Randomized Design with 20 treatment combinations and four replicates. Exactly 14 seeds were allocated for each replicate. Grape seeds were first soaked in distilled water for 24 hours, followed by soaking in 1000ppm gibberellic acid, hydrogen peroxide, acetic acid, and distilled water (control) for another 24 hours. Then the grape seeds were stratified at 4 °C, 5 °C, 6 °C, 7 °C, and 8 °C for 21 days prior to sown in media consist with sand: topsoil: farm manure at 1:1:1 ratio. They were then placed in a growth chamber at 65 % relative humidity and 30 °C with 16 light hours (12.5 lux) followed by 25 °C with 8 dark hours. Germination %, time duration for germination, shoot length of seedlings, and the number of leaves was measured. Mean separation with Duncan Multiple Range Test was done to determine the best treatment combination using SAS 9.1 version. Germination % was Significance in the application of gibberellic acid with cold stratification under 5 °C. Both treatment combinations of 1000 ppm gibberellic acid and cold stratification at 4 °C and 5 °C had significantly higher germination %, longest shoots and no significance in the number of leaves. The treatment of gibberellic acid for 27 days (short time duration) from the day of grape seed soaking was taken for germination. In conclusion, the combination of gibberellic acid and cold stratification at 4 °C and 5 °C induces dormancy breaking of grape seeds and promotes quick germination in grape variety Israel blue.

**Keywords:** Grape, Seed dormancy, Stratification, Germination

# Nutrition, Food Science and Technology

# Development of Novel and Functional Sauce from Beetroot (*Beta vulgaris L.*)

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Plant based products have attracted enormous attention due to their diverse range of biological and therapeutic properties. Beetroot is one of the root vegetable which is rich in antioxidants among other vegetables. Betalain is the natural pigment attributable to the purplish color to beetroot. Therefore, the objective of this study was to develop a novel functional sauce from beetroot. Proximate analysis, physico-chemical analysis, shelf life stability, quantification of betalain and sensory evaluation were carried out. Initially different compositions of sauces were prepared by changing sugar concentration range from 10% to 18.5% and bird chili concentration range from 8% to 16.5%. The most acceptable composition of sauce was screened from sensory evaluation results. Final product contains 72.06% ± 1.68 moisture, 3.03% ± 0.32 ash, 2.83% ± 0.21 protein, 1.34% ± 0.05 fiber, and 0.02 g ± 0.00 fat, 85.33 mmol/L ± 3.05 Calcium, 80.46 mmol/L ± 2.05 Potassium and 409.53 mmol/L ±5.31 Sodium content with the pH of 4.17 and 48˚ Brix value. There was no any growth of yeast, mold and bacteria up to one month of shelf life in dark glass bottle at refrigeration temperature (7 ˚C) without artificial preservatives. The betalain content in the developed beetroot sauce was evaluated by extraction of the betalain in the varying percentages of the aqueous concentrations of sauce was resulted as 0.275 mg/100 g ± 0.001 in 12.5% extraction, 1.166 mg/100 g ± 0.015 in 25% extraction and 4.196 mg/ 100 g ± 0.034 in 50% extraction respectively. The results showed that development of a sauce from beetroot is an effective way of delivering the health benefits to the potential consumers.

**Keywords:** Beetroot, Betalain, Functional sauce, Proximate composition

# Development of Spicy-Snack Incorporated with Palmyrah (*Borassus Flabellifer*) Tuber Flour

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Palmyrah tuber flour has the similar properties of gluten which can be used in bakery industry. However, it is still underutilized and the feasibility of applying the flour in bakery products is not deeply studied so far. This study analysed the possibility of using unboiled Palmyrah raw tuber flour as a partial replacement of wheat flour and formulate a spicy-snacks (SN). Two trials were done, one was to select the suitable flour ratio and another was to select the suitable baking temperature for SN. In the first trial three treatments were done by changing Palmyrah tuber flour and wheat flour ratio as, T1; 3:1, T2; 1:1 and T3; 1:3 respectively. Second trial was done by changing baking temperature as 150 °C, 160 °C and 170 °C while keeping the baking time constant as 10 minutes. The 5 point hedonic scale sensory test was used and attributes such as crispiness, texture, appearance and aroma were evaluated by thirty semi trained panellists. Results revealed the treatment T3; 1:3 as best mixtures and 160 °C as suitable baking temperature. Triplicates of formulated SN were Proximate analysed for using AOAC 2000 procedures. Moisture content, water activity and acid insoluble fat were found 2.8±0.03%, 0.296±0.06% and 0.2±0.04% respectively and these values were within the limits indicated in SLS 256: 210. Developed spicy-snacks were stored in low density polyethylene (LDPE), high density polyethylene (HDPE) and metalized polypropylene (MP) bags and parameters such as moisture, water activity and TPC test were monitored in 14 days interval for the shelf life studies. Moisture, water activity and TPC of SN inside the MP bags showed lower value as 3.23%, 0.42 and $3.36\times10^3$ CFU/g respectively after 28 days. Results revealed that SN was more stable in MP bags. Further studies can be done to increase the utilization of Palmyrah tuber flour in the baking industry.

**Keywords**: Bakery, Metalized polypropylene, Palmyrah tuber flour, Spicy-snacks

# Formulation of *Papad* Incorporated with Dried Palmyrah Tuber Flour

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*Papad* is one of the popular and traditional snacks in Asian cuisine. *Papads* are highly prepared with various types of pulses, cereals, and starchy food with incorporating. Some additives. The most popular *Papad* is made with black gram flour with the addition of rice flour. But nowadays the price of black gram flour is more expensive. The present study was conducted on the formulation of papad using palmyrah (*Borassus flabllifer L*.) unboiled tuber flour (odiyal flour) instead of black gram flour and rice flour. Based on the texture of *Papad* using paired comparison test between the two processing methods as battered and dough, resulted the most preferable one as battered. Then experimental trials were done using battered method by altering the flour ratio of palmyrah unboiled tuber flour and fresh white rice flour. The best ratio of the formulation of *Papad* was identified as 1:1 in odiyal and rice flour-based on the sensory attributes such as appearance, taste, crispiness, and overall acceptability. Chemical characteristics of best-formulated *Papad* complied with SLS 280: 2009 and has 3.02(±0.09) % of total Ash, 0.38(±0.01) % of acid insoluble ash and 0.46±0.02% of alkalinity of ash, 1.99(±0.01) % of fat, 0.155(±0.01) % of salt, 10.24(±0.16) % of total sugar and 6.22(±0.01) of pH value. There were no significant ($p< 0.05$) differences in moisture content, water activity, total plate count, *coliform,* and *E. coli* during the storage period of 14 days intervals up to 28 days when stored in low-density polyethylene (LDPE) at ambient temperature (28±2 $^{o}$C). This study was concluded that Palmyrah unboiled tuber flour is suitable to prepare of *papad* with incorporating fresh white rice flour in 1:1 ratio using battered method.

**Keywords**: Palmyrah tuber flour, *Papad*, Rice flour

# Development of Herbal Biscuit and Evaluation of Sensory and Nutritional Quality

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In Sri Lanka, biscuits are a popular baked snack food. This research was carried out to develop a herbal biscuit incorporating herbal powder mixer of coriander (*Coriandrum sativum*), cinnamon (*Cinnamomum zeylanicum*), curry leaves (*Murraya koenigii*), ginger (*Zingiber officinale*), and liquorice (*Glycyrrhiza glabra*) and were evaluated the sensorial attributes and nutritional quality of the developed product for consumer acceptability. These herbs were chosen based on their medicinal and nutritional qualities, as well as the safe consumption level. Two different mixers of herbs were prepared according to two different proportions. One of them was with equal proportions (F1: 20:20:20:20:20) and another one was made by reducing the amount of liquorice and increasing the other herbs with the same amount for treatment mixer (F2: 22.73:22.73:22.73:22.73:9.09). According to the sensory evaluation, the formulation F2 was selected as the best herbal mixer which was used to develop herbal biscuits with varying amount of 0%, 5%, 10%, and 15%. The other ingredients of wheat flour, fat spread, baking powder, cocoa powder, sugar, vanilla, and liquid milk was used for making the biscuit dough. After sheeting and cutting of biscuits, they were baked at 180 °C for 15 minutes. The color, flavor, texture, taste, mouth feel, and overall acceptability of the biscuits were evaluated using a five-point hedonic scale. Sensory evaluation for the prepared biscuits was carried out with the thirty-one untrained panellists. Based on sensory evaluation, the optimum incorporation of herbal mixture was a biscuit containing 10% mixture of herbs. The selected biscuits (10%) were subjected to evaluate nutritional quality with control sample (except herbal mixture). In the selected biscuit contained total sugar 10.92±0.104%, crude protein 12.41±0.012%, crude fat 15.29±0.146%, moisture 3.05±0.384%, ash 1.83±0.001%, total carbohydrate 64.24±0.004% and fibre 3.15±0.146%. According to the present study 10% herbal mixture could be recommended for herbal biscuits.

**Key words**: Fortification, Herbal Biscuits, Herbs, Sensory quality

# Production of Green Banana Powder from *Ambul* and *Puwalu* Varieties and Comparisons of their Physicochemical, Antioxidant Properties and Shelf-life Evaluation

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Banana is the major fruit available in Sri Lanka subjected to undergo a higher level of postharvest losses due to its perishable nature. This can be overcome by harvesting it in the immature stage and converting it into green banana powder. The green banana powder can be used to replace wheat or rice flour. Thus, the study was to produce green banana powder from two banana varieties, namely *Ambul* and *Puwalu* from Kilinochchi district, Sri Lanka, and evaluate their quality characters. Initially, fresh green banana slices of both varieties were undergone hot water blanching and potassium metabisulphite treatment to prevent browning reactions. Then, drained slices were dehydrated in a cabinet dryer for 18 hours at 65 $^0$C. Dried slices were ground into a fine green banana powder. Proximate composition, antioxidant properties, and keeping quality of both varieties of green banana powder were evaluated. *Ambul* variety recorded the highest powder yield, crude fat, crude fiber, and moisture, whereas the highest crude protein and ash content was obtained in *Puwalu*. The potassium and phosphorus contents were predominant in both green banana powders, however, *Ambul* powder showed a higher value for both P and K contents. Total sugar content was significantly high in *Puwalu*. The *Ambul* powder contained higher vitamin C content. Both banana powders contained a higher degree of antioxidant properties. Total phenolic content and antioxidant capacity were found to be high in *Puwalu*, whereas the highest total flavonoid content was obtained in *Ambul* powder. For the shelf-life analysis, both powders could be stored for up to two months without noticeable changes in their quality characters. Based on the findings of this study, the production of green banana powder from *Ambu*l and *Puwalu* varieties could be possible with acceptable quality characters and it can be used as a tool for the reduction of postharvest losses of banana. Further, research needs to be done on the incorporation of green banana powder in food preparations.

