



IRS UWU 2017

# INTERNATIONAL RESEARCH SYMPOSIUM | 2017

"Global Trends Towards Technopreneurial Development" | 19-20, JANUARY

Uva Wellassa University  
Badulla  
Sri Lanka

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# Acknowledgements

It is great to have listed certain personalities who could give their contribution on the success of the first International Research Symposium of Uva Wellassa University (IRSUWU 2017), which makes a remarkable memory in the history and in the minds of us. Without their support and wishes, this would not have been held successfully, as expected.

Accordingly, the Vice Chancellor, Director/Research Committee, and IRSUWU 2017 Organizing Committee of Uva Wellassa University extend special thanks to Professor Buddhi Marambe, the Chief Guest and Professor Kirsten Benkendorff (Australia), Professor Cheorun Jo (South Korea), and Professor Li Cheng (China), the three Keynote Speakers of IRSUWU 2017, for their contribution and participation in this event.

All Chairpersons and Panel Members of the 17 Technical Sessions are appreciated and acknowledged for providing their expertise to the symposium.

It is also conveyed the gratefulness to the Presenters and all other Authors of Papers (both oral and poster) given the submission of new findings and attendance in the IRSUWU 2017, to make it a successful forum on technopreneurial conceptions.

There was a magnificent contribution from the Editorial Board, Scientific Committee especially in the need of reviewing abstracts aligning with the time frame set. Therefore, they are acknowledged for their unstinted cooperation made to maintain the quality of the proceedings of IRSUWU 2017.

A special gratitude is extended for the Sponsors, Well Wishers and all others who financially supported the event at the time it was really needed.

Further, it expresses a deep appreciation to all Track Coordinators, Event Coordinators and their Team Members for their endless and untired support extended throughout the organizing time period.

At last but not least, sincere thanks go to all academic and non-academic staff members of Uva Wellassa University as well as all those who took part in the IRSUWU 2017 extending their greetings.

## About Symposium

Uva Wellassa University was established primarily to add value to the national resources of the country. IRSUWU-2017 is another milestone, which makes a platform to disseminate the research findings of Uva Wellassa University under the theme of “Global Trends towards Technopreneurial Development”. This is of course a forum for exchanging and constructing views on research findings among scholars while exploring the every possible opportunity to interact with local and foreign experts.

IRSUWU-2017 is undoubtedly going to reach its zenith of adding value to diversified areas of research covering the main areas Agriculture, Science, Humanities and Management paving the way to multitude of research on myriad disciplines coming under seventeen areas. Altogether, three hundred and eighty three (383) abstracts were received under the above disciplines both locally and internationally including some other countries such as India, China, Japan and South Korea. These abstracts were reviewed by over hundred of expertise scholars in a variety of disciplines around the world. After a clear reviewing process and with Editorial Board decisions, 227 and 130 abstracts for oral and poster presentations, respectively, have been selected for IRSUWU-2017 under the following areas;

- Aquaculture and Fisheries
- Bioprocess Technology
- Biodiversity
- Computing and Information Science
- Digital Electronics and Embedded Systems
- Entrepreneurial Agriculture
- Entrepreneurship and Management
- Food Science and Technology
- Genetics and Biotechnology
- Hospitality and Tourism Management
- Humanities and Social Development
- Material Science and Engineering
- Mineral Science and Technology
- Sustainable Animal Production
- Sustainable Crop Production
- Water Science and Technology

Professor Buddhi Marambe, Faculty of Agriculture, University of Peradeniya, has been invited to be the Chief Guest of the IRSUWU 2017 and will speak on “Promoting Technopreneurship - A Pathway for Sustainable Development”.

Professor Kirsten Benkendorff (Australia), Professor Cheorun Jo (South Korea), and Professor Li Cheng (China) are going to deliver the keynote speeches under the themes of “Marine Bioresources: Scientific Research and Development for Value-Added Molluscan Products”, “Application of Plasma Technology on Food Science”, and “Global Trends in Cultural and Heritage Tourism”, respectively. This Inaugural Session is chaired by Professor R. Mapa, Emeritus Professor, University of Peradeniya.

After the Inaugural Session, 17 parallel sessions will be held and the posters will be evaluated from 4:00 to 6:00 p.m. on the first day of the Symposium. On the same day, which is on January 19, January, 2017, a Cultural Show followed by the Symposium Dinner has been organised from 7:00 p.m. onwards.

At the end, the Closing Ceremony of IRSUWU-2017 will be held in the evening of January 20, 2017 where best presenters from both oral and poster sessions in each track will be awarded. Also, Scientific Awards 2015 for the selected academic staff will be granted considering their contribution in research.

## Chancellor's Message



It is with great pleasure I send this message and good wishes to the IRSUWU 2017.

Uva Wellassa University, which focuses value addition to local resources, is an exemplary academic milieu in the Sri Lankan higher education system and also emphasizes knowledge, skills, attitudes & values, discipline and ethics of undergraduates. The graduates of Uva Wellassa University are responsible for the future of the country. Also, it is true that the undergraduates of Uva Wellassa University are guided to be entrepreneurial experts by cultivating innovative ideas in their minds right from the inception. Therefore, this International Research Symposium has provided them an ideal platform to exhibit their innovative thinking in research providing a theme, “Global Trends towards Technopreneurial Development”.

I trust that IRSUWU 2017 will give an immense opportunity to researchers of all fields to discuss, debate, and exchange interactive views on their novel findings. Eventually, their scholarly knowledge will contribute to elevate the social wellbeing and the socio-economic development of Sri Lanka.

As a University, it is our utmost duty to contribute to the development of the country by producing skilled graduates and conducting new research, which will create new paths in the development. Thus, organizing and holding this kind of symposia will undoubtedly invite the scholars to identify the gaps of development and bridge them with their timely findings.

Thus, I would like to convey my wishes to all the presenters, eminent scholars, and other keen participants who have joined the IRSUWU 2017. Finally, I congratulate and thank Vice Chancellor and the Organizing Committee of this event for their commitment, dedication and devotion towards the University, which at the end looks into the development of country.

May Triple Gems Bless You!

**Most Venerable Bengamuwe Sri Dhammadinna Nayaka Thero**  
**Chancellor**  
**Uva Wellassa University**

## Vice Chancellor's Message



I deem it a great privilege to convey my message and earnest greetings to the IRSUWU-2017, organized by Uva Wellassa University. Being the center of excellence for value addition and continuing its unique theme of value addition, Uva Wellassa University is in the journey of producing well capable graduates who are ready to win the world work.

Thus, I believe that IRSUWU-2017, which leads the theme “Global Trends Towards Technopreneurial Development” will provide an irreplaceable platform to showcase especially our young researchers’ knowledge and skills by presenting, discussing and sharing their innovative research findings while giving the same opportunity to other national and international scientists. Further, Uva Wellassa University has openly invited researchers of many fields to attend this forum and disseminate their novel knowledge by forming 17 research tracks which represent the sectors such as Science, Technology, Management, Agriculture and Humanities.

I believe that publishing a successful research paper and presenting its results is not a single day’s effort, yet it is the fruitful outcome of wise problem identification, careful observation and exploration, apposite analysis and timely recommendations, which needs a considerable time, patience, courage as well as enthusiasm. Therefore, I congratulate all such esteemed researchers who are going to share their invaluable research experience in the IRSUWU-2017. Moreover, as the Vice Chancellor of the hosting university I am pleased to be among young researchers, eminent scholars, keynote speakers, chairpersons, panelists and to share the novel knowledge and views that they are about to disseminate.

Further, I wish to express my sincere gratitude to whole Uva Wellassa University family for rendering their untiring assistance to make IRSUWU-2017 a success.

I look forward to witness a symposium par excellence which will contribute to the socio economic development of the country.

**Dr. G. Chandrasena**  
**Vice Chancellor**  
**Uva Wellassa University**



## Director (Research)'s Message



It is with great pleasure and pride I am forwarding this message on the occasion of the first International Research Symposium of Uva Wellassa University, IRSUWU-2017, themed on “Global Trends towards Technopreneurial Development”.

Uva Wellassa University has been different from the rest of the Universities by its design, which provides Entrepreneurial Education with Essential Skills and Broad General Knowledge for all undergraduates in their core curricula. As such, all our degree programmes deliver knowledge and skills to the undergraduates as required by the employers in the industry. Since the inception during last 10 years, Uva Wellassa University takes the responsibility of producing graduates who could make a significant contribution in the economic development of the country. As a University, which is equipped with entrepreneurial conceptions, its theme provides a focus for research related to each discipline giving emphasis towards value addition to local resources base. Hence, I believe that the set theme of the IRSUWU-2017 has led the research community in particular within the University to bring forward technological advancements and entrepreneurial developments to the front line aligning with the demand of the present world.

It can be expected that IRSUWU-2017 will provide a platform for graduating students to present their valuable final year research findings and interact with experts in the sector, peers, and prospective employers. Also, this will no doubt provide an opportunity to enhance the research culture within the University. At last, the research findings basically presented in the IRSUWU-2017 will witness the progress of 10 years old Uva Wellassa University especially in research.

I take this opportunity to congratulate all organizers and the presenters of IRSUWU-2017 for their contribution to succeed this event.

**Dr. H.M. Saman K. Herath**  
**Director/Research Committee**  
**Uva Wellassa University**

## **IRSUWU-2017 Coordinator's Message**



Uva Wellassa University is proud to host its annual research symposium with a promotion towards an International Research Symposium for the year 2017 under the theme of “Global Trends towards Technopreneurial Development”. IRSUWU-2017 is a flagship symposium and represents a larger gathering of researchers, academics and industry professionals with profound impact on many sectors in economy and the potential to lead new paradigms.

Certainly, IRSUWU-2017 will provide a forum for oral & poster presentations and discussions on theory, numerical modeling, experiments, methodologies, results and applications in all aspects of Science, Technology, Agriculture, Management, and Humanities under 17 themes. The event is open to experts, scientists, academicians, graduate and postgraduate students from both local and foreign institutes.

Organization of IRSUWU-2017 would not be possible without the diligent efforts of many individuals. Hence, we are indebted to all who contributed to the various processes that make up this event. In particular, the Scientific Committee completed a thorough and timely peer-reviewing process. The Editorial Board led by Editor-In-Chief worked diligently to select papers of high quality and relevance to various fields of interests. Also, this programme is augmented and complemented by the Keynote Speakers by adding glamour to this remarkable venture. The Organizing Committee, both Event Coordinators and the Theme Coordinators worked tirelessly and extremely hard to ensure the best quality experience for the delegates. Finally, I would like to appreciate all the sponsors, exhibitors and supporters for their invaluable contribution rendered to make this event a success.

In addition to the stimulated programme of IRSUWU-2017, Badulla is an unforgettable place for many people to visit and explore its surroundings and historical values and to enjoy the exotic and vibrant atmosphere of the city.

It has been a great privilege for me to serve as the Coordinator of IRSUWU-2017 and it is my hope that you find the IRSUWU-2017 fulfilling and enjoyable. I thank you for your support and your attendance, and wish you a fruitful and pleasant experience in IRSUWU-2017.

**Dr. L.M.H.R. Alwis**  
**Coordinator/IRSUWU-2017**  
**Uva Wellassa University**

## Chief Guest's Message

### Promoting Technopreneurship – A Pathway for Sustainable Development



“Technopreneurship” is a synergized term, which has resulted from the fusion of “technology” and entrepreneurship”. Global trends in the development of information and communication technology (ICT), biotechnology, engineering, and other science and technology (S & T)-based fields of study have captured the attention of the business community thus reaping richer harvests of their investments targeting development.

Technology-centered entrepreneurial enterprises have undergone revitalization in the recent past, especially in the South and Southeast Asian region. Improving the country's human capital through significant investments in education and promoting policies that encourage and gear the society towards Technopreneurship are considered key in the present-day context to sustain growth and development of developing economies. Technopreneurship-21 initiative by Singapore, launch of the Multimedia Super Corridor by Malaysia, and development of some cities in India as technology-focused cities, all that were initiated in the late 20<sup>th</sup> century, have paid significant dividends to these countries/cities in terms of sustainable growth. Singapore, being a small island city-state with a limited natural resource based, is a classic example for the success in promoting technological advancements in entrepreneurship activities in an appropriate manner, in achieving economic development.

The lessons learned from such initiatives clearly indicate that the developing countries essentially need to recognize new strategies for sustainable economic development. Sri Lanka as a country has lagged behind in such approaches that would have triggered a rapid development phase of its economy. However, formulation and implementation of well-articulated policies, enhanced investments in human capital development with technology-blended entrepreneurship skills, and political will would pave the path for developing countries such as Sri Lanka in achieving the developmental agenda and sustained economic growth in years to come.

**Professor Buddhi Marambe**  
**Department of Crop Science**  
**Faculty of Agriculture, University of Peradeniya**  
**Sri Lanka**

# Keynote Speech 1

## Global Trends in Cultural and Heritage Tourism

*Very good morning to all of you!*



I am thankful to the organizers of this conference for giving me this opportunity to share some of my experience at this important forum.

The topic given to me today is “Global Trends in Cultural and Heritage Tourism” and is running through a much broader scope. It is fascinating that tourism is an industry which is growing consistently, though in different forms. In an era of prompt information transmission and advanced forms of mobilities tourism is evolving into novel niches. As the organizers of this conference have perfectly identified culture and heritage is drawing intensive attention with growing prospects of source markets in international tourism.

Equally, UNWTO has recognized culture and heritage tourism as one of the fastest growing segments according to their statistics. Significantly, cultural and heritage tourism is related to educational level of tourists according to latest research findings and in particular 81% of US tourists are considered to be cultural tourists (UNWTO). It is also evident that majority of tourists are in agreement on the fact that cultural heritage influence their choice of destination and this indeed a promising news for Sri Lanka that has a strong cultural appeal for prospective tourists.

In terms of expenditure the sector has been of competitive with other types of tourists. Mainly the contribution to local economy is promoted through cultural and heritage touristic activities. Culture and heritage tourists often stay longer and spend a lot more money in general than other tourists do. In fact, one study showed that a culture and heritage tourist spent as much as 38% higher per day and they stayed 22% longer overall compared to other kinds of travellers.

Personally, I feel that I’m lucky to associate with Sri Lanka in the above respect and I am impressed with the cultural traditions of Sri Lanka such as Kandy Perahera witnessed and also visited Vedda community in 2015. Similarly, perhaps the smallest land area of the whole world that has six UNESCO cultural world heritage sites, Sri Lanka boasts rich cultural heritage to meet the international markets.

But on the other side, I have to say, culture heritage is also been negative impacted by mass tourist significantly. During the interaction of hosts and guests, i.e. acculturation and enculturation process, we can observe the cultural

changes and cultural conflicts. So authenticity and identity, commercialization and post-modernism, local and global nexus, rural and urban, crises and disasters, those topics become focused topic in the context of culture, heritage and tourism journals. Journal of sustainable tourism, Journal of tourism and cultural change, Annals of tourism research, International Journal of culture tourism and hospitality research, International journal of heritage studies and International journal of tourism anthropology to name few.

Finally, it is with great pleasure I acknowledge that we are about to seal a pact to promote culture, heritage and tourism research in Sri Lanka in corporation with Uva Wellassa University. I believe that not only some culture theories could be tested and verified but also the precious culture heritages could be protected with the rapid tourism development in Sri Lanka through our cooperation and endeavor.

I make this opportunity to invite openly to all of you to corporate with our initiative which definitely would contribute to Uva Wellassa University and to Sri Lanka at large.

I wish very productive interactions to all of you during this forum and I'm looking forward to actively involve in culture, heritage and tourism research in Sri Lanka in the future.

I would like to share the findings of a recent research on cultural and heritage tourism in China and Taiwan. Accordingly, the key extracts of the presentation are outlined below.

Tourism flow has become an important bilateral interaction between the Chinese Mainland and Taiwan in a peaceful of atmosphere in recent years. Since 1987, the tourism development of the two sides has gone through 28 years of political, economic and cultural evolvement. But the theory research for the tourist marketing, the impact and tourist choice behavior lags behind the rapid tourism development of the two sides. This paper uses social representation theory to explore Taiwan youths' perceptions and behavior on mainland destination. The Focus Group Interview is adopted in Taiwan and integrated the regression methods to reveal constitutive factors and structure of the social representation. The central system, peripheral system of the social presentation structure and the mainland destination knowledge system of Taiwan youth are mapped.

This empirical study finds that the very famous & traditional tourist attractions, most of them are cultural and heritage destinations in mainland have negatively impact on Taiwan youth's travel intention to mainland, nevertheless, the other two dimensions, which are Infrastructure Construction & Security, Culture Events & Tradition would have positive impact on the their intention and behavior. In the conclusion, this paper discusses the new findings and puts forward key routes to promote mainland cultural and heritage attraction

for Taiwan youth, namely intensifying traditional culture attribute, impelling infrastructure construction, and implementing individuation & diversification strategy to coincide with the inbound marketing shifting.

Thank you for your attention.

**Professor Cheng, Li Ph.D**  
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**Professor of Department of Tourism and Landscape Studies**  
**Tourism School, Sichuan University**  
**Wangjiang Road 29, Chengdu, Sichuan**  
**P.R.China, 610064.**

## Keynote Speech 2

### Marine bioresources: Scientific research and development for value-added molluscan products



Marine molluscs that have been of great interest to natural products chemists, yielding a diversity of chemical classes and several drug leads currently in clinical trials. Molluscs are also considered as healthy food for human consumption and feature prominently in a broad range of traditional natural medicines. The biologically active ingredients in the more common molluscs that are typically consumed and used on natural medicines are mostly unknown. This presents a great opportunity, for strategic research aimed at developing and optimising natural medicines from molluscs. In this presentation, I will illustrate this using three case studies: 1) nutraceuticals from green mussels; 2) anti-cancer and functional food potential of Muricidae molluscs and 3) cosmeceutical snail skin care creams. These case studies demonstrate the benefits of research for developing new scientifically substantiated products. Strategic research is required to support approval processes for nutraceuticals and can be effective in marketing campaigns for both nutraceuticals and cosmeceuticals. Ultimately, the development of health products from molluscs that can be sustainably harvested or cultured should help increase the economic returns from these marine resources, in comparison to the raw products.

#### Introduction

The marine environment supports phenomenal invertebrate biodiversity, which produce an amazing array of natural products (Leal, Madeira et al. 2012). Many of these marine natural products have useful therapeutic properties, including anticoagulant, antimicrobial, antioxidant, anticancer, anti-inflammatory, antihypertensive, and other medicinal properties (Benkendorff 2010, Perdicalis, Vlachogianni et al. 2013, Senthilkumar and Kim 2013). A number of these bioactive marine natural products have provided important leads for drug development, seven of which are now commercially available for use (Mayer, Glaser et al. 2010). Of the 30 marine drugs currently in the clinical pipeline or already FDA-approved (<http://marinepharmacology.midwestern.edu/clinPipeline.htm>), over half are derived from gastropod molluscs and their microbial symbionts.

Whilst health care in many Western countries has been dominated by the pharmaceutical industry, with clinically substantiated and mostly chemically synthesized medications, traditional medicines based on natural products have

maintained an important share of the health market throughout the world. However, traditional and alternative natural remedies vary greatly with respect to their value, availability and the degree of scientific substantiation supporting their health claims. In 1989 the term “nutraceutical” was introduced to combine the idea of “nutritional” or natural and “pharmaceutical”(Benkendorff 2009). Nutraceuticals can be specifically defined as “food or part of a food that provides medical or health benefits,including the prevention and/or treatment of disease” (Brower 2005), and has been adopted to encompass a wide range of herbal remedies, functional and medicinal foods, with demonstrated pharmacological benefits.Substantial research is required to support the efficacy, safety and quality of new nutraceutical products, as natural products should also not be assumed to be non-toxic(Benkendorff 2009). Research undertaken to chemically characterise and assess the biological activity of marine natural products for nutraceutical development can also assist in marketing the new product, which should in turn lead to greater community awareness, acceptance and economic value.

### **Molluscan Medicines**

Molluscs are the second largest animal phylum, and with an estimated 1-2 hundred thousand species, they currently represent 23% of all named marine species (Benkendorff 2014).Molluscs have a long history of evolution in the ocean and dominate many marine communities. In order to persist in this pathogen and predator rich environment, natural selection has generated an arsenal of chemical compounds that molluscs use to defend themselves (Benkendorff, Davis et al. 2001, Dang, Benkendorff et al. 2015). Well over 1000 distinct secondary metabolites have been reported from marine molluscs to date (Benkendorff 2010, Benkendorff 2014) and yet still less than 1% of the species have been studied for their biologically active compounds. The majority of research has focused on tropical gastropods with reduced physical protection (sea slugs and sea hares), as well as the Condidae family, which are well known to produce toxic peptides. Whilst these targets have generated interesting drug leads, the majority of compounds are too toxic for use in human medicine. Drug development can also be hampered by the complexity of the compounds for chemical synthesis and/or the rarity of species for sustainable collection.

A large number of molluscs are sustainably harvested, or subject to aquaculture, for human consumption. Molluscs have traditionally been considered a healthy food and many species are specifically used in traditional medicines. In contrast to the main molluscs species targeted by natural products researchers for pharmaceutical drug leads, most traditional medicines use more commonly available shelled mollusc species. For example, of 43 listed traditional Chinese marine medicines that utilise molluscs, only three utilise soft-bodied opisthobranchs (sea slugs and sea hares) and the remainder utilise a range of



shelled gastropods, bivalves and polyplacophora (chitons) (Guan and Wang 2009). The ethnomedicinal uses of molluscs by the people in Kosi River Basin, North India, appears to exclusively involve shelled gastropods and bivalves (Prabhakar and Roy 2009). Similarly of the 17 molluscs listed as medicinal animals in Latin America, 15 were shelled gastropods and 2 were soft-bodied cephalopods (octopus and squid), whilst none were opisthobranchs (Alves and Alves 2011). In most cases the active ingredients in these traditional medicines are unknown and there is much potential for strategic research aimed at developing optimised and scientifically substantiated products.