**Keywords:** *Ambul, Puwalu,* Dehydration, Green banana powder, Quality characters

# Development of Banana Pseudo-Stem Incorporated Chips and Study the Acceptability of the Product

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The banana pseudo-stem is an underutilized by-product of banana cultivation and is available throughout the year in Sri Lanka. It is rich in dietary fiber with many health benefits. The study was aimed to develop a banana pseudo-stem incorporated chip and evaluate its proximate composition and shelf-life. Initially fresh banana pseudo-stem was chopped, boiled and ground to fine paste. The dough was formulated by partially replacing wheat flour with boiled paste (wheat flour: pseudo-stem paste, 80:20, 70:30, 60:40, and 50:50), where the dough without the banana pseudo-stem paste was considered as a control (100:0). The cut dough was fried (180 ℃, 10-15 minutes) using coconut oil to prepare chips. Based on the sensory evaluation results, 70:30 wheat flour to banana pseudo-stem was selected as the best formulation. Then the proximate analysis was carried out for ground raw and boiled banana pseudo-stem samples. According to the results, raw pseudo-stem was exhibited the highest proximate composition than boiled stem. For the best formulated chips and control, the proximate composition of ash (2.43±0.01%), crude fiber (3.08±0.10%), and crude fat (26.42±0.33%) contents were significantly higher ($p<0.05$) in the best-formulated chip compared to the control. There was no significant difference in control and best-formulated chip for moisture, crude protein, and total reducing sugar. Shelf-life analysis such as visual observations, moisture content, and total plate count for both chips was carried out in two weeks for three packing methods (normal, vacuum, and nitrogen gas) using polythene as packaging material at room temperature (25 ℃). The results of this study show that they can be stored for up to two weeks without any remarkable changes in the organoleptic and microbial qualities with the evidence of no bacterial and fungal colonies in both control and best-formulated chip during 1st and 2nd weeks of storage. However, a prolonged study is needed to ensure the shelf life of the produced chip. Among the packing methods studied, nitrogen packing was found to be the best packing method compared to others. Overall, the banana pseudo-stem could be a potential source to replace the wheat flour in making healthier chips with good keeping and eating qualities.

**Keywords:** Banana pseudo-stem, Chips, Proximate composition, Nitrogen packing

# Formulation of Palmyrah Wattalappam from Palmyrah Fruit Pulp and Palmyrah Jaggery

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Palmyrah (*Borassus flabellifer*) fruit pulp has bioactive compounds with more health benefits, but due to its bitterness it has less consumer preference. The sap of Palmyrah palm is very rich in simple sugar and used to manufacture jaggery which is used as substitutes for sugar and sweetness. This study was designed as a value addition to Palmyrah Fruit Pulp (PFP) and traditionally prepared Palmyrah Jaggary (PJ) through formulation of Palmyrah Wattalappam (PW). The ingredients PFP, PJ, eggs, coconut milk and spices (garlic powder, tamarind, salt, nutmeg, ginger, pepper) are used as ingredient. Two trials were carried out, one was to select the suitable PFP and coconut milk ratio and another trial was to select the suitable PJ ratio for PW. In the first trial three treatments were done by changing PFP and coconut milk ratio as, T1; 1:1 , T2; 3:1 and T3; 1:3 respectively. Treatment T2; 3:1 ratio was selected among them for second trial. The PW mixed with 37% (m/m) PFP, 12% (m/m) coconut milk, 50% (m/m) PJ, two eggs and <1% (m/m) of spices was found to be best formulation. Triplicates of formulated PW were analyzed for moisture content, water activity, calories, ash, acidity, fat, salt, sugar and pH of using AOAC 2000 procedures. PW was stored in a transparent polypropylene cup No 5 at refrigerator condition of 4°C for one month for shelf life study and moisture content, ash content, acidity and microbial growth were monitored in seven days intervals up to one month. Results revealed that PW consist of moisture content 51.99±0.52%, water activity 0.79±0.001%, calories (energy) 0.86±0.001 kcal, ash 1.96±0.31%, acidity 0.21±0.01%, fat 0.39±0.45%, salt 0.08±0.001%, sugar 37.58±0.36% and pH value of 7.65 at the significant difference ($p>0.05$). PW was more stable in transparent polypropylene and there was no any significant different in moisture, ash content, acidity, yeast & mold and *E. coli* & coliform growth throughout the study period. PW developed with the incorporation of PFP and PJ has good texture flavor, aroma and shelf life of one month. It can be further developed as a successful value added desert product of PFP and PJ to the market by analyzing its antioxidant properties.

**Keywords**: Coconut Milk, Palmyrah fruit pulp, Palmyrah jaggary, Shelf life

# Comparison of Proximate and Nutrient Analysis of Selected Accessions of True Cinnamon (*Cinnamomum zeylanicum* Blume) at Different Maturity Levels

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Cinnamon (*Cinnamomum zeylanicum* Blume) is increasingly becoming an important and potential foreign exchange earner and it is one of the most important highest income generating export crops in Sri Lanka. Cinnamon has been used as a spice in the food industry and anti-microbial agent in the therapeutic medicine for many years. The study was aimed to determine and quantify the nutrient composition of the selected Cinnamon accessions of the commonly cultivated varieties named Sri Gemunu, Sri Wijaya and Common cultivated accession at different maturity levels. Ten replicates of each accession were evaluated for moisture, ash content, crude fat, crude protein, carbohydrate, caloric value, pH value and colour (L* brightness, a* Red and Green, b* Yellow and Blue) by following the standard procedures. Three accessions did not show any significant difference in the nutrient content with maturity. Nutritional analysis of Cinnamon varieties showed that there were no significant differences in the values of crude protein and fat of the three accessions ($\alpha = 0.05$) and only carbohydrate content was significantly higher in the Sri Gemunu variety (78.8%) than the other two varieties. Therefore, energy value is significantly higher in Sri Gemunu variety (323.6 Cal) than the other varieties. The ranges of crude protein percentage and fat percentage of all the Cinnamon accessions varied between 2.3-2.6 and 0.7-0.8 respectively. There were no significant differences among the Cinnamon accessions in the proximate analysis of ash content, pH and colour a*, b* values. Colour L* (brightness) value of Sri Gemunu and Sri Wijaya accessions were significantly lower than the common accession. The range of colour L*, a* and b* values for all three accessions respectively 38.3-42.3, 12.6-12.7 and 21.8-23.8. Ash content percentage and pH value of all the Cinnamon accessions were in the range of 5.6-6.3 and 5.1-5.4 respectively. Therefore, it was concluded that there were no variations in the nutrient content of the Cinnamon barks harvested from the three accessions of Sri Lanka with the maturity.

**Keywords:** Cinnamon, Maturity, Nutrient, Proximate, Sri Gemunu variety

# Production of Novel Ice Cream Enriched with β-carotene using Orange Fleshed Sweet Potato Powder

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Ice cream is a delicious dessert that has a considerable demand throughout the world not only the taste but also it gives high nutritional benefits and high-calorie value. Orange fleshed sweet potato *(Ipomoea batata L.*) is an important staple crop in the world. It is rich in β-carotene and a pigment that gives yellow and orange color to the fruits and vegetables. This study was conducted to produce an ice cream incorporating orange fleshed sweet potato (OFSP) powder with no added artificial food colorant and to study the physical, chemical, nutritional attributes and shelf life of the product. Ice creams were prepared by OFSP powder at 1%, 2%, and 2.6% (w/w) with added water by replacing the milk. Sensory evaluation (5-point hedonic scale) was carried out using 30 panelists. One percent (1%) (w/w) of OFSP powder incorporated ice cream was selected as best for the further analysis. Results were analyzed using Minitab software package. Milk solids non-fat (16.25%) and total solids (36.81%) were complied with SLS Standard. Protein (2.62%) and fat (3.22%) were not significantly differ from Brazil standard (2.5% and 3% respectively). Melting rate pattern of OFSP powder ice cream was similar to standard ice cream meltdown curve. OFSP ice cream was rich in β-carotene ($1.8\times10^6\pm0.0$ µg/l) and color was yellow orange group-15 brilliant yellow. The product was Shelf-stable for four weeks' period according to the microbial study stipulated in SLS standard. The Orange-sweet potato incorporated ice cream was rich in β-carotene and economically profitable novel product.

**Keywords:** β-carotene, Ice cream, Novel product, Orange fleshed sweet potato

# Enhancement of Palmyrah Fruit Leather (*Panattu*) Mouth Feel by Developing *Panattu* Choco Bar

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Palmyrah fruit leather (*Panattu*) is a product obtained by drying the Palmyrah fruit pulp. It has a soft, rubbery texture and a sweet taste with organoleptically acceptable characteristics. Even though, it contains high medicinal and anti-hypoglycemic properties, consumer acceptability is low due to its bitter taste. Mouth feel of the fruit pulp can be enhanced by reducing the bitterness. Therefore, the aim of this study is to increase the mouth feel of the Palmyrah fruit leather by adding different food flavor compounds and develop *Panattu* Choco Bar. Preserved Palmyrah pulp was used to prepare fruit leather with the addition of three different flavorings such as salt, sugar and citric acid in different ratios. Fruit leather treated with salt 0.4% (w/v) and citric acid 0.2% (w/v) was selected as best based on sensory evaluation results. Citric acid treated fruit leather showed low bitterness, good chewiness and mouth feel The overall acceptability of these fruit leathers were significantly different ($p<0.05$) from others. Choco bar was developed with the addition of chocolate, condensed milk and desiccated coconut to selected salt (0.4%), citric acid (0.2%) treated and control Palmyrah fruit leather. Best Choco Bar was selected using sensory evaluation. The overall acceptability of citric acid treated choco bar was significantly different ($p< 0.05$) from others. Chosen Choco Bar was analyzed for sugar, salt, fat and energy content and results were 45.54%, 1.6%, 21.75% and 526.93 kcal respectively. *Panattu* Choco Bar was stored at room temperature for three weeks and TPC, yeast and mold growth, acidity and moisture content were tested at seven days interval. The microbial counts were in the limit according to the SLS standard (SLS: 516 Part 1: 1991) but acidity and the moisture content of the product were increased with storage at room temperature. The newly developed Choco bar has enhanced the mouth feel of *panattu*, thus it would be a value added product of traditionally available Palmyrah leather.