### **Case Study: Nutraceutical Development of Mussel Extracts**

The development of mussel extracts and nutraceuticals from marine and freshwater mussels provide a good example for value-adding traditional mollusc food resources based on their medicinal properties. In particular, the development of the clinically tested Lyprinol<sup>®</sup> from an ethno-medical lead in the green-lipped mussel (*Perna canaliculus*) is a major success story from the New Zealand seafood industry (Sankaran and Mouly 2007). Maori folklore suggested that coastal dwelling communities who regularly consumed the mussel suffered much lower rates of arthritis than inland relatives. Initially, a freeze-dried mussel powder was developed, but the anti-inflammatory activity of the powder was inconclusive until further research led to the development of a stabilized lipid extract with reliable bioactivity (Sankaran and Mouly 2007). The patented product Lyprinol<sup>®</sup> is now commercially available (lyprinol.com) and has been independently tested and shown to be effective in clinical trials for arthritis and asthma bioactivity (Whitehouse, Macrides et al. 1997, Halpern 2000, Emelyanov, Fedoseev et al. 2002, Treschow, Hodges et al. 2007, Halpern 2008).

There are a number of competing green-lipped mussel products available off the shelf as anti-inflammatory nutraceutical or natural health products. These include freeze-dried mussel powders and lipid extracts, with variable biological activity. A systematic review of clinical trials on the freeze-dried green-lipped mussel preparations concluded that there was little consistent evidence supporting the therapeutic use of these products for rheumatoid or osteoarthritis (Cobb and Ernst 2006). There was much variation in the potency of the same product sold in different countries under the same trade name, illustrating the need for quality control of marine nutraceuticals (Benkendorff 2009). However, the different quality products are reflected in the price range, which varies from around \$40 AUD for a packet of 100 tablets containing 50 mg patented stabilized Lyprinol<sup>®</sup> (≈ \$16650 per kg), to ~28 AUD for 100 capsules containing 2500 mg Green lipped Mussel (GML) powder for pets, or \$30 AUD for 300 capsules containing 750mg extract equivalent to 6000mg fresh mussel for humans. One kg of fresh or frozen NZ green lipped mussels

costs around \$5 AUD, thus demonstrating significant value-adding potential for developing natural health products from seafood.

Following on from the success of the development of Nz Green-lipped mussel nutraceuticals, the Central Marine Fisheries Institute has been strategically investigating aquaculture and value-adding of the Indian green mussel *Perna viridis*. A lipid extract known as Cadalmin<sup>TM</sup> (GMe) has developed with anti-inflammatory properties (Chakraborty, Chakkalakal et al. 2014, Chakraborty, Chakkalakal et al. 2015) and was commercialized in 2012 via industry collaboration (Chakraborty 2012). The successful development of Lyprinol® and Cadalmin<sup>TM</sup> from mussels clearly shows how local molluscs that already subjected to sustainable fisheries and aquaculture industries, can be value-added based on their health benefits.

### **Case Study: Muricidae anti-cancer and functional food potential**

The Muricidae are a family of predatory marine gastropods commonly known as rock whelks, purple snails, dog whelks or cartrut shells. Globally there has been a massive increase in the fisheries harvest of Muricidae whelks in the last decade, with a harvest of over 200,000 per annum from a range of countries but dominated by China (FAO 2016). They are also subject to a significant global fisheries trade for their ornamental shells. Muricids are also well known as the source of the historically and spiritually important purple dye and more recently it has been revealed that the dye pigments and precursors have a range of interesting pharmacological properties (Benkendorff 2013, Benkendorff, Rudd et al. 2015). Muricids also feature in a range of traditional medicines from cultures as diverse as ancient Greece, the middle east, China and even Indian homeopathy (Benkendorff, Rudd et al. 2015).

My research program has been strategically investigating the medicinal properties of Muricidae to assess the potential for developing a value-added “functional food” or nutraceutical industry. The Muricidae possess two main classes of pharmacologically active compounds; muscle relaxing choline esters and anticancer brominated indoles (Benkendorff 2013, Benkendorff, Rudd et al. 2015). The choline esters shows potent neuromuscular blocking activity and have been clinically tested for pain relief (Roseghini, Severini et al. 1996). The brominated indoles induce programmed cell death in cancer cells (Benkendorff, McIver et al. 2011, Edwards, Benkendorff et al. 2012, Esmaelian, Benkendorff et al. 2013, Esmaelian, Abbott et al. 2014) and can prevent the formation of colorectal tumors in mice (Westley, McIver et al. 2010, Esmaelian, Abbott et al. 2014), with no major toxic side effects (Westley, Benkendorff et al. 2013, Esmaelian, Abbott et al. 2014, Yazback, Lindsay et al. 2015). The main anticancer compound, 6 bromoisatin can be retained after the snails have been cooked (unpublished data) and is stable after exposure to simulated digestive fluid, suggesting potential for functional food development.

One big problem with marketing the anti-cancer properties of the whelk extracts is that in countries like Australia, the US and Europe, it is not possible to make claims about use for cancer treatment or prevention without rigorous clinical trials in Australia. Furthermore, it is extremely difficult to get research funding and ethic approval to test nutraceuticals in cancer clinical trials. Therefore, we have recently commenced investigation into the anti-inflammatory properties of the Muricid extracts and compounds, with very promising results in vitro and in a mouse model for lung inflammation. This is not surprising given the shared biochemical pathways that can be involved in apoptosis, cell proliferation and inflammatory responses. Overall, this research suggests there is good potential for developing a scientifically substantiated functional food with from Muricidae molluscs. Ongoing research is required to ensure sustainable production of Muricidae species through aquaculture, to support the growing demand for seafood and shells, as well as any valued-added nutraceutical products.

#### **Case Study: Cosmeceutical snail creams**

Products that are not safe for human consumption still have potential for topical application in skin repair and wound healing. Cosmeceuticals do not have to undergo the same rigorous level of clinical testing for safety and efficacy as do pharmaceuticals and nutraceuticals. However, efficacy under-pinned by good science will be useful for marketing the product. One example of this is Elicina® (Locafar, Chile), a cosmetic skin repair cream which is composed of the mucus secretions (mucins) from the brown snail *Cornu aspersum* (Common garden snail). In a small clinical study on human burn victims, the cream was applied twice daily on facial burns for a maximum period of 14 days or until full epithelialization (Tsoutsos, Kakagia et al. 2009). The results indicate that this cream is an effective alternative treatment in open wound management of partial thickness burns in adults (Tsoutsos, Kakagia et al. 2009).

In recent years there has been a proliferation of a range of snail creams for skin care on the market, suggesting the need for quality control. Allantoin and glycolic acid are two bioactive ingredients that have been identified in mollusc mucus and may contribute to their use as cosmetic skin creams. Mubarak et al (2013) validated a method for simultaneous detection of these compounds and demonstrated that there was significant variability in the levels of these compounds between different cosmetic creams, which is likely to reflect the quality of snail mucus content. This demonstrates the importance of quality control for over the counter cosmeceutical and nutraceuticals.

Many snail creams are available to purchase online and a quick comparison of prices indicates that the clinically tested Elicina® is around the top of the range at about \$40 AUD for 40g. Various other products can be found for similar prices with statements claiming 80% mucins, and these may have benefited

from the research done on Elicinia, but are also supported by good marketing with detailed dermatology reviews from members of the public. Other snail skin creams range down in price and mucin levels and/or available information. At the bottom of the range are some Chinese made snail moisturizing and whitening creams for less than \$3 AUD, with no indication of the amount of snail mucus in the products. Overall, this case study shows the potential for a rapid proliferation of mollusc based products in the cosmeceutical industry with limited research and heavy marketing. As yet no marine molluscs have been tested for cosmeceutical potential.

### **Conclusions**

Overall many marine molluscs have a long history of use as a healthy food source and in a range of ethnomedicines. These species are likely to be relatively safe for use in nutraceutical products. Further research to identify the active constituents in these molluscs and testing to confirm their biological activity for specific disease ailments will assist with the strategic development, approval process and marketing of new nutraceuticals. Safety of marine extracts for human consumption should never be assumed, requiring industry investment for preclinical and clinical trials. With a greater level of clinical testing, the products can be registered as therapeutic agents, thus leading to wider commercial markets and higher prices.

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## Keynote Speech 3

### Application of Plasma Technology on Food Science



Serious food safety issues resulting in immediate consumer health problems and recalls potentially contaminated foods from the market place are associated with pathogenic microorganisms. Thermal treatment can effectively inactivate pathogens, but induces side effects in the sensory, nutritional, and functional properties of foods, especially for fresh-like products. Non-thermal treatments have been developed to overcome these disadvantages including chemical treatment, UV, ionizing radiation, high hydrostatic pressure, and natural antimicrobial agents. However, these technologies also have some drawbacks including high cost of application, requirements for specialized equipment, generation of undesirable residues, extended processing times, and lower efficiencies. Plasma is referred to as the fourth state of matter, according to the scheme that expresses energy level increase from solid to liquid to gas, and ultimately to an ionized state of the gas plasma, which exhibits unique properties. Thus, any source of energy, which can ionize gas, can be employed for generation of plasma. Plasma is comprised of several excited atomic, molecular, ionic, and radical species, coexisting with numerous reactive species, including electrons, positive and negative ions, free radicals, gas atoms, molecules in the ground or excited state, and quanta of electromagnetic radiation (UV photons and visible light). Recently, well-controlled cold plasma generators at atmospheric pressure have been developed, and thereby applications of plasma technology for foods, biological surfaces, and medical devices are possible. In this regards, the atmospheric pressure plasma (APP) is considered as an emerging non-thermal sterilization technology for food safety improvement by inactivating food-borne pathogens. Many scientists in the fields of plasma physics, engineering as well as food safety have been collaborating to develop the APP system for food safety improvement and shelf-life extension. In addition to the safety enhancement, several different approaches in plasma application have been made including an alternative method of conventional curing process in processed meat products manufacturing and structural modification of natural molecules for enhancement of bioactivities and functional properties. In this presentation, results of recent studies on 1) improvement of food safety by different APP systems and possible quality changes by APP, 2) replacement of conventional and/or natural curing process with APP-treated water and direct system, and 3) enhancement of bioactivities of natural materials using APP system will be presented and discussed. Finally, some of challenges and

limitations as well as promising research outcomes and practices of plasma technology in food science and industry will be discussed.

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# **Aquaculture and Fisheries**



**Bioaccumulation of Cadmium (Cd) and Mercury (Hg) in Tilapia  
(*Oreochromis niloticus*) Fish Muscles from Three Main Reservoirs in Badulla  
District; Implications on Food Safety**

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Bioaccumulation of toxic trace metals in fish muscle is a major issue in the aquatic environment. The consumption of toxic trace metal contaminated fish cause health risks to human. The objective of the present study was to determine cadmium (Cd) and mercury (Hg) concentrations in muscle tissues of tilapia (*Oreochromis niloticus*) randomly collected from Sorabora (n = 8), Mapakada (n = 7) and Ulhitiya (n = 9) reservoirs in Badulla District from September to October 2016. The samples were digested by microwave accelerated system and Cd and Hg concentrations in muscle tissues of each fish were determined by Atomic Absorption Spectrophotometry (AAS). The recorded mean concentration of Cd in Sorabora reservoir was  $0.024 \pm 0.026$  mg kg<sup>-1</sup> and Hg was not detected, while  $0.018 \pm 0.005$  mg kg<sup>-1</sup> Cd was recorded for Mapakada reservoir and Hg was not detected. The mean concentrations of Cd and Hg in Ulhitiya reservoir were recorded as  $0.009 \pm 0.001$  mg kg<sup>-1</sup> and  $0.049 \pm 0.136$  mg kg<sup>-1</sup>, respectively. The mean concentrations of Cd and Hg those were recorded for three reservoirs were lower than the maximum permissible levels of these two toxic trace metals (Cd < 0.05 mg kg<sup>-1</sup> & Hg < 0.5 mg kg<sup>-1</sup>) recommended by the European Union and Sri Lankan guide lines for food fish. The amount of fish that should be consumed to fulfill weekly protein requirement (total amount by eating fish) of a healthy person was calculated according to the guidelines of the World Health Organization. Thereby, the Probable Weekly Intake (PWI) levels of Cd and Hg were calculated ( $0.0006$  and  $0.0006$  mg kg<sup>-1</sup> of body weight per week, respectively) and those values were well below the Provisional Tolerable Weekly Intake (PTWI) recommended ( $0.275$  for Cd &  $0.385$  mg kg<sup>-1</sup> of body weight per week for Hg) by the Joint Expert Committee for Food Additives (JECFA - FAO and WHO). The results indicate that the consumption of *O. niloticus* fish from studied three reservoirs are generally safe in terms of toxicity risk by Cd & Hg for human health.

*Keywords:* Bioaccumulation, cadmium (Cd), Health risk, Mercury (Hg), Tilapia  
(*Oreochromis niloticus*)

*Acknowledgement :* This research project was funded by the Uva Wellassa University (Capital grants- UWU/R/G/2015/25).

**A Study on Variances in Sensory Properties and Meat Qualities of *Oreochromis niloticus* (L) with Their Sex, Size and Inhabiting Reservoir**

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Nile tilapia (*Oreochromis niloticus*) is one of the commonly captured and highly preferred fish species in inland fisheries and also popularised as tastiest fish among the other freshwater fishes. However, there was a common belief among fisher communities as well as consumers that the taste of tilapia is varying from reservoir to reservoir. It is obvious that condition of the existing reservoir and available food items can affect quality and taste of the fish. Further, sensory qualities, ash and moisture content of fish flesh can be affected by age, sex, fat content, environmental factors and dietary ingredients. The present study aimed to determine the relationship of sensory qualities of Nile tilapia with sex, inhabiting reservoir and size of the fish. It also aimed to identify gut contents of fish samples collected. Male and female fishes from two size ranges were collected from three different reservoirs (Sorabora, Rathkinda, Nagadeepa) in Badulla district. First one third of the gut was immediately separated and preserved in 5% buffered formalin until subjected to gut content analysis. Fish samples were taken in to the Aquaculture laboratory of Uva Wellassa University and stored under -20 °C. Initially, moisture content, ash content, pH, cooking loss and water holding capacity of fish fillets were analysed. Parallely, a sensory test was conducted using cooked tilapia flesh with 30 untrained panellists to identify the sensory properties i.e. taste, colour, appearance, odour, tenderness, juiciness, oiliness and overall acceptance. According to sensory evaluation, female fish in Sorabora reservoir with the size range of 300-500 g, recorded the highest score for overall acceptance. However, male fish collected from the same reservoir with the same size range obtained highest score for taste. Female fishes collected from Rathkinda reservoir in 300-500 g size range scored the lowest overall acceptance. Ash and moisture content of the fish samples collected showed significant difference ( $p < 0.05$ ) with size and the inhabiting reservoir. Cooking loss showed a significant difference with inhabiting reservoir. Phytoplankton was identified as the dominant group present in the gut content of all the individuals analysed. Filamentous algae were the prominent organism in gut contents of fish samples collected from Sorabora reservoir and three identical zooplankton genera were also observed. However, further analysis is needed to evaluate the factors for variance in sensory and meat quality traits of fish samples.

*Keywords:* Fisheries, Fish flesh, Food science, Tilapia

**Impact of Implementation of Better Management Practices on *Penaeus monodon* Farming in Puttlam Zone, Sri Lanka.**

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*Penaeus monodon* farming is the main brackish water, commercial scale aquaculture practice, which targets the export market in Sri Lanka. However, it has been suffering from disease outbreaks due to the unplanned aquaculture development in the North Western area of the country. To overcome these issues National Aquaculture Development Authority has introduced best management practices to farmers for the convenience of management and monitoring. Shrimp farming area of North Western Province has been classified into five major zones as Chilaw, Arachchikattuwa, Mundalama, Kalpitiya and Puttlam. These major zones were divided into 33 sub zones. This study was carried out to investigate the level of implementation of better management practices in the six sub zones and to assess the relationship between better management practices and yield per hectare in Puttlam Zone. Among 120 farms of the Puttlam Zone, 30 individual farms representing six sub zones were selected randomly. Level of implementation of better management practices, yield per hectare, and disease occurrence data were collected through a self-administered questionnaire and farm observation. According to the Principal Component Analysis, farms in Puttlam zone can be categorized into four major groups based on the level of implementation of better management practices as 26.66% optimum level implementation, 40% average level implementation, 10% Minimum level implementation and 23.33% dissatisfied level implementation. Further, levels of implementation of better management practices referring to the sub zones are 57.14%, 42.8%, 25%, and 25%, respectively for the sub zones of Sewwanthiwu, Aneikutti, Manalthiwu and Wadathamunei. Descriptive analysis reveals that the levels of implementation of better management practices in Mee oya and Poorwasikuda sub zone are 7.66% and 3.5% respectively. The significant positive relationship was observed between level of implementation of better management practices and yield per hectare ( $r=0.810$ ,  $P\text{-value}=0.000$ ). Further, significant negative relationship was observed between level of implementation of better management practices and disease occurrence ( $r=-0.837$ ,  $P\text{-value}=0.035$ ).

**Keywords:** Better Management Practices, *Penaeus monodon*, Sub zone



## **Computer Based Fisheries Management Tool to Sustain Consumption of Marine Food Fish Species in Sri Lanka**

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Diverse fish stocks in the Indian Ocean consider as overfished, resulting in large-scale fishery termination will appear in the near future. Prior to taking purchasing decision, identification of the fish species is significant to take the decision correctly. Hence the aim of this study is to provide a tool for fish identification and make attitudinal changes of the consumers to take right purchasing decision for those overfished marine fish species. A questionnaire survey was carried out to collect fish consumption data in Sri Lanka using a random population. Questionnaire survey further investigated the best method to inform the consumer with above information. Selected fish stock status was recorded with the available colour code from Indian Ocean Tuna Commission database. Conservation status was recorded from the International Union for Conservation of Nature database and ranked according to a colour code. Combining stock status and conservation status colour codes, a different scale with five colour sustainable rating was generated. A traffic light method that displays consumer advice to avoid (red), suit (green) or think (yellow) was developed using above sustainable rating. Morphological identification keys for each species under four dominant fisheries impacted marine food fish groups were developed. Lanka fish website was developed to update the consumer using single page application module. Out of 22 selected fish species, three species were to avoid, five species for suit and 14 species need to think prior to purchase. All selected 22 species were clearly separated and identified with distinct characters from generated keys. According to the survey, maximum respondents have selected website (38%) as an effective method to aware the consumers while the minimum was selected radio (4%). The developed website can be used in the actual purchasing moment and it clearly demonstrates the consumer advice for each species in a user-friendly manner. Fisheries resources are highly diverse and depended on responsible management decisions and practices for their sustainable development. Many fish stocks are in a stage of serious decline with overfishing. Hence the future of fish stocks unable to judge by any authority. It should be done by reducing the demand for those unsustainable fish stocks. Practically the developed website, Lanka fish will act as the foremost fisheries management tool in Sri Lanka to aware local and international consumers. Further, it will play an important role in securing future of the selected fish sustainably in the Indian Ocean.

*Keywords:* Consumers, Fishery, Indian Ocean, Lanka fish, Sustainability.

## Comparison of Morphometric Parameters of Blue Swimming Crabs Collected from Three Areas in Northern Sri Lanka

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Blue swimming crab (*Portunus pelagicus*) is an economically important and highly utilized fishery resource in Northern and North-Western coasts of Sri Lanka. Study of population structure of *P. pelagicus* is important to categorize into populations and demonstrate population demographics. Also, it helps in an elaborate study of population and thus makes comparisons possible. Therefore, this study focused to investigate whether different areas in northern Sri Lanka are exploiting a single population or many populations by analysing intraspecific morphological variations among individuals of blue swimming crabs which were collected from Mannar, Pesalai and Jaffna, as that aspect has not been investigated before. Specimens collected from the landing sites at the three areas were subjected to morphological analysis. Sexing was done by using several external morphological characters. Fourteen morphometric characteristics i.e. carapace length, carapace width excluding 9<sup>th</sup> anterior-lateral tooth, carapace width including 9<sup>th</sup> anterior-lateral tooth, major *cheliped merus* length, major *cheliped merus* width, major *cheliped merus* length, major *cheliped dactylus* length, 4<sup>th</sup> *pereiopod merus* length, 4<sup>th</sup> *pereiopod merus* width, *natatory leg dactylus* length, *natatory leg dactylus* width, penultimate segment length, penultimate segment width and telson width of 153 individuals were measured using a vernier calliper and measurements were standardized using ratios before analysis. Principle Component Analysis and Discriminant Function Analysis were used to determine significant variations of standardized morphometric characteristics of individuals from three different areas. First two discriminant functions totally accounted for 100% (72.2% and 27.8%) variance. According to the Principle Component Analysis, populations in the three sampling sites can be determined as a single *P. pelagicus* population. Discriminant Function Analysis also failed to distinguish geographically isolated three different populations. The results of the current study reveal that, *P. pelagicus* individuals collected from three different sampling areas can be categorized into a single population based on their morphometric characteristics. Mature blue swimming crab females reported to be spawned in off-shore areas and their larvae can drift thousands of kilometres, there is high possibility of crab population mixing. Intraspecific similarity of *P. pelagicus* samples from the three areas observed in this study also an evidence for possibility of populations mixing. The results of the current study are important in managing *P. pelagicus* wild populations as fishery resource and supporting to initiate aquaculture practices.

**Keywords:** Crab, Fishery, Intraspecific, Morphometric, Population,

**Growth Performances of *Holothuria scabra* (Sea cucumber) in Pond Culture: A Preliminary Study in Sri Lanka**

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Sea cucumber farming is proposed as an alternative culture practice to utilize the abandoned shrimp farms, especially in the North western province of Sri Lanka. Followed by commercial production of sea cucumber seed in the country in 2013, sea cucumber culture was initiated in Sri Lanka. As the culture experiences are in the infant stage, information on production performances are scant. The current study was carried out in Pulichchikulam area in Puttlam district, to study the growth performance of stocked sea cucumber. Study was carried out from May to November 2014. General methods of pond preparation and bio-security measures for shrimp farming were followed to prepare the pond. Lime was added to the rate of 400 kg/ha and maintain the optimum algal growth. Four thousand juveniles of sea cucumber with the average length of 6.3 cm  $\pm$  0.65 and average weight of 8.7g  $\pm$  2.01 were stocked at the rate of 1 juvenile/m<sup>2</sup> in a pond with approximate area of 4000 m<sup>2</sup>. A mixture of ground shrimp feed and sea weed was used daily, as the supplementary feeds with the rate of 2-3% of the body weight. Specific Growth Rate at monthly interval was calculated using randomly collected animals and it was recorded as 2.63  $\pm$  0.99, 3.04  $\pm$  0.79, 2.85  $\pm$  0.23, 2.53  $\pm$  0.19, 2.19  $\pm$  0.14, 1.96  $\pm$  0.23 g/day respectively. The Specific Growth Rate for the entire culture period was 1.44 g/day. After seven month of the culture period 2722 of the individuals were harvested with the average length of 17cm  $\pm$  1.81 and average weight of 274.6 g  $\pm$  68.96. The survival rate was 68.05%. Salinity and temperature were ranged from 20-34 ppt and 26-31 °C during the culture period respectively. Gross income, operational cost and net income from half hectare pond culture was 568,800.00, 37,400.00 and 194,800.00 LKR.

*Keywords:* Length, Pond culture, Sea cucumber, weight

**Mercury (Hg) and Cadmium (Cd) Concentrations of Tilapia (*Oreochromis niloticus*) Muscle Tissues Collected from Three Major Reservoirs in Monaragala District, Sri Lanka**

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Aquatic ecosystems are under threat of pollution by anthropogenic causes which result accumulation of toxic contaminants, especially toxic trace metals such as Hg and Cd in water and aquatic organisms. Consumption of contaminated fish by toxic trace metals can generate negative health consequences to human. Tilapia (*Oreochromis niloticus*) is the most popular and abundant food fish species found in inland reservoir fishery catch of Sri Lanka. Hence, this study investigated Hg and Cd concentrations of collected tilapia fish muscle samples from three major reservoirs which provide a great contribution to the inland fisheries production in Monaragala district. A total number of 28 tilapia fish were randomly collected from Hambegamuwa (n = 8), Urusita wewa (n = 10) and Weheragala (n = 10) reservoirs during September to October 2016. Each sample was individually subjected to trace metal analysis using Atomic Absorption Spectrophotometry (AAS) subsequent to the microwave accelerated acid digestion. The results revealed that the mean Hg and Cd concentrations in muscle tissues on wet weight basis were Not Detected (ND) &  $0.02 \pm 0.03 \text{ mg kg}^{-1}$  in Urusita wewa,  $0.14 \pm 0.14 \text{ mg kg}^{-1}$  &  $0.01 \pm 0.01 \text{ mg kg}^{-1}$  in Weheragala reservoir and  $0.02 \pm 0.03 \text{ mg kg}^{-1}$  &  $0.03 \pm 0.03 \text{ mg kg}^{-1}$  in Hambegamuwa reservoir, respectively. Recorded trace metal concentrations were below the maximum permissible levels (Hg <  $0.5 \text{ mg kg}^{-1}$  and Cd <  $0.05 \text{ mg kg}^{-1}$ ) as specified in Sri Lankan and European Union standards for food fish. The calculated Probable Weekly Intake (PWI) levels for Hg and Cd ( $0.0018$  &  $0.0007 \text{ mg kg}^{-1}$  of body weight per week, respectively) via dietary intake of tilapia fish were well below the Provisional Tolerable Weekly Intake (PTWI) levels ( $0.275 \text{ Hg}$  &  $0.385 \text{ Cd}$  in  $\text{mg kg}^{-1}$  of body weight per week) which have been jointly established by WHO and FAO. In conclusion, tilapia fish caught from these reservoirs do not pose a risk on human health by Hg and Cd toxicity through consumption.

**Keywords:** Cadmium(Cd), Mercury(Hg), Monaragala district, Muscle tissues, Tilapia (*Oreochromis niloticus*)

**Acknowledgement:** This research project was funded by the Uva Wellassa University (Capital grants- UWU/R/G/2015/25).

**Evaluation of Hatchery Grading System of *Penaeus monodon* Effectiveness of Hatcheries in the North Western Province of Sri Lanka**

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At present, 45 hatcheries operate in the North western province to supply post larvae to the shrimp aquaculture industry. In 2014, all the hatcheries were categorized into 5 grades as A to E, considering 27 factors, based on available facilities and level of Better Management Practices implemented. There were no E graded hatcheries recorded and all D graded hatcheries had been upgraded as a compulsory requirement to issue the aquaculture management license. This study was carried out to evaluate the effectiveness of the implemented hatchery grading system. 26 shrimp hatcheries were selected among 45, using stratified sampling and lottery method. Selected hatcheries were evaluated using the same criteria used for the initial grading process. According to the results, 3 hatcheries with grade B, 20 hatcheries with grade C and 3 hatcheries with grade D were reported. The actual production capacity of the selected hatcheries as their production records is found to be  $1.55 \pm 0.74$  times higher than the estimated hatchery capacity. Principal Component Analysis and Multiple Regression were used to identify the most effective factors on the grading. Principal Component 1 was positively influenced on all the factors ( $p < 0.05$ ), while 14 factors were negatively loaded in Principal Component 2 ( $p < 0.05$ ). Multiple Regression results revealed that among 27 Factors, maturation unit, generator and lab equipment related factors are highly contributed to the higher grades of the hatcheries. Descriptive analysis of production based factors reveals that, the contribution degree of dry feed, wet feed, indoor algae and Spawning were 23.1 %, 34.6%, 46.2% and 61.5% respectively and resulted the hatcheries with lower grades. Proper water quality testing for the Total Vibrio Count or Total Bacterial Count was not followed by any hatchery and record keeping was not complied with required information to evaluate the quality of post larvae. Obtained results showed that legal right has no influenced to the grading because it is a compulsory requirement that is essential to fulfil by each hatchery prior to commencing the hatchery operation.

**Keywords:** Hatchery grading, *Penaeus monodon*, Total Vibrio Count, Total Bacteria Count

## **Morphological Identification Tool for Selected Marine Ornamental Fish Species in Sri Lanka: A Computer Based Approach**

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Marine Ornamental fish industry is a high potential industry for economic development. Marine, freshwater, brackish water, farmed ornamental fish and aquatic plants, mainly export from Sri Lanka. Marine Ornamental fish industry in Sri Lanka has been developing rapidly in the last decade. However, increasing of the marketing trade in marine ornamental fish species leads to catch them in wild. Hence, the attention regarding conservation of marine ornamental fish species needs to be highly considered. This study aimed to develop a management tool for proper marine ornamental fish species. Marine ornamental fish exporting data were collected from Sri Lanka custom and highly demanded 30 marine ornamental fish species were identified under 10 families. The data regarding morphological and ecological characteristics of above 30 species were collected and used to develop a marine ornamental fish database using the MySQL tool. Six dichotomous keys were developed only for selected six fish families and those keys were attached to the database. "Lanka fish" website was developed by single page application (SPA) module to update current status of conservation, habitat information and export data for the awareness of consumers. *Valenciennea puellaris* species was recorded as the most exported species, while *Parupeneus cyclostomus* recorded as least exported species. According to the International Union for Conservation of Nature database seven species were not evaluated while all other 23 species under the least concern category. United State of America has a high import rate while Hungary has the minimum import rate of those Sri Lankan species. Collected data stated that there are 23 ornamental fish export companies in Sri Lanka. Though Sri Lanka has a high export rate of above 30 species, there is a lack of information about the identification, ecological condition and conservation status. Also, exporters don't have proper knowledge of the scientific names of the species. Hence, the development "Lanka fish" website will help to overcome the lack of information on those species and act as a user-friendly application in a meantime. This marine ornamental fish database will play a major role to support education, research and conservation of marine ornamental fish species in Sri Lanka in the future.

**Keywords:** Conservation, Database, Fish export, Lanka fish, Marine ornamental fish

**Evaluation of Effect of Different Fishmeal Products Available in the Local Market on Growth Parameters of Koi Carp (*Cyprinus carpio*)**

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Fishmeal is considered as the most desirable and most expensive animal protein ingredient in fish diets because of its high protein content. Apparently, presence of high levels of digestible protein directly affects on the growth parameters of fish. The current study was carried out to investigate the effect of different fishmeal products available in the local market on the growth performances of Koi (*Cyprinus carpio*) fingerlings. Diets were prepared as five different treatments with Peliyagoda fishmeal (Diet 1), Knife fishmeal (Diet 2), Maldivian fishmeal (Diet 3), Danish fishmeal (Diet 4) and soya meal (Diet 5). Initially, these diets were subjected to the proximate analysis (protein, lipid, ash, moisture). Feeding trial was conducted for 30 days using koi fingerlings having mean initial weight of  $17.00 \pm 0.09$  g which were collected from the same batch. All treatments were triplicated and 15 individuals were used for each treatment. Fish were fed three times per day until satiation. Fecal materials were collected at every morning by siphoning. Collected fecal samples were subjected to the proximate analysis. Wet weight (g) and standard length (cm) of the fish were measured weekly. Food conversion ratio, specific growth rate and weight gain were calculated. According to the proximate analysis, fish fecal sample collected from the fishes fed with Diet 4 contained lowest protein value while fishes fed with Diet 01 had highest protein level. Further, significant difference ( $P < 0.05$ ) was observed in the food conversion ratio, specific growth rate and weight gain between the test diets. Fishes fed with (Diet 4) had highest food conversion ratio, specific growth rate and weight gain while fishes fed with diet 5 showed the lowest. Danish fishmeal is the best protein source which supports the enhancement of growth parameters whilst supplying more digestible protein to Koi fingerlings.

**Keywords:** Feed conversion ratio, Fish feed, Ornamental fish, Specific growth rate, Weight gain

**Study of the Ring- net Landings at Galle fishery Harbor, at the South Coast of Sri Lanka With Special Reference to Trigger Fish (*Canthidermis maculatus*) Catches**

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Ring- net fishery which is mainly targeting medium sized pelagic fish has become popular in the south coast of Sri Lanka . As no studies have been carried out to study the fishery and biology of trigger fish species in Sri Lanka, this study aims to evaluate the variations in ring net catch rates, total catch and length frequency distribution of *Canthidermis maculatus* landed at the Galle fishery harbor from August to November 2016 . Catch and effort data on ring net fishery were collected by making fortnightly field visits to the Galle fishery harbor. Trigger fish samples were collected randomly from the unloaded ring - net landings to estimate the morphometric parameters and length weight relationship. Monthly, an average of 15 multi day boats operating ring-nets are landing at the Galle fishery harbor. In ring- net catches *Thunnus albacares*, *Decapterus russelli*, *Katsuwonus pelamis*, *Canthidermis maculatus* were predominant. Ring- net catch rates variation ranged from 678.75 - 2872.6 kg per boat per trip while catch rates of *C. maculatus* were in the range from 89.37 - 424.41 kg per boat per trip. The total ring net landings at the Galle harbor during the study were 855.8 tonnes of which contribution of *C. maculatus* was 197.37 tonnes. *Decapterus russelli* (Linna) showed the highest contribution (51%) to the total ring - net landings followed by Trigger fish (23.06%). Length and weight of *C. maculatus* ranged from 20.1 cm to 32 cm and 200.4 g to 600.1 g, respectively. More than (75%) *C. maculatus* landed by ring- nets belonged to the length group of 25 - 30 cm. *C. maculatus* exhibits isometric growth ( $b=2.91$ ). The observed variations in ring- net catch rates and contribution of *C. maculatus* to the fishery may be due to several reasons, including the variations in the number of multi day boats operated for ring net fishery, shifting of fishing grounds and seasonal variations in aggregation of these schooling fishes. This study indicates that *C. maculatus* is the second dominant species in the ring net catches landed at the Galle fishery harbor.

**Keywords:** Catch rates, Galle fishery harbor, Ring net, Trigger fish



### **Total Weight, Total Length and Meat Recovery Percentage Relationship of Black Tiger Prawn (*Penaeus monodon*) in Export Oriented Headless Prawn Processing**

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Percentage recovery is a critical factor which has a strong relationship in determining the production yield and ultimately the profits in headless prawn processing industry. This study investigated the relationships of total weight and total length of black tiger prawn (*Penaeus monodon*) with the meat recovery percentage in headless prawn processing since it can assist in selecting and purchasing more suitable farm grown prawn lots into headless prawn processing factories for the profit maximization. Farm grown *P. monodon* (n=400) were randomly collected from the receiving section of a prawn processing factory in North West Province of Sri Lanka. The collected sample represented four average weight groups as 19.7 g  $\pm$  7.8, 22.4 g  $\pm$  8.1, 26.3 g  $\pm$  7.8 & 29.9 g  $\pm$  8.2 and each group consisted with 100 individuals. These four average weight groups were considered in this study since they are the frequently recorded weight categories in receiving raw prawns from farms into export oriented headless prawn processing industry in Sri Lanka. Total length, total weight, carapace weight & abdomen weight were measured in all the sampled prawns and the recovery percentage of each individual was calculated. Complete Randomized Design (CRD) model was performed to identify the significant differences of mean recovery percentages of the above average weight groups and the results showed that all the four mean recovery percentages are significantly different. As results indicated by the multiple comparison analysis, the mean recovery percentages of the average weight groups 26.3 g  $\pm$  7.8 and 19.7 g  $\pm$  7.8 are significantly different, whereas 22.4 g  $\pm$  8.1 and 29.9 g  $\pm$  8.2 had similar mean recovery percentages ( $P < 0.05$ ). The average weight group 26.3 g  $\pm$  7.8 yielded the highest mean recovery percentage as 62.46 %. The prawns above the total length of 11 cm generate more than 60 % of meat recovery in headless prawn processing as resulted by the regression analysis, which analyzed the relationship between the total length and the mean recovery percentage of *P. monodon*. In conclusion, the farm grown *P. monodon* prawn lots with average weight close to the 26 g can be recommended in obtaining higher recovery percentages for the export oriented headless prawn processing industry.

**Keywords:** Black tiger prawn (*Penaeus monodon*), Headless prawn processing, Meat recovery percentage, Total length, Total weight

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**Behavior of The Fish and Fishery Products in Domestic Market Place: A Market Landscape Analysis**

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Marine fisheries industry is playing a vital role in countrys economy. Present approach is to investigate the market mix variables of selected marine fish species in the domestic market place, perform the trend analysis and develop market landscape for those species. Rapid market chain analysis was the key process to collect both primary and secondary data. Key informants of the marine fish value chain, industry specialists and the govern-ment institutions were the primary and secondary data sources. Main data categories were marine fish production by sub sector between 1951-2015, by districts 1983-2014, by fish types 1990-2014, exports and imports of 1983-2015, whole sale and retail prices of 1990-2014. Marketing mix variables, place, price, promotion, product, people, physical evidence, process were analyzed to develop the market landscape. Time series analysis was performed to identify the evolution of marketing mix variables in Sri Lankan context. Product was changed whole fresh form to ready to cook type. Marine fish value chain; structure, actors, functions and roles were changed drastically with the time. Lengthier value chains converted into more consolidated and shorter value chains. Both upstream and downstream linked into large number of vertical and horizontal linkages forming a value web. Market place changed from landing sites, local fish markets or road side selling to e-market with different pricing strategies. Advancements of fishing technology and fishing gear, policies, legal compliance and market intelligence positively linked with value chain upgrading and responsible marketing. Consumer demand on convenience, quality and differentiation generated more waste, high energy consumption and narrow profit margins.

*Keywords:* Marine fish, Marketing mix, Market landscape



# **Bioprocess Technology**



### **Pretreatment of Palmyrah Coir Dust and Bioethanol Production**

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Ethanol is most important renewable fuel in terms of market value. Nowadays it is produced from sugar and starch based materials such as sugarcane and corn. However, second generation of ethanol production also derived from lignocellulosic materials is now being tested in some plants. In this study palmyrah waste material such as molasses, expired pulp and coir dust were selected. Among them molasses and expired pulp were used for primary alcohol production and coir dust was used for secondary alcohol production. Pretreatment of coir dust was carried out with different alkaline and acid solution at 121 °C for 15 min and H<sub>2</sub>SO<sub>4</sub> was selected as the best hydrolysis agent based on the reducing sugar content then used for ethanol production. For H<sub>2</sub>SO<sub>4</sub> pretreatment two factors, as concentration (3, 5 and 7%), times (15, 30 and 45 min) were optimized. Among nine treatments 3% of concentration and 45 min were selected as optimum condition for hydrolysis. Coir dust hydrolyzed solution; molasses and expired palmyrah (°15 initial brix) were used for fermentation. Fermentation was carried out with bakers yeast in peptone yeast extract nutrient medium at room temperature and pH 5.0. The highest significant alcohol production was observed for coir dust H<sub>2</sub>SO<sub>4</sub> hydrolyzed medium (0.4%), molasses (8.6%) and pulp (5.5%) at 4, 6 and 4<sup>th</sup> day of fermentation respectively. During fermentation there were significant different in acidity, pH, reducing sugar and total sugar between the tested days. This acidity and sugar content was determined by titration and spectrophotometry method correspondingly. Total sugar content was significantly decreased during fermentation for all waste materials. Bioethanol production could be enhanced by developing enzymatic pretreatment technologies for coir dust and optimization of fermentation medium.

*Keywords:* Bioethanol, Fermentation, Palmyrah, Acid hydrolysis

## Antibacterial Activities of Endophytic Fungi Isolated from *Cyperus iria*

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Cyperaceae plants are reported to harbour fungal endophytes which produce novel antimicrobial drug leads. Therefore the main objective of this study was to investigate the antibacterial activities of endophytic fungi from *Cyperus iria*. Healthy plants of *C. iria* were collected from a paddy field at Badulla and endophytic fungi were isolated from the surface sterilized aerial and root parts using Potato Dextrose Agar (PDA) medium. The pure fungal cultures obtained were subcultured on ten PDA dishes, incubated 7-21 days, harvested and extracted into ethyl acetate. The crude fungal extracts were tested for antimicrobial activity against two Gram-positive and two Gram-negative bacteria, *Staphylococcus aureus* (ATCC 25928), *Bacillus cereus* (ATCC 11718), *Escherichia coli* (ATCC 35218) and *Pseudomonas aeruginosa* (ATCC 9027) at 400 gdisc concentration using agar disc diffusion method. Methanol was used as the negative control while Cephalexin was used as the positive control. Seventeen endophytic fungi, 12 from aerial parts and five from roots were isolated from *C. iria*. Fourteen, nine, eight and fourteen, number of extracts showed antibacterial activities against *S. aureus*, *B. cereus*, *E. coli* and *P. aeruginosa* respectively at 400 gdisc concentration. All the crude extracts showed activity against at least one bacterium tested. Three extracts showed activity against all the bacteria tested while another three only showed activity against Gram positive bacteria. CIA-12 extract showed the best activity among all. A thin layer chromatography (TLC) study showed CIA-12 extract consists of prominent UV (254 nm) active spots which revealed the presence of some major secondary metabolites. Identities of some of the endophytic fungi were determined as *Aspergillus*, *Fusarium* and *Phomopsis* species. This study revealed *C. iria* harbour a number of endophytic fungi which produce antimicrobial secondary metabolites, and further research may result in potential antimicrobial drug leads.

**Keywords:** Antimicrobial, Endophytic fungi, *Cyperus iria*, Secondary metabolites, Drug leads

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## **Development of Natural Hair Oil using Crude Tea Extract of Black Tea Fluff**

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Hair care oil is one of the most well recognized hair treatments. Caffeine has recently been shown to be a hair growth stimulator and it can counteract the suppressive effects on hair growth and is easily absorbable through scalp skin. Tea fluff is considered as a waste product of secondary manufacturing of tea. As it consists of beneficial chemical components as same as the made tea, it can be used to develop a natural hair care oil. The main objective was to develop natural hair oil using crude tea extract of black tea fluff by considering the caffeine incorporation level which promotes the female hair growth. Caffeine content of the fluff was analyzed and it was recorded as 2.344 mg/100 mg of Tea fluff. Samples with 0.0001%, 0.0003%, 0.0005%, 0.0007%, 0.0009% of caffeine were prepared. Virgin coconut oil, Castor oil, Lavender oil and *Vetiveria zizanioides* roots were used to prepare the oil base. Two sensory evaluations were done to evaluate sensory attributes using 30 untrained panelists. Results were analyzed using MINITAB statistical analysis package according to Friedman test at 5% significance level. 5 point hedonic scale was used for evaluation. Through the first sensory evaluation best base oil was selected from different treatment combinations of base oil samples. For the second sensory evaluation, different combinations of crude tea extract were incorporated to the hair oil and all treatments were subjected to sensory evaluation by applying on hair to select the best sample. According to the results of sensory evaluation, the best sample was selected. The best sample was evaluated through aerobic plate count test and stability test. The acid value and peroxide value were determined according to the SLSI standards and were in acceptable range. Sample with 0.0003% caffeine was identified as the best treatment. It can be concluded that this product is effective to produce a natural and more efficient product and it will add value to waste and cost effective hair care product.