**Keywords:** *Panattu*, Choco bar, Mouth feel, Palmyrah, Bitterness

# Effect of Incorporation of Finger Millet (*Eleusine coracana*) Flour Concentrate on Proximate Composition, Sensory and Microbial Properties of Functional Butter

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There is a growing consumer demand for low fat probiotic butter due to their health beneficial properties. Finger millet powder (FMP) rich in dietary fibre can be fortified into probiotic butter to increase health attributes and commercial viability. Therefore, the aim of this study was to elucidate the impact of incorporation of FMP to probiotic butter on proximate composition, sensory properties and microbial properties over refrigerated storage. Pasteurized cream was inoculated with 5% of starter culture containing *Lactococcus lactis* subsp. *cremoris*, *Leuconostoc*, *L. lactis* subsp. *lactis* and *L. lactis* subsp. *lactis biovar diacetylactis*, enriched with FMP at 0%, 2%, 5% and 6% (w/w). Samples were incubated at 20 °C for 18 hours and finally ripened at 5 °C for 5 hours to produce different treatments. The proximate composition, sensory properties and microbial properties of the fortified probiotic butter were determined monthly for three month of period. Results showed that level of incorporation of FMP had significant effect on appearance, colour, flavour and overall acceptability of butter throughout the storage. In this regards, control sample (0% FMP) showed the highest scores for colour and appearance throughout the storage period compared with other treatments. However, probiotic butter fortified with 5% FMP had the highest scores for taste, flavour and overall acceptability irrespective of storage period. As results revealed, 2% FMP incorporated butter had a better spreadability than other treatments. The crude fat, crude protein, moisture and ash contents of FMP incorporated butter ranged from 75.98-79.40%, 1.2-1.57%, 15.62-15.71% and 2.11-2.15%, respectively. Protein and fat contents significantly decreased over the storage period ($p<0.05$). Microbiological results indicated zero coliform counts in all samples until three months. In conclusion, butter fortified with 5% FMP was selected as the best formulation for the development of functional butter with better nutritional composition than those of others.

**Keywords:** Butter, Dietary fibre, Finger millet powder, Prebiotics, Probiotics

# Development of Lucuma (*Pouteria campechiana* (Kunth) Baehni) Syrup Enriched Ice Cream

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Lucuma (*Pouteria campechiana* (Kunth) Baehni) is an underutilized but economically important fruit tree spices enriched with fiber, minerals, beta-carotene and phenolics. The objective of this study was to develop a locally available lucuma fruit syrup enriched ice cream integrated with better physiochemical properties and sensory attributes. The standard methodology of ice cream making was followed and lucuma syrup incorporated at the levels of 5%, 10 % and 15% (v/v) with ice cream. A sensory evaluation was done based on a 9-point hedonic scale using 20 untrained panelists. Prepared ice cream was tested for physiochemical and microbiological properties. According to the sensory evaluation, the ice cream prepared with 10% of lucuma syrup recorded higher scores for appearance, aroma, body and texture, creaminess, flavor, iciness, melting, viscosity, mouthfeel, taste and overall acceptability ($p<0.05$) except color. Color intensity increased with the increasing concentration of lucuma syrup. The proximate composition of different treatment was differ significantly ($p<0.05$) with the storage period. The average of protein, fat, ash, fiber, moisture and carbohydrate content of developed lucuma syrup incorporated ice cream samples were 3.03±0.03- 4.15±0.15%; 6.9±0.2- 8.88±0.12%; 1.4±0.23- 1.8±0.05%; 0.26±0.01- 0.78±0.22%; 49.2±0.1- 52.7±1.65% and 32.81±0.04- 38.31±0.07% respectively. Total plate count and yeast and mold counts increased during storage period but within the acceptable levels whereas coliform count was absent in all samples throughout the three months of storage. In terms of shelf life, these ice cream samples performed well more than three months under refrigerator condition. In conclusion, 10% lucuma syrup incorporated ice cream was identified as a superior formulation for commercialization based on sensory, physicochemical and microbiological properties.

**Keywords:** Lucuma syrup, Ice cream, Sensory evaluation

# Food Security and Food Safety

# Determination of Egg Compression Force in Texture Analyser

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According to the USDA regulation, the eggs can be divided into three categories. The SI<72 and SI 72-76 shape index eggs were found to be more spherical than the SI>76. The unit mass of the eggs differed significantly when they were categorised. Hen's eggs with a shape index of less than 72% were shown to be heavier than those with a higher shape index. The shape index is proportional to width and inversely proportional to length, based on this shape index the rate at which eggs grow longer is faster than the rate at which they grow shorter as they grow older. The compressive force required to shatter the egg shell is determined in this chapter based on the physical features of white (broiler) and brown (indigenous) eggs. The physical properties of the egg play a significant influence in the design of appropriate equipment for eggshell hatching, usage, transportation, processing, and storage. The natural variety in egg form could be used as a criterion for designing food processing equipment for cracking and separating egg components. Shape index, geometric mean diameter, sphericity, roundness, surface area, volume, weight, thickness, density, and force are the key physical properties of the egg. Hardness, brittleness, adhesiveness, tensile strength, compression force, and other properties of materials are measured with a texture analyser. The compression force of an egg was calculated using a 75 mm cylinder probe and a 25 kg load cell. Before beginning the work, the texture analyzer settings for egg compression are completed based on the results obtained were used to design the egg processing equipments/devices.

**Keywords:** White egg, Brown egg, Hatching, Texture analyser, Compression force.

# A Comparison of Selected Maldives and Dried Fish Processing and Handling Practices among Different Processors in Southern Sri Lanka

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Dried and Maldives fish plays an essential role in human nutrition by providing animal proteins, healthy fats and a unique source of other essential nutrients. Nutritional components and sensory properties of dried fish are influenced by processing and handling practices. Nowadays, it is considered that the dried fishes available in the market are in poor quality due to bacterial and fungal contamination, elevated levels of histamine and low protein and mineral contents. Therefore, this study seeks to compare the nature of selected processing and handling practices of dried and Maldives fish in order to ensure the good manufacturing practices towards better product. The snowball sampling technique was used to select 25 participants, including 10 Maldives fish processors and 15 dried fish processors in Southern Sri Lanka. In-depth interviews were employed to collect primary data and secondary data were collected from reputed published materials. Data were analyzed using descriptive statistical methods. All dried and Maldives fish processors use poor grade large pelagic raw fish species, while 88% of processors use eroded and dirty equipment during their processing. It is reported that 88% of processors use sea water and 12% use fresh water to wash raw fish. Another 40% of fish processors of Maldives fish use curry leaves and gummy-gutta during the boiling and smoking steps to improve taste and smell. Seventy-six percentage of dried fish processors sun dry their products an average of three days and 72% of Maldives fish processors dry the fish for an average of 10 days, while others take less duration for drying during the best sunny season. All Maldives fish and 30% of dried fish processors use drying racks to dry their products, while others lie on mats and tents. About 20% of processors sort their products to separate animal excrement and other contaminations. The 50% of processors grade their products based on appearance, size and texture. In conclusion, processors pay very little attention to the quality of the processing and handling practices. Therefore, appropriate management mechanisms and attention should be put in place to improve the end product quality through the exchange of knowledge between processors.

**Keywords:** Dried fish, Maldives fish, Processing methods, Quality product

# Modified Atmospheric Packaging (MAP) Extends the Postharvest Life of *Sesbania grandiflora* (L.) Pers Fresh Leaves

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*Sesbania grandiflora* (L.) Pers is a popular leafy vegetable. However, postharvest life of fresh leaves at ambient condition is about 2 days, leading to high postharvest losses. Therefore, it is important to extend the postharvest life to increase the usable life where, modified atmospheric packaging (MAP) is being used effectively to extend the postharvest life of perishables. Hence, this experiment was conducted to evaluate the effect of MAP on postharvest life of *S. grandiflora* leaves at ambient condition. Four treatments were used; Sealed non perforated polyethylene bags of gauge 150 (T1), Perforated polyethylene bags of gauge 150 (T2), Sealed polyethylene bags of gauge 300(T3), perforated polyethylene bags of gauge 300 (T4) and control without a package (CR). Physicochemical parameters (leaf color values of L*, a* and b*, total color difference, chlorophyll content, physiological weight loss and visual quality rating) were measured daily. There were significant differences ($p<0.05$) among the treatments for tested quality parameters. Visual quality rating revealed that, T1 treatment showed highest postharvest life, which was 6 days while T3 and control samples showed lowest postharvest life of 2 days. Lowest total color difference was observed in T1 (2.12±0.79) emphasizing the highest color retention while highest total color difference was observed in control samples (21.87±2.47) showing lowest color retention. Highest physiological weight loss was observed in control sample (56.86±1.07) while lowest in T3 samples (0.84±0.13) at the end of their postharvest life. Experimental results revealed that the postharvest life of T1, T2, T3, T4 and control samples as 6, 4, 2, 4 and 2 days respectively. In conclusion, sealed non perforated polyethylene bags of gauge 150 could be used effectively to increase postharvest life of *S. grandiflora* leaves in fresh form.