*Keywords:* Hair care oil, Caffeine , Tea fluff, Waste management



**Bioactivity Evaluation of Some Fractions from the Methanolic Extract of  
*Emilia Sonchifolia* Leaves**

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Natural products from plants are known as secondary metabolites which show several biological properties including antimicrobial activity. Previous studies showed that the methanol extract from *Emilia sonchifolia* had significant antimicrobial activity; but the active components of this plant are still indistinct. Therefore, further research is needed to identify the individual compounds responsible for antimicrobial activity. Leaves of *E. sonchifolia* were collected; shade dried and secondary metabolites were extracted into methanol. The crude methanol extract was subjected to liquid - liquid partitioning first using hexane and methanol/water, secondly with chloroform and thirdly with ethyl acetate. The four layers obtained were hexane, chloroform, ethyl acetate and water. Separation of metabolites in the fractions was checked using Thin Layer Chromatography. The four fractions were tested for antimicrobial activity against *Staphylococcus aureus* using agar well diffusion method. The Minimum Inhibitory Concentration (MIC) was determined and results were analyzed using Minitab Software. Cytotoxicity was studied using Brine Shrimp Lethality Assay (BSLA) against *Artemia salina* and results were expressed as LC<sub>50</sub>. The antimicrobial activity results demonstrated that the ethyl acetate fraction showed the best activity against *S. aureus* where MIC ranged from 40 - 50 mg ml<sup>-1</sup>, while some minor antimicrobial activity was observed in the chloroform fraction. According to the cytotoxicity test, hexane, ethyl acetate and chloroform fractions, have shown LC<sub>50</sub> value < 1000 g ml<sup>-1</sup>, indicating the presence of some toxic compounds responsible for the observed toxicological activity. According to the antimicrobial and cytotoxic results, it can be concluded that the main bio-active compound was in ethyl acetate fraction while some minor compounds may present in the chloroform fraction. Further work about structure elucidation of these compounds is worth investigation.

**Keywords:** Antimicrobial, Brine Shrimp Lethality Assay, Cytotoxicity, *Emilia sonchifolia*

## Antifeedant and Larvicidal Activities of Endophytic Fungi Isolated from *Cyperus rotundus*

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Invasive use of synthetic insecticides has given rise to numerous environmental problems. Thus, there is a crucial need for the development of environmentally friendly and effective insecticides in agricultural pest control. The main aim of the current study was to investigate the antifeedant and larvicidal activities of the endophytic fungi isolated from *Cyperus rotundus* against the insect *Plutella xylostella*, a pest of *Brassica oleracea* (cabbage). Healthy plants of *C. rotundus* were collected from Badulla, and isolation of endophytic fungi from surface sterilized aerial parts and roots was carried out using potato dextrose agar (PDA) medium. Each pure fungal isolate was grown on ten PDA Petri dishes, incubated 7-21 days and was extracted with ethyl acetate. The obtained fungal extracts were tested for antifeedant activity using no-choice leaf disc bioassay and mortality after 24, 48 and 72 hours were tested against *P. xylostella* 2<sup>nd</sup> instar larvae at 200 g cm<sup>-2</sup> concentration. Methanol and neem 1% EC were used as the negative and positive controls respectively. Accordingly, Feeding Deterrence Indexes (FDI) and the mean mortality % were calculated. Thirteen morphologically distinct endophytic fungi, five from aerial parts and eight from roots were isolated from *C. rotundus*. Some of the fungi were identified as *Fusarium*, *Trichoderma* and *Aspergillus* species. Seven fungal extracts showed more than 50% feeding deterrence at 200 g cm<sup>-2</sup> concentration and they showed significantly higher activity (ANOVA and Turkeys HSD, P < 0.05) than the other extracts. Six, two and one extracts showed high (FDI > 60%), moderate (30 < FDI < 60) and low (FDI < 30) antifeedant activity respectively, while four extracts showed feeding stimulant activity. Highest and lowest feeding deterrence were shown by the extracts CRR5 (FDI=96.73 %) and CRR3 (FDI=29.41 %) respectively. None of the extracts exhibited more than 50% mean mortality after 24 hours of exposure. In conclusion, this study revealed endophytic fungi of *C. rotundus* are potential sources for the development of antifeedants for the control of *P. xylostella*.

**Keywords:** *Cyperus rotundus*, Endophytic fungi, Antifeedant, Larvicidal, *Plutella xylostella*

### **Antibacterial Activities of Endophytic Fungi from *Fimbristylis miliacea***

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Majority of pathogenic bacteria causing human infections have developed resistance to the existing antibiotics and thus this has become a public health crisis in the world. Therefore discovering new antibacterial drug leads has become an urgent need today. Isolation of the novel antimicrobial solanionic acid from an endophytic fungus of the medicinal weed plant, *Cyperus rotundus* in Sri Lanka shows the potential of Cyperaceae family plants to harbor new and antibacterial, secondary metabolites. Thus, the main aim of this study was to isolate endophytic fungi from the Cyperaceae family plant, *Fimbristylis miliacea* and investigate the antibacterial activities of the crude fungal extracts. Endophytic fungi were isolated from the surface sterilized plant tissues from healthy *F. miliacea* collected from Badulla, using antibiotic enriched Potato Dextrose Agar (PDA) plates. Each pure fungus isolated was subcultured on ten PDA plates, incubated close to sporulation, extracted into 200 mL of ethyl acetate, filtered and crude extract was obtained by evaporating the solvent. Subsequently, the crude extracts were tested for antibacterial activity against two Gram-positive and two Gram-negative bacteria, *Staphylococcus aureus* (ATCC 25928), *Bacillus cereus* (ATCC 11718), *Escherichia coli* (ATCC 35218) and *Pseudomonas aeruginosa* (ATCC 9027) respectively, at 400 g/disc concentration using agar disc diffusion method. After 20hrs of incubation the inhibition zones of the active extracts were measured. Ten endophytic fungi, four from roots and six from aerial parts were isolated from three *F. miliacea* plants. All the ten extracts showed activity for at least one bacterium tested. Three extracts showed activity against all the four bacterial species while six extracts showed activity against three bacteria tested. Prominent activities (16 and 13 mm inhibition zones) were shown by the extracts FMR4 and FMR6 against *B. cereus*. In conclusion, the data obtained from the current study revealed *F. miliacea* harbor endophytic fungi which produce secondary metabolites with antibacterial activities.

**Keywords:** Antibacterial, Endophytic fungi, *Fimbristylis miliacea*, Cyperaceae, Antibiotic resistance

## **Manufacturing of Laundry Soap from Farm Chicken Waste**

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Farm Chicken Wastes is commonly used in animal feed processing industry in Sri Lanka. Rendered chicken fat (RCF) from farm chicken waste can be used for soap manufacturing as an alternative for long chain fatty acids derived from petrochemicals. There is already soap products produced with animal fat, but there are certain problems associated such as hardness and low foaming ability. The objective of this study was manufacturing laundry soap from RCF with better performances. Farm chicken waste was purchased from commercial breeder farm at Naththandiya. RCF were extracted from breeder chicken skin and breeder chicken fat tissues using water cooking method. The samples were left to boil on the range top for 40 minutes. Both rendered chicken skin fat (CSF) and rendered chicken fat tissue fat (CFTF) samples were used separately for producing soap. 25 ml of CSF and CFTF were separately mixed with 1.25 g, 2.5 g, 3.75 g, 5 g, 6.25 g, and 7.5 g of NaOH and heated in 100 °C water baths. Best soap was selected using sensory evaluation and chemical characteristics. The sensory evaluation criteria were appearance, texture, hardness, foaming ability, skin feel and overall acceptability and 30 un-trained panelists were employed. All the prepared soaps were analyzed for chemical characteristics by testing emulsifying properties, behavior in hard water, alkalinity, and reaction with mineral acid. Based on the all sensory properties and chemical characteristics, most suitable soap composition was NaOH 2.5 g with 25 ml of CSF incorporated soap. Finally best selected soap was compared with three of the commercially available soap using another sensory evaluation for the same properties with 30 un-trained panelists. With the results of second sensory evaluation, it could be concluded that the manufactured soap is comparable with commercial laundry soaps.

*Keywords:* Chicken wastes, Rendered chicken fat, Wet rendering, Soap

## **Effect of Mixer Parameters on Quality and Productivity of Silica Filled Natural Rubber based Solid Tyre Tread Compounds**

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Silica filled natural rubber based solid tyres are extensively used where high level of hygiene is required, such as food and chemical manufacturing industries. Mixing of rubber with other chemical ingredients and fillers is an inevitable operation in rubber compounding prior to product manufacturing. In compounding, mixing parameters play a significant role by affecting on curing and physical properties of vulcanizates which are used as quality determinants of solid tyre compounds. In this study, a tangential internal mixer was used to make silica filled natural rubber compound to determine effect of mixer parameters. As mixer parameters, combinations of mixer rotor speeds at 26.5/30.5 and 28.9/33.4 rpm and total mixing cycle time at 320, 335, 360 and 375 seconds were used in 1<sup>st</sup> and 2<sup>nd</sup> stage compounding. To assess quality of compounds, minimum torque, maximum torque, scorch time, curing time, hardness, specific gravity, tear strength, tensile strength and elongation of the vulcanizates were used while the productivity was measured as the rate of production in tons per day. Data were analyzed using Minitab 16 statistical software and complete randomized design with 10 replicates per each treatment. Results revealed that, rotor speed and mixing cycle time have significant effect on quality and productivity of compound by affecting the curing and physical properties. The productivity of compound has indicated that total mixing cycle time of 320 seconds is better for enhancing the productivity. In conclusion, results indicated that the compounding process at 1st stage 26.5/30.5 rpm rotor speed with 240 seconds of mixing cycle time and 2<sup>nd</sup> stage 28.9/33.4 rpm rotor speed with 120 seconds of mixing cycle time are the best mixer parameters to optimize the production by attaining the acceptable quality of compounds in silica filled solid tyre tread compound production.

**Keywords:** Curing characteristics, Physical properties, Mixer rotor speed, Mixing cycle time, Solid tyre

## **Effectiveness of Introducing High Efficient Motors in Tea Processing Machineries**

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Most of the machinery used in withering and rolling processes in about 700 working tea factories in Sri Lanka is coupled with induction motors working with less than 80% efficiency. These machineries are operated for long hours and consume about 70% of total energy consumption in tea manufacturing. Hence, coupling low energy consuming motors into the machineries would be more economical and environmental friendly. Therefore, this study was conducted to assess the effectiveness of introducing High Efficient Motors (HEM) in tea processing machineries as an energy saving measure. The experiment was conducted at Tea Research Institute, Thalawakelle. Two experiments were done for withering trough and rotorvane rollers separately. In experiment one, the performance of High Efficient Motor and HEM coupled with Variable Speed Drive (VSD) in withering were assessed against Induction motor, using three replicates. And in experiment two, a HEM was compared with Induction motor in rotorvane rollers using three replicates. The results revealed that, significant energy saving ( $p < 0.05$ ) with the use of HEM and HEM coupled with VSD against the induction motor was 0.015 kWh and 0.026 kWh per kg made tea, respectively, in withering trough. Also there was a significant energy saving of 0.00058 kWh per kg made tea ( $p < 0.05$ ) in rotorvane rollers with the use of HEM against the induction motors. Further, estimated annual saving was about Rs. 25,700/- and Rs.44,500/- with the use of HEM and HEM coupled with VSD, respectively in withering and it is about Rs.6,300/- in rotorvane rolling with the use of HEM. Finally, it can be concluded that, coupling HEM in tea processing machineries would be a cost-effective solution only for rotorvane rollers in large scale factories.

*Keywords:* Energy consumption, High Efficient Motor, Induction Motor, Rolling, Withering

### **Extraction and Comparison of Physiochemical Properties of Lipids from Catla (*Catla catla*) and Tuna (*Thunnus albacares*) Fish Skin**

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Fish oil is considered to be an important natural source of Poly Unsaturated Fatty Acid (PUFA) and it provides benefits to human health. The objective of this study was to compare the yield and the physiochemical properties of two fish oils extracted from the freshwater *Catla catla* (catla) and marine *Thunnus albacares* (tuna) respectively using different extraction methods. Fresh fish skins were collected from local market and extracted using Ultrasonic (SO) and Soxhlet (SH) extraction methods with ethanol (EtOH) and Acetone (Ac) at 100% and 50% (v/v) water: EtOH and water: Ac strengths. Yield analysis of different extractions revealed that SH extraction with acetone has the maximum yield ( $p < 0.05$ ). 100% and 50% Acetone showed the highest yield for catla (12.48%) and tuna (4.68%) respectively. Malondialdehyde (TBARS) assay and free fatty acid value of lipid extracts with highest yields (tuna-100% Acetone in Sonicator and 50% Acetone in Soxhlet; Catla- 100% Acetone in Soxhlet and 50% Acetone in sonicator) were tested to determine the effect of extraction method on quality of lipids extracted. Free Fatty acid values were recorded as mg of KOH/g  $2.1 \pm 0.204$ ,  $3.9 \pm 0.04$ ,  $2.13 \pm 0.28$  and  $2.9 \pm 0.13$  in catla SH/ 100%Ac, tuna SO/ 100% Ac, catla SO/100% Ac, tuna SH/ 50% Ac respectively. Also the degradation of lipids due to oxidation during all these extraction methods has been minimum and were in acceptable ranges according to recorded TBARS values. (0.093, 0.025, 0.053, 0.010 Malanoldyhyde mg/kg in catla SH/ 100% Ac, tuna SO/ 100% Ac, catla SO/100% Ac, tuna SH/ 50% Ac). With these results, it can be concluded that Soxhlet method is the best technique used in this study for lipid extraction from fish skin with high yield and optimum quality. Also, more polar solvent systems have increased the extraction efficiency in tuna and this can be due to the high polar nature of lipids in tuna compared to catla. However, Lipid profile analysis is essential for further comparison.

**Keywords:** Acetone, (*Catla catla*), Fatty acids, *Thunnus albacares*, Soxhlet

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### **Antibacterial and Anti-Diabetic Properties of Bioactive Compounds Extracted From *Sonneratia caseolaris* Fruit**

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Mangrove plants are broadly used in Ayurveda medicines for its antibacterial and antiviral properties. Secondary metabolites which produce by these plants have shown antioxidant, antibacterial, antilarval and antiviral activity. But the activities of the *Sonneratia caseolaris* (Kerala) fruit is less studied in Sri Lanka. The objective of this study was to determine antibacterial and anti-diabetic activities of Kerala fruit extracted using different solvents. Medium size (4-6cm), 60-75% ripen fruits were collected from Bentharda, Sri Lanka. Fruits were blended with water and ethanol and kept at 4 °C overnight. Extractions were dialysis to remove the solvents and all samples were lyophilized. Antimicrobial activity was determined by inhibition of locally isolated *Escherichia coli* (*E. coli*) strains. All treatments were replicated (n=3). Antibacterial assay was done for prepared concentration series (1000 - 5000 ppm). *E. coli* were sub cultured using EC broth. Inhibition of *E. coli* was determined using EMB agar well diffusion method and as the positive and negative controls Augmentin (0.001 ppm) and distilled water were used. Anti-diabetic activity was determined by  $\alpha$ -amylase inhibition assay ( $\alpha$ -amylase-13U) finally IC<sub>50</sub> value was measured. According to the results obtained, liquid extractions from the fruit and the remaining pulp of both ethanol and water showed  $1.13 \pm 0.15$ ,  $1.37 \pm 0.06$ ,  $0.73 \pm 0.06$  and  $1.13 \pm 0.21$  cm inhibition zone respectively. By comparing the results obtained ethanol extraction showed high inhibition than water extraction against *E. coli* ( $p < 0.05$ ). In antidiabetic determination assay ethanol extracted liquid sample show the highest amylase inhibition ( $p < 0.05$ ). Even the inhibition showed a higher value in lower concentrations such as 100 ppm (80%). As the conclusion, Kerala fruit extracts can be used as potential antimicrobial and anti-diabetic agent, and further studies required to chemically characterize the active compounds.

**Keywords:** *Sonneratia caseolaris*, Antimicrobial activity, Anti-diabetic activity



**Development of a Simple Protocol to Extract Pure Curcumin from Turmeric  
(*Curcuma longa L.*) Rhizome**

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Turmeric, *Curcuma longa L.* of Zingiberaceae family is a widely cultivated spice in India and other Asian countries. Curcumin is the main colouring substance in *Curcuma longa L.* and together with the two related compounds, demethoxycurcumin and bisdemethoxycurcumin are known as curcuminoids, which is approximately 2.5-6 % by weight of the rhizome of turmeric. Curcumin has powerful biological activities including anti-inflammatory, antioxidant, anti-carcinogenic, anti-viral and anti-infection activities. The objective of this study was to develop novel, high yielding, simple and economical protocol to extract pure curcumin from turmeric rhizome. Six treatments namely, T1-75% acetone extract of turmeric powder Salted out using NaCl, T2- 50% acetone extract of turmeric powder Salted out using NaCl, T3 - Crystal precipitation of saturated extract using 100 g of turmeric powder with 300 mL of acetone, T4 - Crystal precipitation saturated extract using 100 g of turmeric powder with 500 mL of acetone, T5 - Soxhlet extraction with acetone and T6 Soxhlet extraction with ethanol were used and the experiment was conducted at Post harvest Technology laboratory, Central Research Station, Matale. Extracts from different treatments were analyzed for yield and purity of curcumin. TLC and UV VIS Spectrophotometer were used to analyze the extract qualitatively and quantitatively. Pure curcumin was used as the reference standard for TLC to isolate pure curcumin from the curcuminoids. T4 showed significantly the highest curcumin yield and purity percentage while T6 showed significantly the lowest curcumin yield and purity percentage than that of other treatments ( $P < 0.05$ ). Among T1 and T2, high acetone strength has given the best purity ( $P < 0.05$ ) while there was no significant different between T1 and T2 for yield ( $P > 0.05$ ). Therefore crystal precipitation method using 100 g of turmeric powder with 500 mL of acetone (T4) can be considered as the best protocol to isolate curcumin from turmeric rhizome.

**Keywords:** Curcumin, Isolation, Protocol, Turmeric, Yield

## **Formulation and Development of Polyphenol Incorporated Natural Sunscreen Cream**

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The increasing awareness of consumers on the risk of synthetic chemicals in cosmetic products related diseases like skin cancers open up market for natural cosmetic products. The objective of this study was to develop tea polyphenol incorporated natural sunscreen cream using UV absorbance ability of polyphenols. Tea polyphenols were extracted from green tea, black tea and tea fluff at 40 °C by using hot water extraction procedure. Black tea exhibited the highest UV absorbance ability compared to other two. Black tea polyphenols were extracted and tested for concentration of polyphenol content using Folin Ciocalteu phenol reagent method. The base formula for sunscreen cream was selected from three base samples using sensory evaluation. Base samples were made by changing percentage of oil phase (34%, 38.5%, 43%) and water phase (66%, 61.5%, 57%). Ten different sunscreen creams were formulated using 0.5% - 4.5% polyphenol content from freeze dried samples and the sun protection factor (SPF) were determined. The in-vitro SPF of the formulations were determined using UV spectrophotometer at 290-320 nm range. The second sensory evaluation was performed for sensory properties of visual appearance of the sunscreen cream in the jar, feel of the sunscreen cream in the jar, skin feel during absorbance and skin feel after absorbance using the best four cream samples which had the highest SPF values. Two sensory evaluation sessions were performed to evaluate several sensory attributes by using 30 un-trained panelists. The obtained sensory data were analyzed according to the freedman test at 5% level of significance. The identified highest four SPF values were 5.415, 5.814, 6.431 and 7.099. The results revealed that the sample having SPF value of 5.415 and 3% of polyphenol was the best. The best sample was evaluated by aerobic plate count test and visual determinants were observed fortnight to identify the shelf life. Furthermore, pH value, thermal stability, non-volatile matters at 105 °C and peroxide value of the best sample were determined and it maintained the acceptable levels as expressed by Sri Lanka Standard Institute. However, peroxide value was not in the recommended level because of oxidation of lipids. According to the results sample having SPF 5.415 value is an effective sunscreen cream to reduce harmful effects of UV radiation on human skin.

*Keywords:* Sunscreen, Tea polyphenol, Ultraviolet, Sun Protection Factor (SPF)

**Antimicrobial and Amylase Inhibitory Activities of Aqueous Extracts of  
*Kappaphycus alvarezii***

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Marine macro algae are common botanical species naturally found along Northern coastline of Sri Lanka. It is recognized as one of nature's greatest biologically active resources and possess large number of bioactive compounds. Bioactive compounds in red seaweeds are one of the organic substances highly beneficial to human health. Therefore, the objective of this study is to determine bioactive compounds from red seaweeds under different treatments and check its antidiabetic and antimicrobial properties of the extract. Aqueous extraction of secondary metabolites was carried out using distilled water (DW) under 4 °C and room temperature with washed and unwashed conditions and determined antimicrobial and antidiabetic properties of the extract. Aqueous extract was separated at 24 and 48 hrs intervals and lyophilized. All samples were replicated (n=3). Extracts from different treatments showed a color variation from purple to pink resulting a structure change in the compounds isolated. Antimicrobial activity was determined using well diffusion method with locally isolated *E. coli* strain and Augmentin™ (0.001 ppm) as the positive and distilled water as negative control. 200-1000 ppm concentrations were used from all four extracts and complete inhibition was recorded after 48 hours of incubation ( $p < 0.05$ ) and resulting storage temperature doesn't have an effect on the antimicrobial properties. Antidiabetic activity was tested using  $\alpha$ -amylase inhibition assay. More than 50% amylase inhibition activity was recorded at 400 ppm concentration, samples which were not washed from DW and stored in room temperature (54.54%) and in ice (59.58%) and washed samples which were stored in room temperature (50.32%). As conclusion, seaweed aqueous extract without washed, stored under room temperature can be used as a potential antimicrobial and antidiabetic agent. However further studies required for the analysis of the structure and other functional properties of the isolate.

**Keywords:** Anthocyanin, Antidiabetic, Antimicrobial, Seaweeds, Secondary metabolites

### **Development of Green Tea Incorporated Lip Balm**

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Currently there are many cosmetic products in the market made using synthetic chemicals which may have side effects. So there is a growing consumers preference for natural cosmetic products with low side effects. This study was aimed to produce a lip balm which gives smoothness and prevent moisture loss using natural ingredients. This was produced as a value added product from tea to use tea other than its regular usage as a beverage because tea polyphenol can keep lips hydrated and fresh and help to rejuvenate. Soxhlet extraction method with water was flowed to obtain aqueous extract of green tea. A 0.719 g of crude extract was obtained from 2 g of green tea after freeze drying above extract. Polyphenol content of this powder was determined using Folin-Ciocalteu colorimetric method. Lip balm base was prepared using beeswax, Aloe gel, coconut oil, vitamin E, and lavender oil as ingredients. Five samples of base were produced changing the amounts of beeswax (35%, 30%, 28%, 26%, 24%), Aloe gel (16%, 17%, 18%, 19%, 20%) and coconut oil (46%, 50%, 51%, 52%, 53%) keeping amounts of vitamin E (2%) and lavender oil (1%) constant. Three samples were selected among them by conducting a sensory evaluation with 30 untrained panelists. Each base was incorporated with tea extract with 92.45% of polyphenol instead of adding green tea directly, at three different levels (0.5%, 1%, and 1.5%). Then the best final product was selected from those samples conducting a sensory evaluation of 30 untrained participants and its composition was beeswax 0.594g, Aloe gel 0.3564 g, coconut oil 0.99 g, vitamin E 0.0198 g, lavender oil 0.0198g and green tea aqueous crude extract 0.02g. Quality of the product was assured according to the Indian standards specification for lip salve. Newly produced lip balms melting point was 43.67 °C. Consistency was 0.009 and is less than the expected value of Indian Standard. Rancidity and deterioration werent observed in the final product. Improving physical mixing of tea extract with lip balm base and measuring the content of polyphenol of the balm with time can be done as further developments. The newly formulated green tea extract incorporated lip balm will open an opportunity for developing of a natural, safe, and cost effective product.

*Keywords:* Polyphenol, Natural, Cosmetic product

### **Bioactivity Evaluation of an Aqueous Extract of *Phyllanthus amarus* as a Potential Instant Herbal Tea**

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Bioactivities of instant herbal tea prepared by air-dried, powdered aerial parts of *Phyllanthus amarus* Schum. & Thonn (Pitawakka). collected from the Uduvil area in Jaffna peninsula, Sri Lanka were evaluated. Powdered plant samples (0.50 g/100.00 mL, 1.00 g /100.00 mL) were separately subjected to hot water extraction followed by a freeze-drying and subjected to, antimicrobial susceptibility assays using agar well diffusion methods, against *Staphylococcus aureus* (NCTC 6571), *Escherichia coli* (ATCC 25922) and *Aspergillus niger*, with the concentration of extracts (5000 ppm). Total polyphenolic contents were measured using Folin-Ciocaltue (gallic acid equivalent: GAE) method. *Artemia salina* toxicity assay on extracts were carried out using a concentration series (0.75 – 200.00 ppm) and LC<sub>50</sub> was calculated by the probit analysis, Minitab16.0. Sensory attributes of extracts were examined by the Hedonic test and compared with a commercial herbal-tea (*Hemidesmus indicus* R.Br.). *P. amarus* extracts did not show significant antimicrobial activities, giving significant inhibition zones in the agar-well diffusion assay. Considerable polyphenolic content (0.79 ± 0.01 mg: GAE) were observed for dry 1.00 g of plant materials in both 0.50 g and 1.00 g samples. Whereas, cytotoxic activities were exhibited by giving LC<sub>50</sub> at 9.34 ± 0.34, 3.99 ± 0.36 ppm, respectively (positive control: K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>, LC<sub>50</sub> = 19.20 ± 3.14 ppm). Highest significant score (p < 0.05) reported for the commercial sample for taste, however, for the colour and aroma, significant differences were not observed (P > 0.05). It can be concluded that *P. textitamarus* herbal tea sample has considerable bioactivities.

**Keywords:** Herbal tea, Antioxidant, Antimicrobial, Cytotoxicity, *Phyllanthus amarus*

## Screening of Antagonistic Activity of Isolated Yeasts against Selected Common Molds in *Carica papaya*

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Lack of fungicides certified for the control of post-harvest mold damage in fruits has led to the consideration of alternative strategies, such as use of yeasts as bio control agents. The objective of the present study was to screen the antagonistic activity of wild yeasts species and to study their metabolic cytotoxicity to use them as bio control agent for molds, damaging *Carica papaya* fruits. The yeasts were isolated from the surfaces of leaves and flower buds of *C. papaya*, *Psidium guajava* L. and liquid albumen of *Cocos nucifera*. Diluted surface washed distilled water were plated on to Yeast Extract agar with Ampicillin (50 ppm). Three types of yeasts were isolated and coded as A, B and C. Five mold species (*Fusarium sp.*, *Mucor sp.*, *Rhizopus sp.*, *Aspergillus sp.* and M) were isolated from infected *C. papaya* fruits and were tentatively identified by studying their morphological characteristics using a microscope after staining with lacto phenol cotton blue. Dual culture assay was done in triplicate, against isolated yeasts by inoculating isolated molds and yeasts, 3 cm away from each other on Potato Dextrose Agar plates. Radial growth was measured after four days and Percentage of radial Growth Inhibition (PGI) was calculated using a formula. The results were analyzed using Two Way ANOVA and there was significant effect from all the yeast species on all the mold species ( $P < 0.05$ ). Yeast type A and C intensely reduced the radial growth of *Fusarium sp.*, by 53 % and 59% respectively. Moreover they inhibited the growth of *Aspergillus sp.*, by 26% and 25% respectively and growth of *Rhizopus sp.* by 30 % and 29 % respectively. Yeast B only inhibited mold M by 29%. Toxicity for the secondary metabolites of yeasts type A and C were tested in Brine shrimp lethality assay and Lethality Concentration at 50% Mortality ( $LC_{50}$ ) for them were 1898 and 1121 ppm. According to the results yeast type C had shown higher antagonistic activity with lower toxicity. In conclusion, Yeast type C could be more suitable in controlling post-harvest mold damage in *C. papaya* fruits. However further studies are required in identification and characterization of yeast type C to use it as a bio control agent.

**Keywords:** Post-harvest mold damage, Antagonistic activity, Cytotoxicity, Bio controlling yeast

## Screening of Basidiomycetes Fungi Collected in Badulla Area for Increased Laccase Activity

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*Laccase* has been identified as an extra cellular ligninolytic enzyme. White rot basidiomycetes are known to be prominent *laccase* producers. Previous studies have shown that the *laccase* is capable of detoxifying the hazardous effluents discharged by textile and paper industries, without harming the environment. Although this enzyme has many applications, such as bio bleaching and decolourization of textile effluents with azo dyes, the main issue hampering their usage at industrial scale is the low yield of *laccase* in many white rot fungi. This study focuses on screening of basidiomycetes fungi collected in and around Badulla to identify fungal strains with hyper excretion of *laccase* enzyme. Collected basidiocarps were surface sterilized by rinsing in 5% bleach for 3 minutes and 70% ethanol for 1 minute followed by three thorough washings with sterilized distilled water. About 0.5 cm<sup>2</sup> piece from the basidiocarp was cultured on potato dextrose agar medium supplemented with 0.2 mM 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid). Out of 15 basidiocarps subjected to initial ABTS assay, 5 found to be *laccase* hyper excretory as 2 showed characteristic purple and 3 showed blue green colouration. The selected 5 were cultured in potato dextrose broth. A 0.1 mL of the centrifuged culture medium was used in quantitative enzyme assay and absorption was measured at 420 nm. A standard curve of absorbance versus concentration of *laccase* was established using commercially available *laccase* obtained from *Agaricus bisporus*. Absorption data were compared with a standard curve to determine the concentration of *laccase* produced by each fungal strain. The strain G709, which was tentatively identified as *Trametes* sp. was the highest producer of *laccase* which was 1339 ppm. Strains C357, J258, L348, H844 produced 86, 98, 119, 223 ppm respectively. The hyper excretory *Trametes* sp. identified in this study could be used to produce *laccase* in large quantities for industrial applications.

**Keywords:** Basidiomycetes fungi, Laccase hyper excretion, ABTS assay, *Trametes* sp.





# **Biodiversity**



**Egg Laying and Initial Growth Patterns of Sri Lankan Kangaroo Lizard  
(*Otocryptis wiegmanni*) Under Captivity**

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*Otocryptis wiegmanni* is an endemic lizard, whose reproduction and patterns of growth are poorly known. Here, their egg laying and initial growth patterns were observed under captivity. Sixty-seven lizards (females; n=22, males; n=15, and juveniles; n=30) were captured from Lower Hanthana (7.2500N, 80.6002E), and introduced to a wooden cage, which had similar conditions to their natural habitat. Weight and length measurements of the eggs and hatchlings, were made using vernier caliper and digital balance. Female *O. wiegmanni* (n=6) chose loamy sandy soil to lay eggs (mean temperature=27.7 °C). They started digging up to 5 cm by using their forelimbs and snout for few seconds, after which they observed the surrounding. The process of digging (9-14 s intervals) and observation of surroundings (58-120 s intervals) goes on for up to 1.5 hours. After digging, they positioned its cloacae just above the hole they dug and laid eggs. They shifted the soil with their forelimbs and pressed the soil using snout, (spending nearly 1.25 hour) to cover the hole. Egg clutches (n=6) contained 3-5 eggs with slightly different lengths (11.44 ±0.25 mm), widths (6.94±0.50 mm) and weights (0.31±0.02 g). The weight at birth was 0.33 ± 0.03 g (n=22). The initial development of 9 individuals showed similar patterns. Initial tail length was 38.23±3.97 mm and initial snout-vent length was 19.33 ± 1.22 mm. Snout-vent length increased by 3.0–5.4 mm<sup>-month</sup> during the initial 2.5 months. Activities related to reproduction such as mating, egg laying and courtship behaviors occurred during daytime between 1000–1435 h. It suggests that they may need increased body temperature to perform these high energy reproductive activities. Some lizards show temperature-dependent sex determination but it remains to be investigated whether the sex determination of *O.wiegmanni* is temperature dependent or not. All individuals were released to the habitat from which they were captured.

**Keywords:** *Otocryptis wiegmanni*, Lizard, Egg, Captivity, Hatchling

## Long Term Changes in Basal Area and Species Composition of a Lowland Rainforest in Sri Lanka

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Long-term studies of tree population dynamics play an important role in identifying the conservation needs of tropical forest ecosystems. Changes in Basal Area (BA) and species composition over a 37-year period (1979–2016) in the Morapitiya Forest, adjacent to the Sinharaja Man and the Biosphere reserve, Sri Lanka were examined. The Plot size was 5 ha and located in an undisturbed forest. Two censuses have been carried out in 1979 and 1999 and recently the third census was in 2016 measuring all the stems above 30 cm girth at the breast height. Results showed the current BA in Morapitiya forest is 18.4 m<sup>2</sup> ha<sup>-1</sup> and the BA was significantly changed during the study period. Total BA of the canopy species in Morapitiya significantly decreased during the study periods, representing 57.6% and 14.3% between 1979–1999 and 1999–2016 respectively. BA of sub canopy species increased during the 1979–1999 and then decreased 1999-2016 censusing period. The total BA of the understory species increased during 1979–1999 and significantly decreased between 1999–2016 periods. The 1375 individuals enumerated were identified into 86 species, 49 genera and 31 families. The dominant families in the canopy stratum were Dipterocarpaceae (9 species), Sapotaceae (5 species), Clusiaceae (3 species) and followed by Anacardiaceae, Celastraceae, Rhizophoraceae, Meliaceae (2 species each). Based on height attained by mature individuals of a species, 25 canopy, 40 sub canopy and 21 understory tree species were discerned. The findings of the current study revealed that the BA has decreased within approximately a 40 year period. However species composition had not changed significantly. The total BA of forest ecosystems is directly connected to the biomass. Hence, the changes in BA affect the ecosystem services and climate changes through the carbon stock of a forest indicating the importance of the study.

**Keywords:** Tropical Rainforest, Vegetation Structure, Dynamics, Long-term Study, Sri Lanka

## **Evaluating Agro-biodiversity in Kandyan Homegardens in Different Land Use / Land Cover Change Categories in Kandy District**

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Kandyan Homegardens are multi-species traditional agro forestry system which provides food, nutrients, timber, medicine and many other services while conserving bio diversity. Highly intensified Land Use / Land Cover changes in Kandy district during the past few years cause a huge impact on biodiversity of Kandyan Homegardens. Hence, this study was carried out to assess the agro-biodiversity in the mid country wet zone of the Kandy district. Land Use / Land Cover change map prepared using Normalized Difference Vegetation Index change between Landsat images of year 2000 and 2015 was used for the study. Three Land Use / Land Cover change categories were identified as less changed, moderately changed and highly changed. Field investigations were carried out in 90 homegardens in Ambathenna, Pilimathalawa, and Gampola to assess the agro-biodiversity. Land Use / Land Cover change category which Kandyan Homegarden belonged to was identified using a Global Positioning System device. Land holding size in majority of homegardens was between 0.01 to 0.76 ha. Trees, root and tuber crops consisted of 88 species and 45 plant families were identified. Evaluations of species existence showed that number of species present in moderately changed area is 60 compared to 54 species in less changed area and 47 species in highly changed area. Furthermore, twenty seven species were perceived as threatened or lost from Kandyan Homegardens by the dwellers. Species Richness, Shannon-Weiner index and Simpson Diversity Index were used to evaluate the agro-biodiversity. Each LU / LC change category exhibited a wide range of richness due to different land holding sizes. Moderately changed areas have high average species richness (16.61) whereas Shannon-Weiner values for diversity are similar in less changed area (2.33) and moderately changed areas (2.34). Moreover, evenness of abundant species is higher in moderately changed area (0.85). Hence, results of the study suggests that agro-biodiversity in moderately changed area is high in mid country wet zone of Kandy District.

*Keywords:* Agro-biodiversity, Kandyan Homegardens, Land Use/Land Cover change

**Comparison of Germplasm Diversity in Common Bean (*Phaseolus vulgaris L.*)  
Collected in 2010 and 2016 from Badulla and Nuwara Eliya Districts**

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Common bean (*Phaseolus vulgaris L.*) is an economically important vegetable in Sri Lanka which covers around 7900 ha of land area. Germplasm diversity in common bean is vital for systematic management whereas the conservation of the germplasm is important for breeding programmes. Common Bean is mainly cultivated in Badulla and Nuwara Eliya Districts which covers 67% of the total bean cultivation area. This study was carried out to compare the germplasm diversity of common bean in 2010 and 2016. Landraces and growing lines of common bean accessions were collected from Rikillagaskada, Mandaramnuwara, and Mathurata areas in Nuwara Eliya District and Welimada and Bandarawela areas in Badulla District using Snowball Technique in Non-random Sampling method. The number of landraces and growing lines collected from the above areas in 2010 by Regional Agriculture Research and Development Centre (RARDC), Bandarawela and in 2016 was compared using Diversity Indices. Records of RARDC have stated that 86 growing lines had been collected in 2010 and 27 growing lines were collected in 2016. The values obtained for Simpsons Index of Diversity and Simpsons Reciprocal Index for year 2010 were 0.76 and 4.17 respectively whereas the values obtained for year 2016 were 0.57 and 2.33. Diversity indices have indicated that the richness of the germplasm is higher in 2010 than 2016. Records of RARDC and information collected from farmers showed that the main reason for the reduction of number of growing lines in Nuwara Eliya and Badulla districts was due to the cultivation limited for the popular cultivar known as Capri. Farmers select this growing line due to its higher adaptability, higher yield, consumer preference and demand. As a result of this, cultivation of other traditional landraces and growing lines has been neglected. According to the biodiversity indices, the germplasm diversity has been significantly reduced from 2010 to 2016. Hence, it is important to conserve the germplasm of common bean to broaden the genetic base to ensure agricultural sustainability and food security.

*Keywords:* Common bean, Germplasm, Diversity, Growing lines, Conservation

### **Study on phenotypic variations and haemoparasites in village chicken in cascade and ovita agro-eco systems**

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Ancient Sri Lanka had a sustainable ecosystem where people maintained man environment relationship in a passive way to have balanced ecosystems while utilizing for agriculture. Village chicken is commonly reared in such ecosystems and is important in low-income families. Productivity of village chicken can significantly be reduced by Haemoparasitic infections. Objectives of this study was to classify village chicken phenotypes and to determine prevalence of haemoparasites of village chicken reared in two different agro-ecosystems of Sri Lanka. Thirteen farmers from Milleniya of Bandaragama in Kaluthara district (6.7144° N, 79.9891° E) representing Ovita agro-ecosystem and 12 farmers from Gamploa of Giribawa in Kurunagala district (8.1156° N, 80.1973° E) representing Cascade agro-ecosystem were selected. A total of 54 randomly selected mature village chicken from each research site (RS) was included in the study. Both qualitative phenotypic data (plumage color, shank color, sex, comb types, comb size) and quantitative data (shank length, wing span, and body length) were collected from each bird following FAO guidelines. For determination of haemoparasite prevalence, 34 Leishman stained blood smears from each site were examined under the light microscope using standard references as the identification guide. All collected data were analyzed using Minitab 17 and significance of differences of phenotypic parameters between two sites were evaluated using t-test. The both RS mainly consisted with Normal village chicken phenotype (87% in Bandaragama & 91% in Giribawa). Further, 7% long legged and 7% crown chicken were identified in Bandaragama and Giribawa, respectively. There was no significant quantitative phenotypic difference of chicken within site ( $P > 0.05$ ) though the difference is significant between 2 sites ( $P < 0.05$ ). Shank length ( $0.011 < 0.05$ ), Body length ( $0.00 < 0.05$ ) and Wing span ( $0.0004 < 0.05$ ) was higher in female Normal village chicken in Bandaragama than the Giribawa. There was no significant difference between male village chicken in those two sites ( $P > 0.05$ ). Many plumage color patterns were observed due to cross breeding. Most predominant comb type and shank color were single comb and yellow shank, respectively. Microfilaria is the only haemoparasite found in both sites and the prevalence of microfilaria in Bandaragama and Giribawa are 26% and 17.64%, respectively. This could be due to resistance of village chicken to parasitic diseases in the research sites. In conclusion there was significant difference in phenotypic characters between female village chickens of the two sites.

**Keywords:** Haemoparasites, Village chicken, Agro eco systems, Phenotypic variations

**Acknowledgement :** Biodiversity for adaption to Climate Changes (BACC) project

### Distribution of *Gracilaria* species (*Gracilaria edulis*, Rhodophyta) in Sri Lanka

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Seaweeds are the marine aquatic plants which are found in the subtidal region and in the coastal region between low and high tide where 0.01% photosynthetic light is available. Light exposure, depth, temperature, tides, Plant pigments, and the characteristics of the shore combine to create various environments that determine the distribution of seaweeds. Sri Lanka has a rich marine algal flora along its coastal belt. *Gracilaria edulis* farming is considered as an alternative livelihood for fishermen around the coastal region in Sri Lanka Particularly in Kalpitiya. There are several benefits arise from this species such as medical and food wise. In many of the *Gracilaria* species particularly *G.edulis* is inadequately illustrated for its distribution in Sri Lanka. The main objective of this study was to find out the different *Gracilaria* species and their distribution pattern in Sri Lanka based on an intensive regime of local collection. Samples of *Gracilaria* species were observed and collected from a total of 6 regions along the beach areas seasonally between March 2015 and August 2015 period. Seaweed specimen were removed by hand but those specimens that were closely adhering to the substrate such as crustose and mat forming seaweeds were removed with the help of knife or scalpel. The collected specimens were kept in an ice-box while transported back to the laboratory. Mainly four species of *Gracilaria* were recorded in the Sri Lanka, including one *G.corticata* species which was identified in Kalpitiya and mostly abundant *G. edulis* in Puttalam, Jaffna, Trincomalee and Mannar. Most members of genus *Gracilaria* were distributed widely along the coast of Puttalam. Rocky platforms exposed to the open sea had a greater variety of species than either rocky platforms in sheltered areas or those associated with sandy beaches. *G.verrucosa* occurred only in the sublittoral and *G.edulis* only in the eulittoral, and rest of the species were found in both zones. The most common species was *G.salicornia*, followed by *G.corticata* and *G.hikkaduwendensis*. *G.verrucosa* and *G. edulis* have an extremely rich and diverse seaweed flora with a wide variety of marine habitats in Sri Lanka.