**Keywords:** Leafy vegetable, MA packaging, Postharvest losses, Shelf life, Vegetable hummingbird

# Optimization of Ethylene Concentration and Exposure Time to Enhance the Ripening Rate of Avocado Fruits

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Delay in ripening of mature avocado fruits results in excessive weight loss, increasing diseases incidences, desiccating and showing uneven ripening. Application of ethylene gas has been used to enhance the ripening rate of avocado fruits. However, ethylene concentration and exposure time duration have not yet been optimized. This study was conducted to optimize the ethylene concentration (experiment one) and exposure time (experiment two), respectively to enhance the ripening rate of avocado fruits using ethral which is an ethephon source. In the experiment one, avocado fruits (75) were treated with ethral using three different concentrations (200, 300 and 400 ppm) in a hermetically sealed chamber at ambient conditions while water was used as control. In the second experiment, avocado fruits (75) were exposed to selected ethylene gas treatments from the experiment one for three different time periods 12, 18 and 24 h. Physicochemical properties such as weight loss, peel color, total soluble solid and firmness were examined at two days interval. This experiment was conducted using complete randomized design in triplicates and data were analyzed with one way ANOVA. According to the experiment 01, sample treated with 400 ppm of ethral reached the table ripe stage three days after storage and showed significantly ($p<0.05$) higher lightness, redness (+) to green (-) and yellowness (+) to blueness (-) value of peel color (49.06±1.97, -13.98±1.87 and 34.90±3.99 respectively), Total soluble solids (11.07±1.60 ˚Brix), physiological weight loss (7.10± 0.34 %) and lowest firmness retention (2.17±1.30 N) than control sample. According to the experiment 02, sample exposed to 400 ppm of ethral for 24 h reached the table ripe stage after three days of storage and showed significantly ($P<0.05$) higher L*, a* and b* value of peel color (47.11±0.80, -17.91±1.72 and 30.59±2.09 respectively), TSS (11.23±0.75 °Brix), physiological weight loss (7.81± 0.80%) and lowest firmness retention (1.19±0.40 N) than control sample. Hence, exposing avocado fruits to 400 ppm ethral for 24 h can be recommended for enhancing ripening.

**Keywords**: Avocado, Ethral, Ethylene gas, Ripening, Quality

# Investigate the Impact of Temperature Variation on Quality of Banana Fruits during Artificial Ripening

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Ripening includes physiological, biochemical and organoleptic changes in fruits leading to soft and edible commodities with appropriate quality characteristics. Commercially fruits are artificially ripened using various chemicals, and use of ethephone in low cost ripening chambers is a popular method in Sri Lanka. However, some qualitative defects have been reported in bananas "*Embul*" (Musa, AAB) that are ripened in ripening chambers provided by the National Institute of Post-Harvest Management. Hence this study was carried out to investigate the impact of temperature variations on physicochemical properties (pulp firmness, total soluble solid, titratable acidity, weight loss) and to suggest modifications for the ripening chambers to maintain temperature. In this study artificial ripening of approximately 30-50 kg of banana fruits ripened using ethrel treatment (using 10 g calcium carbonate and 1 ml ethrel in 2 liters of tap water) in different agro-climatic locations (Anuradhapura, Kothmale, and Mullaitivu) in Sri Lanka were investigated. Temperature variation inside and outside of the chamber and loaded fruits (24 hours) were recorded during ethylene treatment and changes in physicochemical properties of fruits during ripening were tested (in triplicate) in one-day intervals until table ripe stage in triplicates. The data were analyzed by one way ANOVA. According to results there were significant differences ($p<0.05$) among locations with highest mean of total soluble solids (27.73±0.15), lowest mean of titratable acidity (0.22±0.03), lower mean of weight loss (8.293±0.3) and highest mean of firmness (0.43±0.03) was observed on 3rd day of storage in fruits ripened in Anuradhapura. Results revealed that banana ripened in Anuradhapura (22.5 ºC) has the optimum quality during ripening in comparison to other two locations Kothmale (18.87 ºC) and Mullativu (28.82 ºC). Hence, maintenance of optimum temperature during ripening is essential to obtain the quality product. Therefore, modifications to the existing chambers were applied by introducing an air inlet fan (as a ventilation system) and a heating system to prevent the temperature fluctuations during ripening.

**Keywords**: Ethylene treatment, Fruit ripening, Quality, Ripening chamber

# Isolation, Identification and Detection of *Listeria monocytogenes* Persistence in Chicken Raw Meat Products and Comminuted Ready-To-Eat Sausages in Nelna Chicken Processing and Further Processing Plant (Pvt.) Ltd. Sri Lanka

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*Listeria monocytogenes*, a food borne pathogenic bacterium often isolated from meat and meat products, is considered a major causative agent responsible for serious diseases in both humans and animals. This study was carried out to determine the persistence rate and occurrence of *L. monocytogenes* in poultry meat and ready to eat sausages from Nelna Farm poultry meat processing plant, Meethirigala, Sri Lanka. A total of 100 samples were (50 samples of poultry meat and 50 samples of sausages) collected and tested for *L. monocytogenes* using Fraser Broth and HiCrome Agar Listeria medium, examined by ISO 11290 method and confirmed by biochemical tests (catalase, beta-hemolysis, CAMP test) and the motility test in semi-solid nutrient broth. Out of 100, only 13 samples were suspected as *Listeria spp.* by the colony appearance. After the biochemical tests, those 13 samples were also confirmed as not contaminated from *L. monocytogenes.* All the fifty chicken raw meat samples and fifty comminuted sausages samples from Nelna Farm were all negative for *L. monocytogenes*. As all the results are negative, some of the paired samples were sent to the Bureau Veritas, Colombo and those results were also negative. The samples are 100% free from virulent *L. monocytogenes* and also can conclude this factory has been following good hygienic practices based on hazard analysis and critical control point programs throughout the industry.

**Keywords:** Biochemical test, Isolation, *Listeria monocytogenes,* Poultry meat

# Initiation Trigger on Pin Head of Oyster Mushroom *Pleurotus ostreatus* by Plant Extracts and Blue Light

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*Pleurotus ostreatus* is known as oyster mushroom, its cultivation has become popular as it is highly nutritious and medicinally important. It requires twenty-one days of incubation period generally before exposing to light to induce the fruiting. This study was designed to reduce the incubation period and to induce the pin head initiation. Paddy straw was used as the substrate and were sprayed with 5%, 10% and 15% of banana pseudostem and fenugreek extract and exposed to the 1W blue light on the 10th day of inoculation. The temperature was maintained at 29 ± 1 ˚C throughout the experiment period. Harvest was obtained until 31 days from the inoculation. Earliest pin head was initiated on the 22nd day from the 15 % fenugreek juice and 5% banana pseudostem juice applied treatment. 25 numbers of fruiting bodies were obtained from 15% banana pseudostem juice application and, the lowest was recorded from the 5% banana pseudostem juice applied treatment. Highest fresh weight of 127.55 ± 10.52 g was recorded from the 15% banana pseudostem juice application and the lowest was recorded 77.63 ± 5.56 g from 5% banana stem juice application. Biological efficiency was significantly higher in 15% banana pseudostem juice application, which was 85.03%. Pin head initiation was not recorded from 5% and 10% of fenugreek juice applied treatment during the thirty-one days from the inoculation. It reveals that, there is a positive effect of blue light in inducing pin heads formation of *P. ostreatus*.

**Keywords:** *Pleurotus ostreatus*, Blue light, Plant extract, Fruiting body.

# Livestock and Poultry Production

# Effect of Anthelmintic Treatment in Indigenous Goats of Sri Lanka

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Gastrointestinal parasite of livestock are nematodes, trematodes, cestodes and protozoans (including coccidians) which represent an important cause of reduced productivity of goats worldwide. Anthelmintic treatment is an effective way to control these parasites, the present study evaluated the effect of an anthelmintic drug in indigenous goats of a livestock farm in Puliyankulam, Vavuniya district of Sri Lanka from mid of March to May 2021. A randomly selected 20 indigenous goats were divided into following groups: below one year, one to three years, above three years and control group which was selected without considering age. The fecal samples were collected and treatment groups were subjected to oral dosing of closeted 96% and abamectin 4%. Then fecal samples examined using McMaster techniques to count the egg per gram/ oocyst per gram of gastrointestinal parasitic species for ten weeks with two weeks interval. The results were analyzed in SPSS statistical package through the ANOVA table. The result showed 100% Nematode population (*Trichostrongylus* spp., *Strongyloides* spp., and *Trichuris* spp.) in goats was effectively controlled in two weeks after of anthelmintic treatment. Drug was not effective to control *Eimeria* spp. and *Monezia* spp. After four week of treatment *Trichostrongylus* spp. was reappeared in all treatment groups and *Strongyloides* spp. was reappeared only in one to three years goats. After eight week of treatment all Nematodes species were increased because the effectiveness of drug was highly reduced. The closantel 96% and abamectin 4% oral dosing was effective to control Nematode species less than eight weeks.

**Keywords**: Anthelmintic, Parasitism, Goats, McMaster egg counting

# Effect of Feeding *Alternanthera sessilis* Leaf Meal (ASLM) on Growth Performance of Japanese Quails (*Coturnix coturnix japonica*)

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Japanese quail production has been extensively practiced in worldwide as its meat is lean and low in cholesterol. Many efforts are made to use different leaf meals in their diet to enhance the performance. The present study was conducted with the aim of assessing the effect of feeding *Alternanthera sessilis* leaf meal (ASLM) on growth performance of Japanese quails (*Coturnix coturnix japonica*). A total of 96 unsexed, fourteen days old Japanese quail chicks were randomly assigned to four equal treatments of 24 birds and further subdivided into four replicates according to a completely randomized design. The first (control) treatment (T1) was a diet without ASLM while ASLM was added in diets at levels of 1%, 3% and 5% in the second (T2), third (T3) and fourth (T4) treatments, respectively. Ad-libitum feeding was practiced till the end of sixth week. Body weight and feed consumption were recorded at weekly intervals, while body weight gain and feed conversion ratio (FCR) were calculated. On forty second day, quails were slaughtered, and the dressing percentage was calculated. The results indicated that the supplementation of ASLM in Japanese quail diets significantly ($p<0.05$) affected the feed intake, body weight, body weight gain and feed conversion ratio. T4 had the lowest feed intake than other treatments on the 22-28, 29-35 and 36-42 days, whereas on 35$^{th}$ and 42$^{nd}$ day it had the highest ($p<0.05$) body weight of 167.49±17.97 g and 181.85±16.08 g, respectively. On 29$^{th}$ to 35$^{th}$ day the body weight gain of T4 was significantly higher ($p<0.05$) than other treatments. Feed conversion ratio was decreased with increasing level of ASLM where T4 had the lowest ($p<0.05$) FCR on 21-28 and 29-35 days. However, ASLM supplementation had no significant ($p>0.05$) influence on the dressing percentage and it was between 70-73%. This study revealed that supplementing diet with 5% ASLM enhanced the growth performance of Japanese quails.

**Keywords**: *Alternanthera sessilis*, Feed conversion ratio, Growth performance, Japanese quails

# Anthelmintic Efficacy against the Prevalent Gastrointestinal Parasite in Cattle

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Gastrointestinal parasitic infections are a major constraint in cattle management. Twenty cattle (n=20) were randomly selected and divided into different groups as treatment group and control group. Treatment group had 15 number of animals and control group had 5 animals. The treatment group was divided into three different categories based on the age as 5 animals in each group (< 1 ½ year age, 1 ½ - 3 years age, > 3 year age) and group of cattle did not separate into groups was considered as the control group. Then anthelmintic treatment was given according to the body weight using Albendazole (10 mg/kg). Thereafter, fecal samples were collected from each animal every two weeks until 10th week of post treatment. Each fecal sample was examined using McMaster technique to count the parasitic eggs per gram (EPG). Data was analyzed using SPSS univariate method. The highest ($p<0.05$) egg count was observed in the initial stage (before giving treatment) and it was more than 1500 EPG. Two weeks after the treatment marginal means of egg count was reduced suddenly and it was less than 500 EPG ($p<0.05$). The 4th week after treatment also shown a reduction in egg count than the 2nd week after treatment. The least marginal means of egg count was shown by the 4th week after treatment ($p<0.05$). Thereafter the marginal means of egg count was started to raised. At the eighth weeks after treatment the egg count was increased than previous week and it was less than the 500 EPG ($p<0.05$). 10th weeks after treatment egg count was increased than previous weeks. Thus, it can be concluded as Albendozole oral administration was effective to control gastrointestinal parasites until 4th weeks and it was strongly recommended to treat the animals regularly of every 8 weeks interval.

**Keywords**: Anthelmintic, Cattle, McMaster egg counting, Parasitism

# Analysis of Productive and Reproductive Traits of Murrah Buffaloes in a Large-scale Farm in North Western Province of Sri Lanka

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The buffalo milk production contributed to 15.9% of the Sri Lankan fresh milk production in 2019. The scarcity of updated information on buffalo production and reproduction leads to problems in farm decision-making which results in reduced productivity. The objective of the present study was to analyze some selected milk production and reproduction parameters of a large-scale farm in North Western Province of Sri Lanka. Farm records of semi-intensively managed, 132 crossbred Murrah buffalos (ages ranged from 4.15 to 16.55 years) at Marandawila farm from 2007-2019 were used in the analysis. The following production and reproduction parameters were calculated for the first five lactations: (i) The average milk yield per buffalo per day (MYD; Liters) (ii) average milk yield per buffalo per lactation (MYL; Liters) (iii) average lactation length (LL; days) iv) age at first calving (AFC; months) (v) average calving intervals (ACI; days) (vi) stillbirth (SBR) (vii) abortions (ABR). The average values ± SEM obtained for the above parameters were: (i) 5.40 ± 0.21, (ii) 1561.76 ± 60.33, (iii) 285.90 ± 8.07, (iv) 59.95 ± 0.79, (v) 462.34 ± 21.14 (vi) 6.77% (vii) 2.26%. The MYD was higher ($p < 0.05$) in 4$^{th}$ lactation compared with the rest of the lactations. The first LL and the first ACI were longer ($p < 0.05$) than that of subsequent lactations. A weak negative correlation ($r = -0.221$; $p < 0.05$) was observed between the birth weight (BW) and AFC of the same buffalo cow. Among 532 births recorded, 91% were healthy calves. The average BW was not statistically significant between male and female calves. In conclusion, the productive and reproductive parameters were slightly substandard when the optimum local production standards are considered. It can be speculated that the adoption of proper husbandry practices including improved feeding management may improve the tested production and reproduction parameters up to the optimum level.

**Keywords:** Buffalo, Lactation curve, Murrah, Productive parameters, Reproductive parameters

# Plant Protection

# Identification of Suitable Spacing and Herbicides for Dry Drilled Seeded Rice Cultivation

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Rice consumption in Sri Lanka is outstripping production, and with the increasing population, demand is likely to be increased. Weeds are the main hindrances affecting rice production. A study was carried out from October 2020 to January 2021 at Rice Research Station, Paranthan, Kilinochchi, to evaluate suitable spacing and herbicides for dry drilled seeded rice cultivation. Bg366 rice variety was used for this study. The study was laid in a Randomized Complete Block Design (RCBD) with three replicates under two different spacing (15×15 $cm^2$ and 20×20 $cm^2$ row SSspacing) in row seeding at a seed rate of 20 kg/ha. *Pretilachlor, Oxyfluotfen, Florpyrauxifen-benzyl* and *Bispyribac-sodium* were used as the treatments. Hand weeding was the control. The plot size of each treatment was 6×3 $m^2$. Plant height, number of weeds, weed dry biomass, number of tillers per plant, number spikelets per panicle, filled grains percentage and grain yield were measured. The data were assessed through ANOVA test by using SAS computer software package. The result revealed that an increase in crop density (15×15 $cm^2$) significantly reduced the number and dry matter production of weeds. The average weed reduction (grasses and sedges) was higher in *Florpyrauxifen-benzyl* (15×15 $cm^2$) followed by hand weeding. However, *Florpyrauxifen-benzyl* at 20×20 $cm^2$ row spacing was negatively controlled the broadleaved weeds. However, Maximum grain yield was recorded in hand weeding at 15×15 $cm^2$ (4.493 t/ha) followed by *Florpyrauxifen-benzyl* at 15×15 $cm^2$ (4.156 t/ha). The minimum weed population was observed in narrow spacing (15×15 $cm^2$). The result of the study revealed that the weed biomass and density were efficiently controlled by *Florpyrauxifen-benzyl* which also increased the plant height, total number of tillers, and number of spikelets per panicle (176.11) at 15×15 $cm^2$ spacing under the dry drilled seeded method.

**Keywords**: Drilled seeded rice, Herbicide, Plant spacing, Weed density, Yield

# Allelopathic Effect of *Zea mays*, *Senna spectabilis* and *Muntingia calabura* on Weeds: Potential Implication for Controlling Weeds in Tea Lands

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Identification of eco-friendly weed control measures is imperative due to the adverse effects of excessive use of synthetic herbicides. Thus, a series of bioassays and field studies were conducted to evaluate the allelopathic potential of three plant spp., namely, Maize (*Zea mays*), Kaha-kona (*Senna spectabilis)* and Jam (*Muntingia calabura*) in tea lands. The specific objectives were to identify the most phytotoxic extract, its effective concentration and effective extraction method, synergistic/antagonistic effects, allelochemical releasing mode and field efficacy to control weeds. Plant extracts for bioassays were prepared with dry powders of leaves/husk in four concentrations (4, 6, 8 and 10% w/v) using hot and cold-distilled water. Synergistic/antagonistic effects were tested using cocktails of different extracts mixed at different ratios. Allelochemical releasing mode (decomposition, volatilization and leaching) was identified by pot bioassay, dish-pack and sandwich methods, respectively. These treatments were evaluated on lettuce as an indicator plant. Meanwhile, the three most allelopathic extracts/materials were tested in the field by spraying/mulching. Results revealed no significant difference among hot and cold-water extraction ($p$>0.05). 10% concentration showed the highest phytotoxicity (lowest germination of lettuce). Jam and Kaha-kona showed the highest phytotoxicity evidenced by the lowest germination (22-23%), followed by Maize (44%). Germination was inhibited at 100% in all cocktails indicating their synergistic effect. Leaching was prominent in Kaha-kona evidenced by the lowest germination (61%) and the highest inhibitory effect on radical (77%) and hypocotyl (71%) elongation. Volatilization was prominent in Kaha-kona and Jam while decomposition was notable in Maize (leaves) and Kaha-kona. Mulching was effective compared to spraying (10%, 450 ml $m^{-2}$), where maize mulching recorded the lowest weed emergence, followed by Jam (77-84% weed dry weight reduction). In conclusion, *S. spectabilis* and *M.calabura* demonstrate high allelopathic potential, followed by *Z. mays* highlighting its potential implication for eco-friendly weed control. Further investigations are needed to evaluate the field efficacy of these botanicals in controlling different weed species.

**Keywords:** Allelopathic potential, Bioassay, Decomposition, Leaching

# Effect of Selected Bacteria Isolates on the Yield of Improved Rice Variety Bg300 under Field Condition

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Use of inorganic fertilizers, exceeding the recommendation by Department Agriculture is common practice among most farmers, which is accused of environmental, health and social issues in Sri Lanka. The necessity of introducing alternative fertilizers for synthetic fertilizer has emerged as an important topic in Sri Lankan agriculture. Plant growth-promoting bacteria are recognized as an eco-friendly approach to replace inorganic fertilizer. The objective of this study was to determine the effect of two selected bacteria isolates (I-1 and I-2), on the yield of improved rice variety Bg300 under field condition in the low country wet zone of Sri Lanka. The experiment was carried out with treatments of I-1 inoculation, I-2 inoculation, recommended dose of inorganic fertilizer (F), and recommended dose of inorganic fertilizer with each isolate (I-1+F and I-2+F respectively) in Horana, which is located in the agro-ecological zone of WL1 during *Maha* season in 2018 and 2019. The experiment was laid as a Randomized Complete Block design (RCBD) with two replicates for each treatment. Each replicate was a 30 $m^2$ plot of 5 m x 6 m. The germinated seeds were inoculated with respective bacteria isolate at mid-log phase of growth, prior to seed sowing. Regular agronomic practices were followed for the cultivation of rice. The total yield of each plot was measured at harvest. Data were analyzed using SAS software for ANOVA and Duncan's Multiple Range Test (DMRT) for mean separation. Inoculation of bacteria had significantly affected the yield as average values of 12.75±0.25 kg and 12.5±0.3 kg were recorded for I-1 and I-2 treatments in contrast to that of the control (8.9±0.3 kg). The average yields of the recommended dose of inorganic fertilizer (11.9±0.1 kg) and the combination of I-2 and inorganic fertilizer (12.3±0.3 kg) were not significantly different over bacteria inoculation alone. The isolate I-1 and inorganic fertilizer combination could not be tested due to a wild boar attack on one of the plots. Further experiments on the efficacy of the above bacteria isolates under different agro-ecological regions of the country will be useful for their utilization as bio fertilizers in the future.