**Keywords:** Seaweeds, Sublittoral, Eulittoral, Distribution, *Gracilaria*





# **Computing and Information Science**



**Project LangfiKA Open Source Language Enhancement Tool**

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Spellings, correct use of grammar and the plagiarism checking were identified as the hardest parts in the academic writing. Therefore, English writing enhancement software tool called "LangfiKA" was introduced to fulfill the above requirement. The main objective of this tool is to enhance the level of English literacy and grammatical knowledge of the academics while making it fully open sourced. Becoming a good competitor for existing word enhancement applications was one of the main objectives of this project. LangfiKA is an open source English writing enhancement software tool where English spellings and grammar of any given text will be checked and necessary suggestions are provided to the user. The text will be checked for plagiarism, which is highly beneficial in academic writing. Further, the instant word translation will also be provided to the user in this LangfiKA tool. The grammar checking module was implemented by using core natural language processing concepts. First, the text will be split into sentences and then it will derive the part of speech tags of them. Then it will chunk into groups of part of speech tags and will compare with the grammar pattern rules which were defined through XML file format. After that, it will give the user with accurate suggestions for their error corrections. The plagiarism checking in this tool consists of both offline and online modules. It will indicate the user whether the text is plagiarized or not based on the defined threshold value of plagiarism. The results of using each feature in this system may help the user to create a better academic document with a higher quality compared to other available high priced tools. The number of grammatical techniques in this grammar checking module was limited to a certain amount and due to that, it includes the extended capability of adding new grammatical techniques for further development.

*Keywords:* Grammar Checking, Natural Language Processing, Plagiarism, Instant Word Translation

## **High Efficient Tamil Speech Recognition System for Sri Lanka**

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Speech recognition is the technology which converts an audio signal into sequences of words that a user spoke. Speech recognition enables a rich Human-Computer interaction in many emerging applications. This research presents a speech recognition system, especially for the Tamil language. Building a speech recognition process involves mainly of three processes, namely as feature extraction, developing models and the matching process. Recognizing speech using a computer is a difficult task since speeding up the word search process is a complex task. Dynamic Time Warping, Image Processing, and many other approaches have been made to develop an accurate speech recognition system where these attempts have been done for English, Chinese, Mandarin and Arabic languages. Therefore, we intend to develop a speech recognition system for the Tamil language. Our research is concerned with building an independent speech recognition system using the CMUSphinx toolkit. The system was developed for a number of desktop applications employing Hidden Markov Models and Viterbi search algorithm. Audio recordings from ten people, both male and female were recorded in different environments and they were converted to the .wav file format with 16-bit depth, 16 KHz sampling rate, and mono channel. The collected audio recordings were divided into two different corpora as training data and testing data. A text corpus, transcription file and fields file for both training and testing database were prepared accordingly. Three models, Acoustic model, Language model and Pronunciation model have been developed. The SphinxTrain was used for the purpose of developing Acoustic Model while the SRI Language Modeling toolkit was used for building Language model. The Pronunciation model was manually prepared. A language could be pronounced differently by different people. Therefore, the performance of the system over various speaker subsets of different sex, age and dialect was examined. The results that were obtained through this examination showed a significant efficiency of around 85% which were calculated using Word Error Rate. The developed system can be used by developers and researchers who are interested in implementing a Tamil speech recognition system. Further, the system can be used to cater for large vocabularies with a large amount of data of voice recordings.

*Keywords:* Tamil Speech Recognition, Hidden Markov Model, Acoustic Model

## **Lemma and Latent Semantic Analysis based Assessment Classification**

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Final theory exam paper questions are the main assessment techniques in higher educational institutes. Therefore it is necessary to spend adequate amount of time to develop final assessment questions. Further, when preparing an assessment, a teacher should think carefully about the learning outcomes of the subject which they are planning to measure. However, with the current exam paper evaluation process, it is difficult to identify how well the assessment reflects the defined objectives. It is due to a number of factors such as lack of awareness of the course objectives, course contents, time constraints to evaluate the exam papers and difficulty in identifying and categorizing exam questions as high or low levels. Therefore this ongoing research focuses on developing a framework to assess the level of the exam paper questions automatically according to a well-defined educational taxonomy (Blooms Taxonomy). Knowledge, Comprehension and Application are the lower levels and Analysis, Synthesis, Evaluation are the higher levels of Blooms taxonomy. A sample set of exam questions of the Department of Computing and Information System, University of Wayamba was used to evaluate the accuracy of the exam questions. Lemma similarity and Latent Semantic Analysis (LSA) Similarity of exam questions were tested with Blooms taxonomy levels to develop a set of rules to categorize the exam questions. Term frequency and Inverted document frequency (TF-IDF) module preparation and vector module preparation were done as part of LSA similarity techniques. Training and testing exam paper questions were manually categorized with the subject experts. The outcome of the final classification is a set of weight assigned on each questions. According to the generated set of rule the accuracy of detecting the main category of the question is 78%. Since there is no such accepted methodology to assign weights on exam questions by academics, an automatic weight assignment has given partially accurate results.

*Keywords:* Assessments, Lemma Similarity, Latent Semantic Indexing, Term Frequency

## **Logical Framework for Sri Lankan Vegetable Market to Mitigate Price Invisibility**

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Vegetables are an important component of the daily diet of the people in Sri Lanka. Therefore, vegetable selling plays a major role in Sri Lankan economy. Nowadays, the collector handles the majority of the key activities in the vegetable selling process. But, there is no any formalized structure. Most of the collectors and intermediators running the process in their own way. Therefore, according to the conducted survey, a majority of the upcountry vegetable farmers is not receiving a fair market price for their vegetables even to cover the basic production costs. Since there is no any manageable structure with the business, Consumer Affair Authority is unable to put their hands on this. Except the major problem, some more issues were affirmed from the conducted survey. Those are, delays of the cash payments, granting fraud cheques and confirmation of the cash settlements through the telephone. The reason for these issues is the unmanageable structure of the existing process. Therefore, this research is aimed to eliminate identified issues by constructing a logical framework followed by a web based system to track every record occurs in the vegetable selling process. When achieving this, vegetable price and major factors that affect the price formation of the selected vegetables were considered. As a result, the eveg price model, which can determine the last selling price of a vegetable, is implemented with the eveg web based system. The actual product owner, the farmer, will be able to get a reasonable value to the products through the system and indirectly, the collectors will be able to maintain a maximum retail price for vegetables. Also, due to the solution, vegetable prices will be standardized in a logical way and Consumer Affair Authority can investigate the structure to take certain actions in critical situations. Further, integration of a bank to proceed with electronic payments should be addressed as some future works to the "eveg".

*Keywords:* Sri Lankan Vegetables, Vegetable Price, Price Model, Web System

## **Color, Texture and Shape For Fruit Image Recognition**

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Every image must be manually annotated by a human in the text based image retrieval systems. These systems were associated with textual information like captions, keywords and filename of images in the image database. The manual annotation requires large amount of labor. Due to the involvement of human, the text based image retrieval system becomes time consuming. It is required to design the image retrieval algorithms with less human intervention. CBIR is also known as CBVIR (Content Based Visual Information Retrieval) and QBIC (Query by Image Content). This method is used to retrieve images from a large image database. Image retrieval based on contents is a natural and an effective way of retrieving images. The objective of research is to design and develop a algorithm for the recognition of fruit images using the visual features like color, texture and shape. Color feature is independent of the fruit image size and orientation, The shape feature is the reflective of the human perception. Texture feature describes the surface and structure of given fruit images. These features can be used in conjunction for the retrieval of fruit images. The proposed algorithm for the retrieval of fruit images uses mean of pixel values in the RGB color space, the shape descriptor-eccentricity, and the texture descriptor-entropy as the features of fruit images. This proposed algorithm is applied to a large fruit image database consisting of 3000 fruit images. These fruit images belong to six different categories / classes of fruits. The images are of Apple, Banana, Coconut, Green Grapes, Black Grapes and Orange. Out of these 50% images are taken as training images and 50% as test images. After extracting the features of training images and test images, the supervised learning algorithm k-nearest neighbor is used for the object classification. The comparison is performed with respect to the Euclidean distance and k-NN classifier. The percentage of recognition accuracy obtained is 95.82. The clustering of color, texture and shape features of fruit images gives a strong feature set for the recognition of the image.

*Keywords:* CBIR, QBIC, CBVIR, Color, Shape, Texture



## **Personal POI Recommender with Social Data and Augmented Reality**

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In recent years, research on location based services has attracted a huge attention and a wide interest due to the wide applications. Increased used of smart phones and GPS are the most important factors for this attraction. Meanwhile, Point of Interest (POI) is a more interesting research area with the location based services enabled world. It is a specific point location that someone may find useful or interesting. Furthermore, personalization is a very key concept in modern smart phone applications, which involves the usage of technology to accommodate the differences and variations between different individuals. Like most technologies that eventually reach a mass market, augmented reality is probably being used in almost everywhere to depict virtual reality. This research proposes a future concept called Personal POI Recommender with Social Data which is a location based system that takes a user's personal points of interest from social data, notify and recommend him about those places from time to time. This system analyzes social factors like Facebook likes, Facebook check-ins, foursquare check-ins, Location data of user's tweets and his public, private status updates on social network sites such as Facebook, Twitter, Google+, Instagram and etc. This system stores all the collected and analyzed data from Social Networks sites in the local storage of the device in XML format. Then, this gets users location and time and weather of that particular location and push notifications about nearby interesting places according to users like. A user can store his preferred places in this system as well. That is also stored in the XML file as a whole. Although there are various recommender systems existing at present, they dont have all the three key concepts like personalization, social data and augmented reality. All those types of recommender systems work with items and users in a two dimensional space. Therefore, a better platform for Personalized Point of Interest services based on social networks and user preference with augmented reality is proposed here.

*Keywords:* Tourism, Opinion Mining, User Preferences, Virtual Reality

## **eye4U An Effective Mobile Based Solution for the Visually Impaired**

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"Ability to read" is the greatest gift of all for human beings to become wise. It is forbidden for blind people by nature. Their reading capacity is limited for documents that are in Braille system. Many reading materials are not converted to Braille system. Hence, it is utmost important to find a method such that a blind could read newspapers, text books, bills, etc. without Braille system. This research is completely focused on finding a method which could expose blind people to a new way of reading. The main objective of the research was to develop an application which could identify words and numbers written using a standard font in a given document, and convert those into an audible format such that blind could understand. The process should be easy for blind by providing voice notifications and smart touch techniques. Tesseract Optical Character Recognition library is used in order to identify the characters in documents. Mainly there are two interfaces in the application. One is to capture the text and the other is to display the text. There are some operations that could be performed once detecting the text such as read again function. The application is enhanced to guide the blind to capture an image of the reading material using voice commands. Furthermore, there is another difficulty face by the blind which is identifying the currency notes. Because of the similarity in size of some currency notes, it is hard to recognize them using the size. Due to that issue, blind are often cheated. For future improvements, the application should be enhanced to detect the currency notes. To accomplish that goal the researcher could use a database which contains a set of images of the currency notes and match them with the image which will be taken from the camera. The significance of this research is that there are no existing applications for the blind with these features.

*Keywords:* Text-to-Speech, Blind community, OCR, Android, Tesseract

**Tidal Pattern Forecaster: Lazy IBk Algorithm Based Tide Height Prediction Model for Colombo Seaport**

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As a coastal nation, Sri Lanka has both direct and indirect benefits from the ocean. The precise prediction of the tidal height is very important for human activities, especially in the sectors such as shipping and fisheries. The global level generic prediction models based on astronomical and non-astronomical components are less accurate in the local context. Therefore, the primary objective of this study is to develop a tidal height prediction model based on the lunar and solar gravitational forces occurred in Colombo seaport. The tide height data for the past two years was collected from the hydrology survey department of Sri Lanka navy and the distances between the seaport and the celestial objects were gathered from NASA official web site. Preprocessing of the data was invoked to rectify and impute the missing values. The basic classification modeling was done using Waikato Environment for Knowledge Analysis workbench. Due to the few number of attributes bound with the dataset, Lazy IBk classification model was selected over several other classification models namely Meta Bagging, Meta Random Committee and Meta-regression by Discretization. Lazy IBk model was trained with the correlation coefficient and Root Relative Squared Error of 0.9299 and 0.392 respectively. According to the training statistics obtained, Lazy IBk model was fitted to predict the tide height and tested with the actual values. The resultant correlation coefficient between the predicted tide heights and the actual heights was close to one while the RRSE was minimized. Based on the results obtained during the analysis, it can be concluded that the contribution of the effect of celestial objects is significant to the tide height prediction with respect to the effect of non-astronomical components (local climatic factors). The results reveal that the textitLazy IBk model can provide a precise prediction about the tide height of Colombo seaport to minimize the deprivation faced by the sailors and anglers.

*Keywords:* Tide height, Predictive model, Lazy IBk, Data models

### **High Standard Exam Paper Maker**

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Every university in the world has their own standards and guidelines for examination papers. Invoking those standards are comparatively difficult when using different kinds of word processing tools. It is more time consuming and the outputs may end up violating the pre-defined standards. Though there are more technical solutions, most of the educators do not possess enough technical background. Because of recognizing those difficulties, we are proposing a more efficient and user-friendly exam paper maker for universities. The support of graphical user interface reduces the complexity of the paper maker and automatically generating an exam paper. The paper setters can consider more about the quality of questions rather than the formatting. The paper setter only needs to choose the examination paper template and input required data through the simple user interface. The pre-defined templates were designed for the different types of examination papers and a setter can choose the number of questions and mark. The header of the examination paper that contains the detail of the institute, faculties and courses can be customized according to the user inputs. The most significant part of this paper maker is, the paper setter can include code snippets, mathematical equations, images, diagrams, tables and other symbols very easily. The proposed system is a standalone application and a combination of technologies such as XML, XSLT, and LATEX to generate the examination papers. The user has to enter details, questions and answers through the front end of the graphical user interface and the inserted data are stored in an XML file on the users hard drive. The XML file is transformed into LATEX commands using XSLT stylesheet and generated the final output of PDF file. This application provided 100% accuracy, 90% of the time saving compared with other conventional applications and easy adaptability for the user-friendly interfaces.

*Keywords:* Automated exam papers, Latex exam papers, Latex papers, Latex questions maker, format papers

## **Development of Novel Biometric Trait Key for Person Recognition System**

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The biometric is an advanced way to recognize a person based on the physiological or behavioral characteristics of the human beings. Nowadays, the technologies based on biometric characteristics are getting advanced for law enforcement, user authentication, door security and various domains of security. The palm vein biometric is an advanced biometric used to recognize every individual based on the uniqueness in the blood vascular structure of their palm. The step performed for the extraction of blood vessel structure by means of Gabor filter and canny edge detector. This is followed by detection of the blood vascular structure from the palm region of hand using corner point detection method would be useful to gain feature vector set. The extracted and detected blood vascular structure would be regarded as the feature, as it found unique and distinct from person to person. Thereafter the proposed algorithm has used to test the experiment over 3000 set of 250 individual palm vein images. The recognition of person efficiently results with a higher rate of accuracy through the generation of biometric trait key. The proposed work gave a fine extraction and detection of blood vascular structure with key points. The proposed work based on uniqueness in biometric trait key prominently results into 99.47% of Genuine Acceptance Rate compared with the evolved and existing techniques

*Keywords:* Biometric, Edge detector, Blood vascular structure, Recognition, Genuine Acceptance Rate

## **Voice and Movement Based Input Interface System for Retarded People**

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People who have serious disabilities cannot use any kind of stationary or computer in their day today life. Especially the people who cannot work their legs and arms are suffering a lot from this problem. Although they need to interact with the world, it is impossible due to their special necessities. There are several systems that enable retarded people to work with computers which are high in cost and hard to maintain. This study is providing a free and open source, voice and head movement based input interface that directly address the above problems by providing a convenient computer input interface. This interface provides a virtual keyboard and a cursor controlling mechanism for the windows operating system. Mouse pointer and cursor controlling mechanism handled using an ablaze blob located in users forehead. Usual web camera with image processing techniques were used to map the blob movements in to window position. Important click operations including single click, double-click and right click are handling by the voice commands. This enable users to point out and operate applications only by head movement. Virtual key board senses the mouse cursor for identifying user input. Word prediction system with auto complete facility enhances the efficiency of the virtual keyboard. So that users can type on the screen without using arms. In addition to that, the system consists of a voice command analyzer which can store and identify customized commands that can be used to start a given application. Interface was tested under the supervision of medical officer. System has given to retarded people for check the usability and satisfied with good results.

*Keywords:* Input Interface, Retarded People

## **A Case Study on Internet Usage and the Internet Addiction of Undergraduates**

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Internet access is a very critical factor to the undergraduates. It helps them to improve their knowledge and much more. Because of that currently most of the Sri Lankan universities provide free internet facility to their students, but sometimes undergraduates are misusing this facility through addicting to the internet by disregarding their educational purposes. To solve this problem, universities have to control internet usage and addiction of their students. With the aid of survey research and an Artificial Neural Network (ANN), this study analyzed about internet addiction and the user characteristics that affected to the addiction of internet usage of undergraduates. ANN is a small and statistical technique for obtaining a close approximation to a solution for a particular situation. Selected population for the survey was 183 students in the Information Technology Department of a university in Sri Lanka. The sample size that used for the survey was 100 students from that department. The analysis done by using this ANN first generates a result using observed data and then it tests this solution with the previously obtained answers. It proved that undergraduates are not addicted to the internet and out of 20 factors only 6 factors contribute to the prediction of internet usage of undergraduates. Age, number of hours spent by using the internet at the university, experience using the internet browsers, number of hours spends on a computer per week, number of hours spends on the internet per week for personal research, and number of hours spends on the internet per week to satisfy work requirements are factors that affect to the internet usage of undergraduates. Also out of these 6 variables, most affecting characteristic has identified as the number of hours spend on a computer per week. As for implications of this study, it provides sense to the university to control the internet supply for their students to uplift the efficiency.

*Keywords:* Artificial Neural Network, Internet Addiction

**Multi-Attribute Decision-Making: Use Weighted Product Method for Find Best Image Filtering Techniques for Noisy Image Using Image Quality Assessment**

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Multiple Attribute Decision Making (MADM) contains evaluation, prioritization, selection and etc to make the preference decisions over the available alternatives that are described by different attributes. The issues of multiple attribute decision making are various, and can be found in, for all intents and purposes under any topic. In this paper, six image quality assessments were used for select the best image filtering techniques for any type of noisy images. The requirement for such a decision support system arises from the way that each of the several image quality parameters which were used to analyze the image filters, has its own particular attributes, advantages and disadvantages. These characteristics or attributes are generally conflicting. Here, three image filtering techniques which are Gaussian filter, Mean Filter and Median Filter and the six different multi-attribute scoring methods which are Peak Signal to Noise Ratio Method (PSNR), Average Difference method (AD), Maximum Difference Method (MD), Mean Square Error Method (MSE), Structural Content Method (SC) and Normalized Cross Correlation (NC) were used for the comparison study. The six methods are depicted in detail, and afterward used to rank the image quality assessments using weighted product method (WPM). The experimental result shows that the weighted product method gives a significantly successful achievement and also possible to identify the best filter for any type of noisy images by using the image quality assessments.

*Keywords:* Multiple attribute decision making (MADM), Image filtering techniques, Multi-attribute scoring, Quality assessment (QA), Weighted Product Method



## **Hybrid Learning System for Software Engineering Education**

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Software Engineering courses are focus part of the computer science program since it tunes up the students as software engineers for the industry needs. Whereas the major effort of such component is to give students hands-on industry-pertinent software engineering in the immense acquaintance, usually such courses drop short of this considerable objective owed to be short of industrial awareness and hold up infrastructure. Face-to-face and online learning method incorporated with learning style and learning analytics make leisurelier to convalesce the learning process via checking the students engagement in their learning process and make ready the students as software professional as per the industrial needs. Algorithms were developed to create an online learning system which incorporated the identification of learning style and learning analytics. Hybrid system was developed and the efficiency of the system was analysed with the students who learn software engineering. This system increases the deep insights and increases knowledge acquisition in software engineering education.

*Keywords:* Software engineering education, Learning Analytics, Learning style and Software engineering

## **Loopholes in ICT Law in Sri Lanka and Suggested Corrective Measures**

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Information Communication Technology is a rapidly growing industry and crimes related to technologies are also increasing simultaneously as the technology. Research suggests the corrective measures to the existing Information Communication Technology Laws to ensure the domestic legal protection of the Information Communication Technology users by analyzing the loopholes in the legal system of Sri Lanka. The objectives of the research are making recommendations to the legal measures which need to be taken to overcome the loopholes in legal system, identify the legal developments that has been taken place at the international level or in other jurisdictions and identify the real problem behind the existing Information Communication Technology laws in legal system by analyzing the data gathered from a stratified random sample of the Sri Lankan population. The data were analyzed using Univariate Analysis method and used with primary and secondary sources to make practical corrective measures for the identified issues and experts of the field were interviewed to gather expertise knowledge about existing legal system. Issues that identified were, the ignorance among the public related to the legal system, existence of obsolete laws that need to be updated, lack of proper computer crime reporting system, deficiency in Acts to address the commuting provisions in the industry such as data and database protection, m-Commerce, online violation, consumer protection and lack of a proper procedure to identify the needed modifications for Information Communication Technology laws. The identified loopholes need to be treated as burning issues and dealt meticulously whereas laws regarding Information Communication Technology must be given equal priority as laws related to land, family and contract, while increasing the public awareness properly and establishing a fast Information Communication Technology complaining and investigation mechanism, introducing new laws and establishing an institution responsible of researching the issues regarding computer crimes, commuting provisions and reporting them to the responsible governing bodies who are potent of executing necessary actions and decisions.