**Keywords**: Plant Growth Promoting Bacteria, Rice, Yield

# Evaluating Host Plant Reaction of Indian Musa Germplasm for Resistance to Root lesion and Burrowing Nematodes under Greenhouse

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Investigations were carried out in 59 banana genotypes (*Musa* spp.) comprising of 10 diploids and 49 triploids belonging to Eumusa section, comprising of wild and cultivated banana accessions against burrowing nematode (*Radopholus similis*) and root lesion nematode (*Pratylenchus coffeae*) under greenhouse condition. Healthy suckers were planted in cement pots and two experiments were conducted for diploid and triploid accessions in a factorial completely randomized design (FCRD) with five replications. controls and varieties (Yangambi Km5, Pisang Lilin and Nendran) with known reaction to burrowing and lesion nematodes were included as reference clones. Banana accessions in pots were inoculated with infective juveniles of root-lesion nematode or burrowing nematode, 45 days after planting 1,000 nematodes and 400 nematodes/pot, respectively. Ninety days after inoculation, Data were recorded and subjected to statistical scrutiny by analysis of variance (ANOVA) using the AgRes statistical software (1994, Pascal International Software Solutions). Root necrosis percentage varied from 10-85%. Lowest root necrosis (10%) was observed in *M. balbisiana*, *Karthobiumtham* and *Athiakol*. *P.coffeae* root nematode population was lowest in Bhimkol (54), Kanai Bansi (58) and Karthobiumtham (65). Root studies indicated higher number of roots, root resistant and tolerant accessions even after nematode inoculation. Experiments revealed that triploids Ankur-II (ABB), Kachkel (ABB) and Karthobiumtham (ABB) and diploids *M. balbisiana* (BB), Bhimkol (BB), Athiakol (BB), Aittakola (BB), Kechulepa (BB) and Kanai Bansi (AA) were resistant to *P. coffeae*. Least number of *R. similis* infected roots was recorded in Kanai Bansi (2.4%) while maximum was observed in Manguthamng (11%). Lowest root nematode population was recorded in Bhimkol (33), Kanai Bansi (40) and Kothia (70). Root necrosis percentage varies from 10-85%. The least RNI (10%) was recorded in *M. balbisiana*, Elakkiebale and high in Jahaji (85%) and Barjahaji (80%). Diploid accessions, Kanai Bansi (AA), Elakkiebale (AB), *M. balbisiana* (BB), Bhimkol (BB), Athiakol(BB) and Aittakola (BB) and Triploids Kothia (ABB) and Ankur II (ABB) were resistant to *R. similis.*

**Keywords:** Banana, *Pratylenchus coffeae*, *Radopholus similis*, Resistance

# Biological Control of Soft Rot caused by *Pectobacterium caratovorum* using Lactic acid Bacteria, *Pseudomonas fluorescens and* Botanicals

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Productivity of various crops is greatly affected due to infestation of diseases caused by microorganisms. More than 100 known bacterial species are able to cause plant disease. *Pectobacterium caratovorum* is the causal agent of bacterial soft rot is one of the most serious diseases that damage to fruits and vegetables in the field as well as in storage. This study was carried out to evaluate the antibacterial activity of Lactic acid bacteria *Pseudomonas fluorescens* and selected plant extracts against to *P. caratovorum*. In- vitro screening of botanicals against soft rot bacteria was done with well diffusion assay and Poisoned food assay by using Potato Dextrose Agar (PDA) and Nutrient agar media. Reason for selecting the botanicals is to evaluate the efficacy of them against to *P. caratovorum*. Bacteria grow well in Nutrient Agar than the Potato Dextrose Agar media. In this study CRD design was used with three replicates of each treatment. The plants such as *Anagalis arvensis, Annona squamosa, Cassia senna, Cymbopogon citratus, Vitex negundo, Piper longum, Aerva lanata, Wild Ricinus communis* and *Azadirachta indica* were used to prepare 25% concentrations of aqueous extracts. During the *in-vitro* experiment, remarkable inhibitory percentage was observed in case of leaf extracts of *A. squamosa* (74.91%) followed by leaf extracts *Cassia senna* (68.73%) and *A. arvensis* (68.73%). *P. longum* with *P*. *fluorescens* and *A. lanata* with *P*. *fluorescens* were reported (98.86 %) of inhibition followed by *A. squamosa* with *P*. *fluorescens* (96.85%), *C. senna* with *P*. *fluorescens* (93.04%) and *V. negundo* with Lactic acid bacteria gave (96.81%) of inhibition followed by *P. longum* with Lactic acid bacteria (93.35%), *A. squamosa* with Lactic acid bacteria (91.93%). In future, investigation on the different concentrations of plant extracts on inhibition of *P*. c*aratovorum* and analyzes the phyto-chemical compounds responsible for the antibacterial activity in botanicals and antagonistic bacteria are suggested.

**Keywords**: Soft rot, *Pectobacterium caratovorum*, Antagonistic bacteria, Lactic acid bacteria, *Pseudomonas fluorescens*.

# Plant Breeding and Biotechnology

# Assessing the Sustainable Growth of Non-Traditional Arid Zone Fruit Crops under Semiarid Vertisol Condition of Tamil Nadu

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The semi-arid regions of Tami Nadu are characterized by extreme weather conditions and poor soil and water quality, which limit the productivity of fruit crops. However, to enhance the effective utilization of land area, preliminary research was conducted to assess the sustainability of growing non-traditional fruits crops under the semiarid vertisol condition of Tamil Nadu. Research was conducted at the Regional Research Station, Tamil Nadu Agricultural University, Aruppukottai, during the year 2019-2021. The research station is located in semi-arid region, which experiences an annual average rainfall of 770 mm in about 42 rainy days mainly during the North-East Monsoon. The soil type is vertisol (Black clay loam soil with underlying canker nodules) and soil depth ranges between 0.6 to 1.2 m. This research station caters the needs of the people living in semi-arid zones of Sothern districts of Tamil Nadu. In order to carry out the experiment, different nontraditional fruit crops were collected from different zones of India and introduced into Regional Research Station, Aruppukottai. The fruit crops introduced were Karonda (*Carissa congesta*), Chironji *(Buchanania lanzan),* Mahua (*Bassia latifolia*), Khirni (*Manilkara hexandra*), Bael (*Aegle marmelos*), Wood apple (*Feronia limonia*) and Jamun (*Syzigium cumini*) from Indian Council of Agricultural Research (ICAR) - Central Horticultural Experimental Station (ICAR–CHES), Godhra, Gujarat and Phalsa (*Grewia asiatica*), Lasoda (*Cordia myxa*), Mulbery, Apple ber plants and Khejri (*Prosopis cineraria*) from ICAR - Central Institute for Arid Horticulture (CIAH), Bikaner, Rajasthan. After evaluating growth performances for one year of period, the Karonda var. Thar Kamal, Phalsa var. Thar Pragati, Lasoda var. Thar Bold, Mulbery var. Thar Lohit and Thar Harit and Khejri var. Thar Shobha showed comparatively higher mean growth performances and initiation of flowering under semi-arid vertisol condition. Mass multiplication is in progress for commercial cultivation.

**Keywords:** Semiarid zones, Arid zone nontraditional fruits, Vertisol condition

# Determination of Leaf Spot Disease Incidence and Severity of a Cinnamon Collection for Two Consecutive Years

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Leaf spot disease (LSD) is considered to be a major disease of cinnamon (*Cinnamomum verum* J. Presl). Comprehensive information on temporal variation of LSD is not available in Sri Lanka. A collection of forty cinnamon accessions, established at Faculty of Agriculture, University of Ruhuna (UoR) from six major cinnamon growing areas was used to determine the temporal variation of above disease incidence (LSDI) during September, 2018 and December 2019, disease severity (LSDS) and correlation between selected morphological characters and LSDI. Using a disease assessment key, developed by Azad *et al* in 2019, the LSDS was determined during 2019. The selected morphological characters of tree height (Th), leaf length (LL), leaf width (LW), leaf length-width ratio (Ll/Lw) and petiole length (Pl), bark thickness (Bth), trunk circumference (Tc) and twig diameter (Twd) were recorded following the Descriptors for Cinnamon (*Cinnamomum verum*) (Team of TURIS 2013 Project, 2016). All accessions reported 50 - 100% of LSDI in both years. Mean LSDI (76.97) was low during 2018 with average monthly rainfall (MRF) of 95.62 mm in contrast to that of 2019 (87.42) with 189.4 mm of MRF, according to the Paired T test. Average values of LSDS of accessions collected from Matara, Galle, Kalutara, Kurunegala, Ratnapura and Hambantota in the established collection at UoR were 4.08, 3.30, 3.74, 2.00, 2.67 and 3.50 respectively during 2019. Above values were different from those during the collection period of June, 2014 to April, 2015 (as 4.50, 4.82, 4.74, 4.60, 3.65 and 3.91 respectively). The accessions were grouped into 3 clusters based on selected morphological characters at rescaled distance of 60.25 in the cluster analysis. Morphological characters of the accessions did not correlate with the LSDI. Above results indicate that LSDS is variable among accessions. There is a temporal variation of LSDI among accessions in the tested location.

**Keywords:** *Cinnamomum verum* collection, Leaf spot disease incidence, Leaf spot disease severity, Temporal variation

# *In-Vivo* Evaluation of Anti-Histamine Activity of *Siddha* Formulation of Extract Powder of the Stem of *Tinospora cordifolia*

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Siddha system of medicine is one of the ancient systems of medicine practiced among Tamil speaking communities particularly in southern parts of India, Northern and Eastern provinces of Sri Lanka. "*Seendhil Sarkkarai*" is one of the authentic and multipurpose *Siddha* single herbal preparation of extract powder of the stem of *Tinospora cordifolia*. Initiation of antigen reaction stimulates mast cells to release histamine into the blood. Which interacts with the cells to produce most of the symptoms of allergy. Drugs that block only the action of histamine are known as antihistaminic while the drugs preventing mast cells from releasing histamine are considered anti-allergic agents. In this study, the effects of *Siddha* drug, extract powder of the stem of *T. cordifolia* was studied on the active anaphylaxis and mast cell stabilization in matured Wister rats and histamine induced bronchospasm in matured guinea pigs. The aim of study was to evaluate the anti-histaminic activity on extract powder of the stem of *T. cordifolia* in histamine-induced bronchospasm in guinea pigs. Inbred Wister rats 175-200 g) and guinea pigs (400-600 g) of either sex were used and housed in standard conditions (temperature 22±2 °C, relative humidity 60±5% and 12 h light/dark cycle). They were fed with standard pellet diet and water as required. Mast cell stabilizing activity was studied in twenty-four rats, divided into four groups each with six individuals. Bronchospasm was induced in guinea pigs by exposing them to 1% histamine aerosol under constant pressure (1 kg/cm$^2$) in an aerosol chamber (24×14×24 cm) made of persplex glass, of three groups each with six animals. The result showed that the extract powder of the stem of *T. cordifolia* at a dose of 100 mg/kg and 200 mg/kg for 2 weeks resulted in a significant reduction ($p<0.001$) in the number of disrupted mast cells and significantly prolonged the latent period of Primary Ciliary Dyskinesia (PCD) ($p<0.001$) as compared to control, following exposure to histamine aerosols on day five. Future studies are needed to determine the phytoconstituent responsible for the above mentioned findings, as well as their clinical usefulness in the treatment of associated disorders.

**Keywords**: Broncho spasm, Herbal preparation, Mast cell, *Tinospora cordifolia*

# Principal Component and Correlation Analysis of Groundnut Germplasm (*Arachis hypogaea.*L.) towards Pod Filling Ability

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Groundnut, *Arachis hypogea.* L.*,* which belongs to the family Fabaceae, is a popular oil crop in Sri Lanka. Pod is the economically important parts of the groundnut. However, pod filling is one of the significant yield components and it is a primary problem in groundnut cultivation that decides the yield and demand of the Groundnut. Therefore, the present study was conducted to select the characters correlated with pod filling ability. Specifically, to identify the cause and effect of the relationship between different pairs of characters, select the parents for future breeding programs and improve a complex character like pod filling ability. Therefore, this study was carried out from February to May 2021 to perform principal component and correlation analysis of selected groundnut varieties and few advanced breeding lines toward their pod filling ability. Seeds of selected twelve germplasms *viz*., *Lanka Jumbo, ANKG1, Tissa, Indi, Tikiri, KCGN1, K2, K3, K4, K5, MUK* and *MU* lines were used. This experiment was conducted using Randomized Complete Block Design with three replicates each with twelve plots. Fifty-four seeds per line were planted in each plot. Selected phenotypic characters of groundnut were recorded from ten randomly selected plants from each plot. Principle component and correlation analysis were carried out on all recorded observations related to pod filling. The results revealed that the number of days to first flowering, number of days to 50% flowering, plant height at 50% flowering and plant height at maturity were the principal components that had a higher influence on traits within the analyzed components. Moreover, the number of days to 50% flowering and number of pegs per plant had a greater correlation with grain filling. Therefore, this study concludes that the selection based on these characters will lead to simultaneous improvement in pod filling in Groundnut.

**Keywords:** Groundnut, Pod filling, Principle components, Shelling percentage

# Comparative *In-Vitro* Antimicrobial Activities of Selected Medicinal Plant Seeds used in Control of Diabetes Mellitus

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The management of Diabetes mellitus is a major challenge for clinicians in and around the world. Uncontrollable hyperglycemia increases the risk of numerous complications in the body systems. Although a number of anti-diabetic drugs are available for therapeutic intervention, herbal management for diabetes is encouraged due to its low side effects and effectiveness worldwide. The present study deals with the evaluation of antibacterial activity of selected medicinal plant seeds namely *Syzygium cumini* (L.) Skeels, *Brassica alba* L., *Trigonella foenum-gra*ecum L. and *Nigella sativa* L. Crude ethanolic seeds extract was investigated for their antibacterial activity against *Enterococcus faecalis* (ATCC 29212-gram positive), *Staphylococcus aureus* (ATCC 29213-gram positive), and *Escherichia coli* (ATCC 25922- gram negative) by agar well diffusion method in triplicates. The *S. cumini* seed extract exhibited maximum zone of inhibitions (24.70, 16.14 and 10.37 mm) against all three bacterial species (*E. faecalis* 29212, *S. aureus* 29213 and *E. coli* 25922) respectively. However, the antibacterial potential of *B. alba* seed extract represented minimum zone of inhibitions (1.08, 1.08, 0 mm) against all three bacteria; *E. faecalis* 29212, *S. aureus* 29213 and *E. coli* 25922 respectively. Moderate antibacterial activity was revealed by *T. foenum-graecum* (10.83, 11.70 mm) against *E. faecalis* 29212 and *E. coli* 25922 and by *N. sativa* (15.70 mm) against *E. coli* 25922. There were no inhibition zones against *S. aureus* 29213 by *T. foenum-graecum* and *E. faecalis* 29212 by *N. sativa*. Results indicated that a significant amount of inhibition zone was achieved against all the selected bacterial species, which was comparable with positive control streptomycin. According to these results, *S. cumini* seed extract showed highest antimicrobial activity against selected bacteria species. In conclusion, the present study shows that *S. cumini* seeds can be used not only to treat diabetes mellitus but also as an antimicrobial agent.

**Keywords:** Antimicrobial activity, Diabetes mellitus, Medicinal plants, Seeds, *Syzygium cumini*

# Soil Science and Nutrient Management

# Total Potassium Concentration of Major Paddy Growing Soils in Sri Lanka

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Total potassium (K) concentration represents the K pool in a soil, and that provides the required K for plant uptake after making K available through biochemical changes. Knowledge on K pool in different soil types is important for sustainable management of crops and soils. Therefore, this research was conducted to estimate the total K concentration in different rice growing soil types from agro-climatic zones (ACZs) of Sri Lanka. Total of 200 soil samples representing six ACZs (except for Upcountry Wet zone) in Sri Lanka were collected though a stratified random sampling approach. Soil total K concentration was determined through X-ray florescence (XRF) analyser. Soil total K concentration had a wide range of values *i.e.* 316-31,153 mg $kg^{-1}$. The Reddish Brown Earths & Immature Brown Loams (RBE-IBL) had the highest soil total K concentration (20,127 mg $kg^{-1}$) followed by Rock Knob Plain (RKP), Reddish Brown Earths with high amount of gravel in subsoil & Low Humic Gley (RBE-LHG), Noncalcic Brown soils & Low Humic Gley soils (NB-LHG), Reddish Brown Earths, Noncalcic Brown soils & Low Humic Gley (RBE-NB-LHG) and Noncalcic Brown soils, soils on old alluvium & Solonetz (NB-S) soils. All these soils had total K concentration greater than 13,000 mg $kg^{-1}$. Soils of Bog and Half-Bog soils (BHB) and Red-Yellow Podzolic soils with soft or hard laterite (RYP) reported the lowest total K, *i.e.* <5,000 mg $kg^{-1}$. Soil total K concentration was high in Intermediate Zone Upcountry followed by Dry Zone Low Country, Intermediate Zone Low Country and Intermediate Zone Mid Country and the lowest in Wet Zone Low Country. The results confirm that, soil total K concentration in Sri Lankan paddy growing soils had a clear spatial variability associated with soil type and ACZ. This information would be important for sustainable K-nutrient management in Sri Lankan rice fields.

**Keywords:** Agro climatic zones, Soil types, Total potassium, X-ray florescence

# Total and Available Phosphorus Concentrations in Major Rice Growing Soils and Their Relationships with Rice Grain Phosphorus Concentration

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Phosphorus (P) is an essential macro nutrient for plant growth and development. Soil P exists in organic and inorganic forms. However, only a fraction of soil P is readily available to plant. Plant available and total P concentrations in soils vary among soil types due to the differences in soil mineralogy, structure, physical & chemical properties, and fertilizer application. Therefore, this research was conducted to estimate the concentrations of plant available and total P in major rice growing soils (i.e. 18 soil types) in Sri Lanka, and to study their relationships with grain P concentration. Total of 200 soil samples and grain samples were collected representing paddy lands across the country using a stratified random sampling approach. Available P (Olsen-P) and total P in soils, and grain P concentrations were measured. Available P concentration in paddy soil samples ranged from 5.4-76.9 mg $kg^{-1}$. The highest available P concentration was recorded in Reddish Brown Earths & Immature Brown Loams soil (RBE_IBL) (34 mg $kg^{-1}$) and the lowest in Red-Yellow Latosols soil (RYL) (12 mg $kg^{-1}$). Soil total P concentration had a wide range of values *i.e.*, 142-5685 mg $kg^{-1}$. The Red-Yellow Podzolic soils with soft or hard laterite (RYP) had the highest soil total P concentration (2525 mg $kg^{-1}$). Grumusol soil and RYL soil reported the lowest total P, *i.e.*, < 1000 mg $kg^{-1}$. Grain P concentration varied among soil types and it ranged between 0.6-1.8 mg $g^{-1}$. However, there was no correlation between the grain and soil P concentrations. This information would be important for sustainable P-nutrient management in Sri Lankan rice soils.