*Keywords:* ICT Law, Domestic legal protection, Computer Crime, Corrective Measures

## **Smart Vocabulary Building Application based on Human Memory Behaviours**

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English language is the global business communication media and it is playing a major role in many sectors. Particularly as a developing country, Sri Lanka needs to make use of this world-wide spoken language in order to get the maximum benefit of its international power. In order to master English, the most important thing next to grammar is having a strong vocabulary. The main objective of this research was to make an effective vocabulary builder application which uses humans brain behaviors. The target is to overcome the humans forgetting curve using the technology automation. The application uses a combination of brain science and technology which provides a solution for keeping remember the words we search on the dictionary and helps to boost the vocabulary. There are some theories that says if we need to keep remember something, we need to recall it after two days, two weeks and two months. Otherwise, our brain thinks that information is no longer necessary. The application has got an inbuilt dictionary and keeps tracks of the words searched by user. It gives some multiple choice questions to the user every day on computer start up using the scheduled list of words based on search history. So, the user can remember the meaning of each word effortlessly and without hard cramming meanwhile testing the memory. This process will take place after two days, two weeks and two months for every word searched while taking not more than five minutes a day. The application has been developed using Java swing and uses a SQLite database. Application provides service for Sinhala to English and English to Sinhala both with Sinhala Unicode support. The application provides a statistical analysis of the progress for each user to check the improvement of their vocabulary. The application was being tested with test users and their overall feedback is collected. The results shows that the study is a successful effort and the application has achieved the objectives of the study.

*Keywords:* Forgetting Curve, Dictionary, Vocabulary

## **Ranking Environmental Problems in Sri Lanka Using Crowdsourcing and Natural Language Processing**

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Deforestation, pollution of water bodies, natural disasters are few environmental problems in Sri Lanka. Communities who agonize from such environmental problems are not conquering solutions to their problems due to lack of awareness and carelessness in agreeable parties. In most influential situations, community uses mass media for gaining responsiveness of authorized parties. Virtual communities in Sri Lanka used social media for emphasizing numerous forms of social problems occurred within past few years. The intention of this research is to assist amenable organizations in making better decisions according to the public views. The prototype discussed in here is obtaining the content of environmental problems by soliciting the contributions from the virtual community. The online community can report environmental problems by using text and images. Users can vote or comment on the problems reported by other users. Each problem will receive points according to a pre-defined procedure based on the number of up or down votes and polarity of user comments they have received. The application highlights high-quality problems while allocating points for each user in the application. Text categorization techniques are effective for filtering environmental related information which is not used yet for the most important natural language applications. The polarity of the user comments is generated as positive or negative by using sentiment analysis tools. This research is a study of the interaction between sentiment analysis and topic-based text categorization. The prototype is capable of highlighting environmental problems by considering pre-defined user features, user activity measures and community process features. The accuracy of the web application can be automatically improved on the growth of the corpus provided by the users of the application by using crowdsourcing.

*Keywords:* Natural language processing, Text classification, Sentiment analysis, Crowdsourcing

### **Smart Bulletin Board**

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Research and development are continuously done around the world to improve the quality of living standards today. Smart homes and smart cities have become a popular concept in current researches. Smart meters, smart parking, intelligent traffic management systems, lighting control systems have become popular researches in the world today. Manual notice boards are commonly seen at institutions, organizations which require human labor in posting, transporting and removing notices. This current situation lacks efficiency in information flow among administration, organizers, lecturers and students. Henceforth, the proposed system engages in eliminating these pitfalls. The proposed system is a Smart Bulletin Board which is capable of transferring notices over wireless medium- Wi-Fi (IEEE 802.11) to the VGA monitor which acts as the notice board. The proposed system consists of a web based notice entry module which will enable notices to be pushed into the system by the authorized people (admin). The notice board uses face recognition to identify each registered viewer and display the relevant notice. Criteria for filtering notices could be defined according to various requirements, but in the implementation we used the year of university students as the filter for displaying notices. An android application is been developed to enhance the interactivity of the smart notice board. The user can view the notice from their mobile phone too. Notices are displayed on the notice board according to the priority of the most recent viewers. The notice board displays notices according to a layered format with the most recent viewer's notice at the top, followed by the others below. Technologies used for the system include PHP as the scripting language, C# programming language for display modules, Android for mobile developments, HTML5, CSS for web developments, and MySQL for databases. This proposed system would henceforth provide easy, reliable access to customized notices and advertisements for the user through the Smart Bulletin Board.

*Keywords:* Bulletin board, Wi-Fi, Face recognition, Smart notice board

**Use of Information Communication Technology (ICT) as a Learning tool by the Undergraduates: A Case of Agriculture Faculty, Rajarata University of Sri Lanka**

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ICT capability is fundamental to participation and engagement in modern information society. A recent meta-analysis by the National Institute of Multimedia Education in Japan proved that an increase in undergraduate exposure to educational ICT has a significant and positive impact on increased learning gains for students, creating opportunities for learners to develop their creativity, problem-solving abilities, informational reasoning skills, communication skills, and other higher-order thinking skills. However, there is currently very limited, evidence to support this belief especially within Sri Lankan context. Drawing from this empirical gap this paper seeks to examine the use ICT as a learning tool by the undergraduates. Accordingly, the paper aims at first, identify the frequency of ICT usage for the undergraduate learning purposes and secondly, to identify the undergraduates perception towards the impact of ICT on their educational achievements. A survey was conducted by using a structure questionnaire among the first year undergraduates of the faculty of Agriculture, Rajarata University of Sri Lanka and the sample size was 100. The findings in terms of frequency of ICT usage for the undergraduate learning purposes revealed that majority of students (85%) considered internet/web surfing for seeking information as the main use of ICT in their studies. Further, collecting background data for assignments (78%), accessing scholarly work for research purposes (70), use of MS office package for presentations and assignments (68%), use of the data bases for referencing (41%), communication and networking with others (37%), library online catalogue (14%) are rated as the subsequent uses of ICT in learning. Accordingly, results show that there is a growing tendency of using ICT for undergraduates educational purposes. However, they rarely use library online catalogue for find the books in the library. The findings, in terms of undergraduate perception towards the impact of ICT on their educational achievements showed that the majority (78%) perceived ICT strongly affects their educational achievements while 18% reported moderate impact of ICT and the rest of 4% believe ICT do not have any impact on the educational achievement. Accordingly, it can be seen that these is a common perception among undergraduates that ICT facilitates their educational capabilities. Hence it can be concluded that there is a growing trend of usage of ICT as learning tool for different educational purposes among and undergraduates possess strong perception that ICT as a core facilitator of their educational achievements.

*Keywords:* ICT, Undergraduates, learning tool, ICT usage, Education

### **Analyzing Accuracy of Existing Feature Extraction Methods**

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With the development of technology, digitization, and availability of image processing tools, face recognition research grows up in recent years. Face recognition systems are used in many circumstances such as security, access control, government ID cards. Here, we analyzed the impact of existing feature extraction methods on face recognition and we exactly focused on HOG and SURF methods. This research was focused on finding the impact of HOG, SURF and combination of HOG and SURF methods on face recognition and build up a face recognition system based on the efficient method. Face images of twenty persons were collected in different angles, backgrounds, illumination conditions. Firstly, features of collected training images were separately extracted by using HOG, SURF algorithms, and constructed codebook. Support Vector Machine which uses the class labels and Bag of words approach was used for multi-class classification. Testing image set descriptors were extracted using the same way. Then two features were compared to get the accuracy rate. Features needed for the analysis of the combination of HOG and SURF were taken by adding the features of HOG and SURF. When analyzing the images, the codebook was built from a training image set and a testing image set. By matching these two codebooks by using Euclidian distance, the accuracy rates were found for the above mentioned three methods. Average accuracy rates of HOG, SURF, combination of HOG and SURF were 88.35%, 86.47%, 65.23% accordingly. Even though HOG algorithm provided slightly higher accuracy rate (~2%) than SURF algorithm, SURF algorithm was selected because of its high performance when comparing the execution time which is greater than a HOG. After considering factors such as execution time, accuracy rate and reliability; SURF algorithm can be suggested as the best algorithm for feature extraction in face recognition.

*Keywords:* Speeded-Up Robust Features (SURF), Histogram of Gradients (HOG), Feature extraction method

## **A Composite Method for Biometric Palm Vein Extraction and Detection**

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Nowadays the biometric technologies are getting advanced as a tool for law enforcement, user authentication, door security and various domains of security. The biometric is a way to recognize a person based on the physiological or behavioral characteristics of human beings. The physiological characteristics are external features of an individual mainly includes characteristic such as face, palm, finger, palm vein, iris, etc. and behavior based characteristics such as signature, gesture, keystrokes, etc. The palm vein biometric is an advanced biometric used to recognize a person based on the uniqueness in blood vascular structure of an every individual. The work is about to state the palm vein characteristics as the new dimension of an evolving biometric system. The palm vein characteristic is a superior compared to other biometric characteristics regarding high authentication accuracy. The palm vein is non-transferable means of identifying people and it stays constant throughout ones lifetime. The research is focused on demonstrating the experimentation performed for extraction of blood vessel pattern by means of Gabor filter and canny edge detector followed by detection of blood vascular structure from the palm region of hand using corner point detection method. The extracted and detected blood vascular structure would be regarded as a feature. The proposed algorithm is tested on a sample size of 250 individual palm vein images. The result shows a fine and prominent extraction, detection of blood vascular pattern marked with detected key points useful for the phase of classification.

*Keywords:* Blood vein, Biometric, pattern recognition, feature extraction, Harris-Stephens Corner point Detection



### **Effective Document Management System (EDMS))**

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Document Management Systems (DMSs) are used to track, manage and store documents to reduce paper based work like Google Docs, but the functionality and the purpose will be different compare to Google Docs. Nowadays, most DMSs are capable of keeping records of the various versions created and modified by the users like history tracking, but the EDMS is go beyond these traditional functionalities and allows to perform routine tasks such as storing, organizing, retrieving, modifying and maintaining files and documents. Also EDMS transform the information management in the organization from basic operations such as search and retrieval, to the most complex business functions like regulatory document control that comes in many shapes and sizes. EDMS is designed to cater specific organizations like Universities with some specific functionalities which are very important. The aim of the study is to keep track of the document changes and to reduce the paperwork in the document management process by developing a cloud based system with version controlling capabilities and enabling the system to handle multiple user request simultaneously with the help of version control techniques. As a result, the EDMS allows the users to view and save different versions of the same document, and also allows to assign tasks for users to make changes to the current version. The system is also capable of giving real time collaboration with all the user activities and allowing the users to use the workflow control mechanism to control the paths and access level of the users. During the implementation, featured like metadata, version controlling, workflow management functionalities were successfully completed with other generic functionalities. As future works, usage of some advanced encryption algorithms to increase the security of the system and more refinements to the version controlling mechanism should be done to improve the security and effectiveness of the system.

*Keywords:* Documents, Document Management System, Version Controlling, Workflow, Metadata

## **HTTP1.1 Based Secure Download Manager to Minimize the Data Lost due to Data Corruptions in Downloading**

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Internet download manager is a software use to download files through the internet. Users can download files without using download managers. But download managers download the files more secure than web browsers. But when a data corruption occurs while downloading, these download managers cannot efficiently handle it. This study discusses develop a download manager software to download multiple streams of the file, which can be defined by the user in parallel streams. The components of the system are divided into modules, and each module is capable of operating independently. The GUI Model interacts with the user and displays the relevant information to the user as well as it takes the inputs from the user. Setting Loader Module works as a bridge. All the changes done by download manager will save to the file call Config.properties. When use the download manager the Setting loader will load all the setting Settings from Config.properties file that already have saved. File Divider and Downloader Module divides the file according to our requests and downloading it as responses. When Download Manger download the file, it requests whole file as small separate files. These small files act as independent separate files and Download Manger requests those files in two different ways. For that Download Manger uses two algorithms. First algorithm is that user specifies the how many parts he wants to download and then the algorithm decide the sizes of the small files and download them separately. Second algorithm is that user specifies the size of a small file and then the algorithm decide the number of files and download them separately. After achieving this download Manger modify those algorithms. It chunks the small files and use multiple threads to download that files. Download Manger has a file joiner to combine those separate files. After downloading all those small files, file joiner combines those files and make the complete file. The system is able to increase download speeds, resume and schedule downloads. It has a smart download logic accelerator that features intelligent dynamic file segmentation and safe multipart downloading technology to accelerate downloads. The download manager software which can downloads complete file as small separate files and create the original file by combining the small separate files. Therefore, it Reduce the waste of data usage in data corruption, Avoid the server single file size limitation, Time saving and Increase efficiency.

*Keywords:* HTTP1.1, GUI

## **Kids Learning Kit: An Android Application For Effective Learning Environment For Kids**

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The claimants of the modern technology are the younger kids in any society. Nowadays mobile devices (Tablet PCs and Smart Phones) play considerable role in the technology revolution. One of the major challenges the parents face today is, to keep their children away from those devices due to various reasons. If it is possible to bring the kids desires, new technology and the learning curriculum together, that will allow them to experience an edutainment environment. Therefore, the main intention of this study is to develop an Android application based on the child learning psychology and to substantiate the use of modern technology. The application consists of two modules namely Learning and Drawing. The activities of the application were designed according to the child learning standards while the interfaces were designed based on the Child Computer Interaction principles. The Learning module was designed in a way that the kids could be able to grab the lessons more attractively. The Drawing module was designed in order to improve their selection and matching skills. The effectiveness of Kids Learning Kit was evaluated statistically using randomly selected two groups of fifteen kids. The two groups were labeled as A and B. There were four tasks to cover two modules where first two tasks represented the learning module while the other two tasks covered the drawing module. According to the results obtained for task one and two, Group A was successful than B with the rates of 80% and 66.66% respectively. For the task three and four, the learning environment was interchanged among group A and B and evaluated the results. The success of the group that used the mobile app for learning was 86.66%; on the other hand, the kids who were taught using the traditional method had the percentages of 73.33%. The results implied that the mobile app has influenced and reflected a constructive improvement in kids learning than the traditional environment. Therefore, as a conclusion, the developed application can be effectively used to improve the kids learning interest as well as their edutainment without letting them to puzzle with the technology.

*Keywords:* Kids learning, Mobile app, Edutainment, Mobile device, Android app

## **Federated Cloud Market Models for Sri Lankan Small and Medium-sized Enterprises**

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A federated cloud is an integration or combination of private clouds, community clouds, and public clouds that remain distinctive entities but are assured together by standardized or proprietary technology. A market model shows how to minimize cost optimizing benefits. Companies with the number of employees less than 250 are defined as small and medium-sized enterprises. The cause for the study was that Sri Lankan companies under this category currently is not using optimized federated cloud market models in fulfilling their requirements. By using the optimized market models for federated cloud they can minimize their costs while increasing efficiency. The objectives of the study are to analyze the current context of federated cloud usage by small and medium-sized enterprises in Sri Lanka and, suggesting adequate market models based on the requirements of those enterprises while minimizing their cloud-related costs. A study was conducted to make aware about the current state of the market models in the federated cloud. Then an industrial survey was carried out to collect data about market models for federated cloud requirements of small and medium-sized enterprises in Sri Lanka. In Sri Lankan context some of them did not have required knowledge about cloud technologies as identified by the industrial survey. Sri Lankans prefer cloud service providers who offer free and trial services so much. In some cases, the companies duplicate from their peers without studying the benefits of the cloud services in the market. But it is not appropriate for all times. After getting sufficient data, they were analyzed using linear programming mathematical model and solved it to get an optimized federated cloud market model for a given requirement of a particular company or companies. According to the solution of the proposed mathematical model, most of the Sri Lankan small and medium-sized enterprises are not using optimized federated cloud market models. The results have been compared in order to obtain a more optimal solution to the real world problem. Therefore, customizations of federated cloud market models need to be introduced to the companies.

*Keywords:* Cloud computing, Market models, Federated cloud, Small and medium-sized enterprises

**Effective Awareness Framework for Better Password Security for Advanced Users (BPS Awareness Framework)**

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The study is designed to provide an effective awareness framework which can be used to aware advanced IT users about the best practises of password security. While maintaining straitened password policies, most of the organizations conduct password security awareness sessions frequently to make aware the users who are having various levels of IT knowledge. Due to this variety of IT knowledge, aligning a proper syllabus for all the groups is a hard task and also conducting awareness sessions frequently are high in cost and time consumption. Although the sessions are interesting, effectiveness is doubtful and hard to measure. BPS Awareness Framework is providing a proven guideline and supporting materials to conduct awareness sessions without intervention of costly expert knowledge frequently. This framework carries six parts practical based syllabus including an introduction and pre evaluation, best password creation techniques and difficulties, psychological reasons to have bad passwords, bad effects of sharing password, password manager and its psychology and evaluation based award. Software system was implemented to carrying out the related practical program. Specially, designed MCQ paper was used to create a psychological force to avoid the weaknesses of each user. Unstructured telephone interview was conducted to identify the requirements. Seven security experts who deliver awareness sessions (instructors) and sixty two advanced IT users who follow awareness sessions were interviewed for their expectations on awareness session. Framework was evaluated and reviewed twice by evaluating feedback of instructors. A program which was designed using the framework was delivered to thirty one advanced users and evaluated their improvement where the average score was 90%. The rest thirty one got the usual awareness session followed by the same MCQ paper where the average score was 78%. The save of human hours for fifty users due to the awareness framework was calculated as 38 hours. By considering the evaluation results, this framework provides flexible, secure and acceptable outcome.

*Keywords:* Password Security, Awareness Framework

## **Diabetes Complications Risk Prediction System**

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Diabetes is a chronic disease, which arise when the pancreas does not attain enough insulin, or when the body cannot completely handle the insulin it produces. The terrible fact is diabetes complication symptoms are gradually developed in the body and outwardly show with slight warnings. So finally these complications condemned the patient to the death. The recognized problem for this study is, since longer term diabetes damage to the major organs with the least symptoms and suddenly appear with severe complications, if there is a computerized system to categorize high risk level patients, it will help them to save their lives because early diagnosis and prevention helps to nip the disease at the earliest stage. The objective of this study is to develop a tool which is able to predict the risk level of getting certain diabetes complication in future for already diagnosed diabetes patient. So the ultimate output of this study is Diabetes complication risk prediction system, which is a standalone application which is capable of predicting risk of four diabetes related complications such as Diabetes Retinopathy, Diabetes Nephropathy, Foot complication and Cardiovascular diseases. The prototype was developed with the knowledge base and appropriate graphical user interfaces. The resulting System presents a list of diagnostic questions to the user, which are similar to the questions normally asks by a doctor. And furthermore, this systems really behaves like a face to face discussion manner and ask only yes or no responses from the user to ensure and control the maximum level of user friendliness. Depending on users responses prototype system will analyze the knowledge base and come up with the appropriate risk level for each user. Previously, data collection was conducted for the testing purposes. The prototype was validate using patients actual medical records. Black box testing method use to system validation .With this validation, system shows 68.5% accuracy level. The key technology used to implement this system is SWI-Prolog with JPL. By expanding this application for more complications, predict the risk level as a percentage and create a web application by connecting SWI-Prolog with PHP, MySQL, can achieve more desirable results in future.

*Keywords:* SWI-Prolog, PHP, MySQL, JPL

## **A Mobile Based Application To Visualize The Road Signs For Minimizing The Road Accidents**

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Road signs are one of the most important elements in a transportation system. The drivers face lots of problems while driving the vehicle due to difficulties in identifying the road signs. Because road signs may be rusted, partially collapsed or hidden in the bushes which can be led to the road accidents. In order to minimize these issues, a system was developed including two modules; the web application and the mobile-based application. The web application is used for the purpose of maintaining details of road signs and the mobile-based application is used to assist drivers to identify the correct road signs at the right moment. Initially, the system was developed by gathering road signs data from Kirillewala Junction to Trackmo Junction which was given as a plan by the Road Development Authority. Further, the collected data was verified through successful field visits and by accessing the Google street view. Then the GPS coordination of each road sign was identified by analyzing Google map. When drivers need to use this mobile application, they need to enable internet connection and GPS. Then the GPS coordination of the particular path is sent to the web application by using the Google API and the web application retrieves all the road sign data of the particular path. The retrieved road signs' data was filtered by using the simple linear mathematical equation to check that signs are in particular path or nearest path. Finally, the mobile application checks the current location and informs corresponding road sign to the driver. The mobile application can be run without the internet connection after loading the road sign details to the mobile application. Through the journey, the mobile application guides the drivers by showing the road signs and it gives warnings to the driver in an important case prior to the moment. This system will be a better solution for the most of the road accidents which occurs due to the lack of visibility of road signs.

*Keywords:* Road signs, Mobile-based application, Global Positioning System (GPS), Application Programming Interface (API).

## **STYLFIT3D: A Crowd-source Based Online 3D Modeling Framework for Apparel Industry**

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Fashion can make us more creative in our everyday life. It is really difficult to guess what designs people may like most. The most challenging factor in fashion designing is to design them to fit with the customer measurements. When an apparel design is launched to the open market, dressmakers consider the standard sizes rather than the customized production. Since the variation is more complex in apparel designing and dressmaking, designers and vendors make decisions by guessing what consumers will like. STYLFIT3D is a crowd-sourced social commercial platform to make your own apparel designs and allows consumers to interact on preproduction decisions with the designers, creating an opportunity for virtual collaboration between the consumer and the designer. Main objective of the study is to develop an online 3D modeling platform for dress customizing to match with customer-defined measurements through visualizing. In this study, Crowdsourcing has been employed to enlist the customers in the process of designing and dressmaking unlike in the traditional manual process. Because of that, it brings realistic advantages to companies and individuals looking to complete defined tasks with affordable price in efficient way. The main attraction of the system is its fairly lower price, compared to the price of hiring a dedicated professional. STYLFIT3D provides a fit-on platform for the registered users (customers) where they can customize the 3D model (dummy) according to the measurements provided in real-time. The dynamic 3D dummies were developed using the Unity framework in which the models can be changed according to the parameters passed by the customer. At the same time, the apparel designers are allowed to provide their designs to the system so that the customers can select and match the dresses online using the real-time fit-on facility. The apparel designs were converted into the suitable 3D objects using Blender framework and fitted with the 3D human model. The selected dress can be ordered online and the rest of the business processes are invoked according to the conventional E-commerce procedures. Finally user can check the 360<sup>0</sup> view of the final product. As the conclusion of the innovation, the conception gap between the designer and the customer has been eliminated while the efficiency of the whole production line is improved.