**Keywords**: Available phosphorous, Paddy, Soil categories, Total phosphorus

# Relationships between Total Mineral Element Concentrations of Major Paddy Growing Soils in Sri Lanka

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The knowledge on the accumulation of essential and toxic trace elements in rice growing soils is crucial for sustainable soil nutrient management and rice crop production. The aim of the present study was to investigate the total concentration of essential and toxic trace elements and their relationships in Sri Lankan paddy soils. Two hundred soil samples were collected representing three climatic zones and seventeen soil types using stratified random sampling approach. The total elements concentrations were measured using X-ray florescence (XRF) analyzer. The minimum and maximum total element concentrations were determined using descriptive statistics. Relationships among total element concentrations were tested using correlation and principle component (PC) analyses, and the concentrations of elements among climatic zones and soil types were compared using ANOVA. The highest mean total element concentration in soil samples was recoded in Fe which ranged from 220 to 71,994 mg $kg^{-1}$ followed by K (316-31, 153 mg $kg^{-1}$) and Ca (44-19, 436 mg $kg^{-1}$). The lowest mean total concentrations were observed in As and Mo (<3 mg $kg^{-1}$). Soil Fe concentration was positively correlated with Mn, Cu, Zn, As and Pb ($r$ > 0.5, $p<0.05$). Among the climatic zones, Wet Zone soils (WZ) contained higher concentrations of Fe, Zn, As and Pb whereas Dry Zone and Intermediate Zone soils had higher concentrations of Ca and K compared to WZ soils. When compare different soils categories, Bog and Half-Bog soils and Red-Yellow Podzolic soils had higher Fe, Zn, As and Pb concentrations whereas lower concentration of Ca and K were observed. The highest Mn concentration was in Grumusols while Cu concentration was relatively uniform in all soil types tested. Elements concentrations and their relationships studied in this research would be important in sustainable nutrient management in Sri Lankan rice fields.

**Keywords**: Heavy metals, Macronutrients, Micronutrients, Trace elements, XRF

# Potential use of *Chlorella sp.* Grown in Parboiled Effluent on Growth and Yield of Water Spinach (*Ipomoea aquatica L.)*

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Usage of organic fertilizers is the best solution to overcome the detrimental effects caused by synthetic fertilizers. However, readily available quality organic fertilizers are limited. Microalgae could be used as bio fertilizers to the crops. A pot experiment (1kg soil/ pot) was conducted to assess the potential use of *Chlorella sp.* grown in wastewater on growth and yield of *Ipomea aquatica* with different organic fertilizer and application combinations. Treatments were T1 Control (No fertilizer application), T2 *Chlorella* soil application (SA) – 2 g/pot soil, T3 *Chlorella* SA – 4 g/pot soil, T4 *Chlorella* foliar application(FA) – 165 mg live biomass /pot through foliar, T5 *Chlorella* FA- 33 mg dry biomass/pot through foliar, T6 100% cattle manure 3.23 g/pot, T7 *Chlorella* SA- 1 g/pot soil + 50% cattle manure, T8 *Chlorella* SA 2 g/pot soil + 50% cattle manure, T9 *Chlorella* FA 82.5 mg live biomass/pot through foliar + 50% cattle manure, T10 *Chlorella* FA 16.5 mg dry biomass/pot through foliar + 50% cattle manure, T11 50% cattle manure (1.61 g/pot). Treatments were arranged as completely randomized design with three replicates. Plant height, number of leaves, leaf area, and fresh and dry weight of edible yield were measured at the end of four weeks. Data were statistically analysed using ANOVA and mean separation was done using Duncan's multiple range test. Results of nutrient analysis of *Chlorella* indicated that it has considerable amount potassium (0.73%), phosphorous (3.23%), nitrogen (27%) and carbon (38.05%). At the time of harvest, significantly higher plant height was recorded in T2, T7 and T8, significantly higher leaf number was observed in T3, while the significantly highest leaf area was found in T3 compared with other treatments. The fresh and dry weight yield were significantly higher in T2, T3, T7 and T8, and T2, T3 and T7 respectively, indicating a better response to soil application of *Chlorella* compared to foliar application. It is interesting to note that the yield of *Ipomea aquatica* was either equal or higher in treatments of *Chlorella* as sole soil application or combination with cattle manure compared to 100% cattle manure treatment, indicating the potential of *Chlorella sp.* as a bio fertilizer.

**Keywords:** Bio fertilizer, *Chlorella spp,* Foliar application, *Ipomoea aquatic, Soil application*

# Farm Mechanization and Post Harvest Management

# Design, Fabrication and Performance Evaluation of Super Tine Cultivator

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Tillage is an inevitable aspect in agriculture and various tillage methods are being utilized in Sri Lanka. Considerable amount of money is spent on tillage. Mechanical tillage activities are not much accessible by poor farmers. This study was aimed to design and fabricate a super tine cultivator as an attempt to solve this issue. Objective of this research is to modify the spring loaded tine cultivator in to super tine cultivator for secondary tillage and to evaluate the performance of modified cultivator in terms of fuel consumption and time requirement for field performance. By considering the availability, cost, strength and durability the iron bar was selected as the material to design the super tine cultivator. The time needed to till the land area of one acre and the volume of fuel required for such tillage were recorded. The fuel consumption was found to be lowest for super tine cultivator for clay, sandy and loamy soil compared to spring loaded tine cultivator. While considering the time required for tilling one acre of land, the lowest time duration was observed for super tine cultivator for all three kind of soil. The lowest fuel consumption (2.5 Liter/acre) was recorded for the super tine cultivator in sandy soil while the highest fuel consumption (4.88 Liter/acre) was recorded for the spring loaded tine cultivator in clay soil. The lowest time required (0.43 hour/acre) was observed in sandy soil with the usage of super tine cultivator whereas the highest time duration (0.75 hour/acre) was recorded for spring load tine cultivator in clay soil. In addition, tillage with 15-30 cm depth is achieved in super tine cultivator without any struggle in soil. As the toggle and link assembly and heavy coil spring have been excluded in the design, totally the weight of 60 kg is reduced in super tine cultivator which facilitates easy hitching of implement. Therefore, it can be concluded that the super tine cultivator performed efficiently than spring load tine cultivator. Tillage of larger land area with lower time duration and fuel requirement is possible with super tine cultivator. The super tine cultivator can be sold in the market for sixty-nine thousand Sri Lankan rupees.

**Keywords**: Fuel consumption, Field performance, Modification, Spring loaded

# Design, Fabrication and Performance Evaluation of Onion Topper

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Onion is one of the important condiments which is highly demanded by Sri Lankan to make their food delicious. Within the available varieties, red onion is very popular in Sri Lanka. It is widely grown in the Northern part of Sri Lanka and has good demand all around the country for its fine taste and aroma. In the onion production chain, the bulb separation contributes a considerable amount as a production cost. This study was aimed to rectify this issue by designing onion topper with required features. The objectives of this study are to design and fabricate onion topper, to improve the cutting and cleaning process of onion leaf and root and to reduce the time of processing while increasing the product quality. The materials were selected considering some factors like availability, applicability, durability, strength and cost of the materials. Onion with root and stalk was fed in to the machine and allowed to be processed during which the cleaning of onion by removal of dust and debris carried out by incorporating rotation via compression motor along with cutting off and removal of root and stalk of the onion, which were inhaled under high air pressure with a motorized knife. Capacity of the machine, power requirement and electricity cost were estimated. The onion topper processed 30 kg of onion within an hour with the power consumption of 0.38 kWh which accounts for 2.47 Sri Lankan rupees. Therefore, the cost of onion processing and man power requirement can be reduced through this onion topper. Consequently, the income of the farmers can be increased sufficiently. Further this machine showed less noise effect (29.98 dB) and no greenhouse effect. This onion topper can be sold in market for thirty-five thousand Sri Lankan rupees.

**Keywords:** Motorized knife, Man power, Onion topper, Red onion, Rotation

# Effect of Parboiling Methods on Milling yield and Resistance Starch of Three Rice Varieties

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Rice is one of the leading food crops in the world and is the primary dietary source of carbohydrates in over half of the world's population. The parboiling process leads to improve rice quality and changed physicochemical properties of grains and also parboiled rice exhibits several advantages over raw rice products such as increased milling recovery, and prevention of the loss of nutrients during milling and cooking. The study was aimed to evaluate milling yield analysis in three methods of parboiling and non-parboiling paddy and cooking qualities in three methods parboiled and non-parboiled rice by extrusion test. One traditional variety (Attakari), and two Department recommended varieties At362 and Bg366 were used for this study. Rice of these varieties was parboiled in three methods; Soak Steamed Parboiling (SSP), Pressure Soak Steamed Parboiling (PSSP), (15 psi/121 ˚C), Open Steamed Parboiling (OSP). All varieties were soaked in water at ambient temperature (30 ˚C) for 1-5 days duration before steaming. The lowest steaming time (20 min) and higher head rice yield were observed in the PSSP method at 2 days soaking time duration. Other parboiling methods give higher head rice yield at 3 days soaking time duration. Raw paddy gives less head rice yield than parboiled paddy samples. Non-parboiled paddy samples recorded higher broken % during milling compare to parboiled paddy samples. In the PSSP method samples show a lower level of extrusion percentage than other methods of parboiled paddy as there is high resistant starch content. Non-parboiled samples and soaked steam samples show a higher extrusion percentage than other parboiling methods.

**Keywords**: Resistant starch, Pressurized steaming, Extrusion and Head rice yield

# Quality Rice Flour Production for Extruded Products through Wet-Milling

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Rice *(Oryza sativa L.)* is one of the leading cereal crops in the developing world. Rice grain is a major source of carbohydrates, protein and other essential nutrients. The Degree of Milling (DOM) is a term used to describe the milling process. With an increase in DOM, the preservation of bran decreases. This, in turn, has an influence on the level of head rice yield and the related economics. Sri Lanka has two types of raw rice varieties based on pericarp color. Those were white rice and red rice which contained polished red rice and unpolished red rice. This study was aimed to investigate the quality of extruder processed rice flour from raw rice at different intervals of soaking as it is a significant factor in determining the quality of rice products. The weight of 100 grains, length, width and whiteness value of raw rice samples were tested. Rice grinding has been used to minimize particle size and to obtain rice flour. Rice flour yield of white rice, polished rice and unpolished rice with 256 microns sieved were 96%, 92% and 90% respectively. Based on this outcome of extruded products, it can be concluded that soaking for two hours is needed for white rice and polished rice to get optimum yield through wet-milling and unpolished red rice requires 4 hours of soaking to give optimum yield. The quality of the flour products depends on the soaking time and the type of milling. All the raw rice can be used for the wet-milling after 2 to 4 hours of cold water soaking to yield more than 90% of 256-micron particle size granules.

**Keywords:** Degree of Milling, Wet-milling, Whiteness

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