*Keywords:* 3D modeling, crowd-source, online fit-on, apparel design





# **Digital Electronics and Embedded Systems**



### **Kinect Based Human Following Robot**

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Human following robots had been mostly developed and researched by many countries due to its prized applications in daily life and in industrial applications. Mainly the human following robot requires several techniques to generate an interaction between human and robot. The human following robot, can be implemented using various approaches such as the stereo camera, a laser range finder (LFR) and RFID system. The *Kinect Xbox 360* sensor is used for this research to track the human and it was developed for identifying and tracking the targeted human using skeleton view. Compared to other existing tracking methods, the human skeleton tracking method has the capability to distinguish a person and other objects in an efficient manner. Furthermore, the *Kinect Xbox 360* sensor can detect person's position and distance as well. Human skeleton law is used here for the purpose of tracking the master. This method is more accurate because it detects only human beings in the field of view and keeps the reference point of a person longer than the method of the center of mass. For this research, the laptop is used to process the data from the *Kinect 360* and transfer to the *Arduino Mega 2560* through serial communication. *Kinect* sensor is the main part of the system which is used for identifying the human. All the data in the *Kinect* sensor processes by the software in the personal computer located on the robot. Moreover, *Arduino* instructs to control the speed and direction of the mobile robot via the motor controller. In existing systems, depth images of the human had been taken to follow the human. But in this system one reference point of the human skeleton is taken to do that. This method saves the processing power and the time in image processing, reduce the errors. Hence the accuracy of this system is high. The results for the whole hardware and software the mobile robot able to follow human according to the coordinate positions of the person detect by *Kinect* sensor. The interaction of human and robot assist human in various situations such as carry load that were required by people working in airports, hospitals, and other moving activities. Human following robot can bring many benefits to mankind. Through this implementation robust method has been developed to address to robots and make them follow the master on move.

*Keywords:* Kinect sensor, Arduino board, Stereo camera, RFID System, Laser range finder

### **Ammonia Detection Method Using RGB Sensor**

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Ammonia is one of the important component in chemical fertilizers and industrial air conditioning coolants. Thus, general detectors of ammonia form the basis of devices used to check for pollution in the vicinity of urban settlements. Such as in lakes, rivers, buildings, etc. Prevailing detectors include ion-selective electrodes, infrared gas analyzers, detectors all are based on semiconductor films, or else sensors that depend on ammonias reaction with an acidity-sensitive dye. The purpose of ammonia detectors is simply to sense and communicate the presence of ammonia for human or property protection. A variety of sensors are developing with emerging technologies and methods are changing day by day. However, existing methods are expensive and require specialized instruments to detect ammonia content such as ammonia selective electrode. In this research ammonia concentration is detected using a color sensor TCS 3200 which records red, green, blue (RGB) values of the brown color complex formed when ammonia is reacted with the Nessler's reagent. First a series of concentration of aqueous ammonia (0.00001 M, 0.00002 M, 0.00005 M, 0.0001 M, 0.0002 M, 0.0005 M, 0.001M, 1.0 M) was prepared. Then 15.0 ml of ammonia solution is reacted with 1.0 ml of Nessler reagent. The absorbance of the colored complex formed was measured using UV-Visible spectrophotometer. These data were used to calibrate the ammonia detector developed in this project. Next, six drops of the ammonia-Nessler reagent complex formed according to above procedure was added on to filter paper. The RGB values of the filter paper color was then recorded using the color detector. Then calibration curves were constructed as R or G or B values against concentration. Finally, several unknown concentrations of ammonia solutions were prepared and concentrations were measured using the RGB vs. concentration calibration plot. The accuracy of the results were validated using the absorbance vs. concentration plot developed using UV-Visible spectroscopy data. Comparing the results of the graphs system was checked for the errors. Error was 0.05941 according to the results and this method was used to build the instrument for ammonia detection and predict ammonia concentration.

*Keywords:* Ammonia, RGB sensor, UV spectroscopy, Color sensor ,Ammonia detection

## **Vision Based Autonomous Micro Areal Vehicle With Graphic Processing Unit Acceleration**

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The research was conducted based on autonomous vision navigation, mapping, and localization. The final outcome was a Micro Areal Vehicle which maps and localizes in unknown environments and navigates with fine accuracy and efficiency. All algorithms necessary for autonomous mapping and navigation executes real-time in the processing board of the Micro Areal Vehicle, with a front-looking stereo camera as the main exteroceptive sensor. The Micro Areal Vehicle was embedded with an Xbox Kinect as the stereo camera, and it was also capable of processing visual data real-time with the Jetson TK1 onboard development kit. Stereo camera inputs were inserted into a particle filter algorithm in order to generate the map. The research was conducted using a particle filter in which each particle carries an individual map of the environment. Gmapping was used as a highly efficient particle filter to learn grid maps from laser range data captured from the Kinect. The visual data input given by the Kinect was processed through the Jetson TK1 which was equipped with a RISC Machines Cortex Central Processing Unit and a NVIDIA Kepler Graphic Processing Unit. The Graphic Processing Unit cores were used to accelerate Simultaneous Localization and Mapping algorithms. The map generated by Gmapping using the Kinect visual data was the source to control the effective navigation of the Micro Areal Vehicle. Controlling the Micro Areal Vehicle was done using an Arduino compatible open source flight controller system. The map was used to navigate the system while processing sensor data from the 3-axis gyro, accelerometer, magnetometer and barometer to localize the Micro Areal Vehicle. Robotics Operating System has been used as the middleware package to communicate between the processes executing in the Jetson board, Kinect, and the flight controller for smooth navigation and localization. It was also used to implement the nodes to combine hardware and software used in the project.

*Keywords:* Vision-based MAV, GPU-based MAV, GPU Micro Areal Vehicle

## **Hexacopter With Altitude Hold Mode, Ground Inclination Detection, Global Positioning System Navigation and Custom Built Software Support**

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A hexacopter with altitude hold mode, ground inclination detection, Global Positioning System navigation, and custom built software support was built. The aim is to enhance user friendliness and ease of controlling by providing the data of the hexacopter such as altitude, Global Positioning System location, speed, horizon level, angle of inclination of hexacopter and acceleration along each direction to the user and facilitating the user with automated safe landing and safe take-off features. Global Positioning System module was used to get the details of the location of the hexacopter, stability was obtained through gyroscope, optical sensor was used to locate the ground and handle the ground position, altitude was found using the barometric pressure sensor, airflow sensor was used to measure the speed of the vehicle while laser module with the help of the optical sensor was used to measure the inclination of the land for landing purposes. The sensors were integrated with Arduino Mega 2560 development board which was programmed using proportional – integral -derivative controller algorithm for error free flying of the hexacopter. Custom made software developed in Microsoft Visual Studio using C# programming language was used to receive all the data and monitor the hexacopter. The data transmission was performed by two 915MHz Radio Frequency transceivers. Obtained outputs show the expected working of sensors resulted in improved user friendliness and ease of control. The results show an accuracy of 99% in the travelling path obtained by Global Positioning System sensor, 95-98% in both air flow sensor and optical sensor outputs. Accuracy of the ground inclination detection for safe landing purposes is approximately 70%. Maximum tested altitude without losing the Radio Frequency signal from the controlling station was (950-1000) meters and the maximum tested distance travelled with Global Positioning System is around 2km with full usage of the battery capacity. Maximum tested hover time with full discharge of the battery is 15 minutes. The range of the wireless communication can be increased with more powerful Radio Frequency transceivers and with a more efficient battery the flying time can be increased. With the obtained results, the hexacopter with altitude hold mode, ground inclination detection, Global Positioning System navigation, and custom built software support can be used with higher user friendliness and ease of controlling experience.

*Keywords:* Hexacopter, Altitude, Navigation, Gyroscope, Programming

## **Voice Recognition Electric Wheelchair**

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Wheel chairs are the evaded partner for most of disabled people lives to support their day to day activities. Manual and powered wheelchairs fail to meet the needs of the quadruple amputees. The objective of this study is to produce wheelchair to meet the needs of quadruple amputees by adjustable seat and control the wheelchair movement by means of voice commands. Aluminium frames were used to make the body of the wheelchair and modified wheel and caster wheels were used as wheels. Jack was connected with the motor to make the seats adjustable to various heights. Wheelchair was designed to work with two modes, which were human voice control and switch control. In voice control mode, commands were given through microphone which was connected to the voice recognition module. Access port 137 software was used to access the voice recognition module via computer. This software recognizes and records the voice. Voice recognition module was initially trained to identify our voice commands. It was attached with USB TTL to connect with the computer. Given voice command was identified by voice recognition module, converted as serial signal and was input to Arduino programming board (Uno) which was programmed to control the wheelchair. Five essential actions which were "forward", "backward", "left side turning", "right side turning" and "stop" were implemented in this project. Based on the serial signal input generated by Voice recognition module, commands were identified in Arduino and required signals were sent to motor control circuit to control the viper motor in order to get the desired motion for the command. In Switch mode command signals from switch were directly connected to Arduino and were identified. 94% of the voice commands were successfully identified and desired actions resulted.

*Keywords:* Voice recognition, Wheelchair, Arduino, Quadruple amputees



## **Autonomous Transport Vehicle For Factory With Auto Charging Dock Using PID**

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Autonomous transport vehicle for factory with auto charging dock-using PID, falls under the autonomous guided vehicle (AGV) category. The intention of this study is to develop the electronic circuit system to measure the battery charge value, computer program and intelligent steering drive method using Proportional, Integral and Derivative (PID) functions. PID control of transport vehicle is a method consisting of Proportional, Integral and Derivative functions to improve the movement of the robot. Nowadays there are many types of autonomous vehicles. Most of them use wired communication methods which have to change their battery manually. This project deals with development of a transport vehicle based on magnetic line follows. The vehicle battery is charged automatically in specific charging dock (charging area) and special sensors were used to identify the line which support the bot to stay on the track. Brushless DC gear motors were used to drive the robot to control the movement of the wheels. The Roboteq FBL2360 was used to perform and implement PID algorithm to control the speed of the motors steering the robot to travel along the line smoothly. The main objective of this present project is to implement the PID algorithm and to achieve better performance by controlling the movements of the robot properly. 5mm MS metal increased the weight and strength of AGV chassis than the existing vehicle chassis. The special SICK Obstacle sensor gave customize obstacle area than the normal ultrasonic and laser type sensors. High current of the battery caused a trouble with charging dock and it can be avoided by developing new concept for the charging dock.

*Keywords:* Autonomous, PID, DC, Motor

### **Smart Light Controlling System for Lecture Halls**

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A considerable amount of energy is consumed in universities as it is structured with electrical equipment and lighting systems. Controlling the lights manually will not be an efficient way, as it increases the energy wastage. Therefore, this research proposes a smart light controlling system which can automate the light controlling based on the factors such as luminance and occupancy. This system is able to provide the right intensity of light in the right place at the right time. It has the capability to count the number of people in the lecture hall and to control the number of lights to be turned on and turned off based on the presence level. The system turns off the light when the light is not needed. Therefore, the system plays a major role in power and time saving. A Raspberry Pi and sensors are used to develop this system. The system is integrated with the Ubidots IoT platform to transfer the data. To detect the presence of humans, Passive Infra-Red sensor (PIR) is used at the entrance. If any human movement is detected, then the Light Dependent Resistance (LDR) module will be automatically turned on and check the luminance level. If the luminance is not enough, then the main light will be switched on and if the luminance level is enough lights will not be turned on. The hall is divided into four blocks and the lights in the each row are controlled by the Infra-Red sensors (IR) based on the human presence in each row. The web camera is automatically turned on when the first light is switched on with the signal of LDR to count the number of heads using haar-cascade feature detection. Lights are switched off when the head count becomes zero. A delay is given to check the conditions constantly. Luminance level in the environment, human presence, and human presence level are the factors considered. This system is the solution to monitor all these factors and control the lighting system. The system reduced a vast amount of energy wastage and saved the time.

*Keywords:* Smart light, Smart lecture hall, Smart light system

### **Automated Letter Registering System**

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According to the mission of postal department of Sri Lanka, they should create and develop new services and improve the existing services using modern technology. To achieve this goal, automated letter registering system can be used to give a continuous service to the customers. A lot of registered letters and parcels are exchange daily via registered post. In holidays and late hours letter registering is impossible. Also, a long queue can be observed in the post offices during working hours for letter registering. If there is a self-service machine at the post office like automated teller machine (ATM), it is easy for the customers as well as the service providers. Automated letter registering system will increase both amount of letters registering per day and also the quality of the service. To achieve this, we had designed and fabricated an automated letter registering system which is suitable for Sri Lanka. The main points of the process are identifying the letter, weighing, sealing, sorting and printing the bill. Arduino board was used as the main processor and a pic microcontroller was used to handle sensor signals. A load-cell measures the weight and convey the letter to a belt conveyer. On the conveyer, letters are sorted according to the weight and the receiving city. For the prototype system, we used two cities and two weight categories for testing. This can be extended according to the requirement. The bill could be displayed via a TFT LCD and can also be printed. The final achievement of this research project was to provide a quality service to the customers at the post office for letter and parcel registering. We believe this concept can be further extended for many situations in the manufacturing and service sector industries where automated sorting is required.

*Keywords:* Load cell, Automation, Microcontrollers

## **Automatic Accident Detection System Using CCTV Camera**

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This paper deals with development of an automatic accident detection system using Closed Circuit Television (CCTV) camera videos. These systems were designed to identify and indicate safety levels of the roads and vehicles. Most of systems are using highly accuracy sensors, equipment with higher cost to determine the above requirements. It requires higher cost and higher technology. This paper describes a cost-effective accident detection system based on the speed of the vehicle. Videos taken from the CCTV camera were analyzed using algorithm based on image processing and video processing methods by using OpenCV software. Two yellow color patches were set on the road with specific distance. Specified color filters and area filters were used to detect patches. Speed of the vehicle was measured by calculating time for a vehicle to reach from first color patch to the second color patch. By analyzing each and every frame on the video files, speed calculation was done according to the algorithm and average speed was taken to the final result. Threshold value for speed was defined by the system and calculated average speed was compared with threshold value. Threshold value of the speed is depending the place of the road where CCTV camera was mounted like high sensitive junctions, bends. By analyzing above results system was able to give a statement about the safety level of the vehicle depend on the speed of the vehicle.

*Keywords:* CCTV camera, Speed, Image Processing, Color

## **Automated Forklift Scheduling System**

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In manufacturing organizations, forklifts can be seen and they are being used to carry various things that cannot be handled by humans. In Sri Lanka, most organizations are being used conventional methods which consume more time and reduce efficiency. This project is useful to have a smooth flow of the production. This system can save time as well as can increase the productivity, and it is cost effective. This research is mainly based on Arduino. GSM technology is used as the communication method. GSM Sim 900a module was used in this project. GSM is a better communication method than the other communication methods because the noises or the disturbances that can occur during the communication is lower than the other types of communication methods. Arduino is used for all processing parts, and GSM module is used for data transmission. Two types of communication units were designed, one for forklifts and the other unit for machines or the area of the work floor that produce the jobs for forklifts. When a product finished in the production machine, it will automatically send an SMS, or when a job is available in the working area, a laborer can send an SMS to all the units in forklifts and indicate about the job to the forklift drivers. Then drivers can either accept the job, or they can reject the job by pushing the relevant push button. Multiple drivers can provide responses to the same job alert. The first person who responds to accept the job alert will receive the job and others who responded to get the job, will be informed about it. All the indications of the system are done using LEDs, in order to understand easily and gain the attention of the forklift drivers. The system is easy to use for any person as it is consisting of push buttons and LED indicators. Units are easy to handle and need less space to install. This project can use to increase the efficiency of the forklifts and increase the efficiency of production. Both drivers and machine operators are aware of the jobs available and which forklift received the job. That helps to minimize the confusion among the forklift drivers about the jobs available in the work floor and there is no need for machine operators to waste the time to find a forklift for unloading.

*Keywords:* GSM Technology, Arduino, Automated SMS, Forklift scheduling, GSM Sim 900a

## **An Automated Tennis Ball Throwing Machine**

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This study seeks to innovate an automated tennis ball throwing machine which is used to provide varieties of pitching styles. Tennis ball throwing machines are used to practice batting in the game of cricket. These machines facilitate batsmen in the absence of a baller, but still a batsman is not able to receive variety of pitching styles from conventional machines. An automated tennis ball throwing machine could provide variety of pitching types. The automated tennis ball throwing machine was constructed by designing the mechanical, electrical and software base. Mechanical design was constructed by fixing the externally purchased parts with the reference of the manual and the electronic design was completed with the power supply and the electronic circuit. Finally the software development was done to develop the project using Arduino language. The coding was setup to sense the command given in American pronunciation and it was transferred to Arduino to get the output. The wheel can be turned by the axle with respect to the horizontal and vertical planes. As a result of the study an automated tennis ball throwing machine was made up with low cost and the special feature of random balling which is beneficial for children. The machine comes with 5 balls and is capable of holding up to 9. It has a flat base and 3 angles from which the balls can be pitched that lead children to learn how to hit airborne balls and his pitcher is an easy and simple way for kids to improve on their hand eye coordination and skills and it does not require man power for operation. Further studies should be done in mat lap simulation voice control using android application.

*Keywords:* Automated tennis ball throwing machine, pitching style varieties

## **Automated Plates Washer**

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Washing plates normally done by hand and it uses water, energy, chemicals as well as need to spend valuable time. So an efficient approach can save a lot of time as well as chemicals. Though the dish washing machine gives some relief for that, the existing dishwashing machines in the world market consist many defects in the process such as wastage of water, requirement of man power, high installation cost, poor quality of cleaning etc. Specially, there is no proper turning off system after the washing has been completed. Hence it takes more than one hour to complete one cycle of washing and waste large amount of water. This project is about developing an automated plates washer, which was having following main objectives, that should be in minimal cost, user friendly and easy to use. It must give optimum cleaning using least amount of water and energy. Important objective is turning off the system when the plates are cleaned, without wasting time and water. The system controlled by arduino and has to supply high pressure water to the machine in order to start the washing process. Initially need to spray soapy liquid to the plates. A D.C motor had been used to drive the system. Outlet removes all the waste water and there is a PH sensor to detect the quality of the waste water. It can give signal when the PH=7. That is, the water does not contain any contaminant. It means the plates are cleaned and the machine will be turned off automatically. Though for normal washing takes about 8 minutes to wash 10 plates, the proposed machine takes only 90 seconds (400 plates per hour). It can develop using minimal cost of lower than Rs.20,000, without spending Rs.50,000 - Rs.150,000 to buy a plate washing machine from the market. The system is very user friendly. It can be used in large scale kitchens such as in marriage ceremonies, receptions, business parties, hospitals and hotels where there is a requirement of more number of plates. Not only that this plates washer is useful for household usage as same as the washing machine, which can save time and cost rather than spending in washing plates by hand and wasting large amount of energy. The machine can further developed as fully automated system, by inserting plates in to the machine, and releasing dried plates and storing them properly.

*Keywords:* Automated, Arduino, PH sensor





# **Entrepreneurial Agriculture**



### **Willingness of Stakeholders to Adopt US Dollars in Colombo Tea Auction**

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Ceylon tea plays a major role in Sri Lankan Economy. Colombo Auction is the major marketing channel of tea. All the auction transactions are currently done by Sri Lankan Rupees which is continuously depreciating with related to the US Dollars. Therefore, the objective of this study is to evaluate the major stakeholders' willingness to adopt US Dollars in place of Sri Lanka Rupee at Colombo auction. By considering the possibility to move into the US Dollars in place Sri Lanka Rupee, target benefits can be accomplished mainly by the producers who suffer from the less income and high cost of production. By dollarizing the auction, foreign exchange gain could be transferred to the manufacturers. As the sample, 146 producers, 40 Auctioneers and 69 buyers were selected using simple random sampling technique. Ordered logistic regression was used to find out the determinants of willingness to adopt US Dollars. According to the results, quantity of tea exportation, experience in tea trade, transaction mode of main foreign buyers, have significantly affected the willingness of buyers and brokers. Experience in tea trade, awareness about the exchange rate and engagement for private sales have significantly affected the willingness of manufacturers. 79% manufacturers, 62% brokers and 13% buyers are willing to adopt US Dollars at Colombo auction. Finally, this study concludes that the most of the producers and brokers are willing to adopt US Dollars, but the preponderance of the buyers is not willing to adopt US Dollars in place of Sri Lankan Rupees at Colombo auction.

*Keywords:* Auction, Willingness, Dollarizing, Tea, Foreign exchange

**Participation of Women Farmers in Agricultural Extension Service in  
Medadumbara Divisional Secretariat Division**

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Agriculture extension service plays a significant role in dissemination of technology among rural farmers. Therefore, participation of female farmers as well as male farmers for these activities and application of agricultural knowledge is vital in developing the agricultural sector. However, to our knowledge, studies on women participation in extension activities are lacking in Sri Lanka. Therefore, the present study is an attempt to find the determinants of women participation of extension activities. Taking a sample of one hundred and fifty female farmers, this study was conducted in Medadumbara Divisional Secretariat Division and Poisson regression model was applied to find the determinants. The results suggest that age, ethnicity, education level of family members, monthly income, monthly expenditure for agricultural activities, labor availability for agricultural activities, number of working hours, average scheduled extension programme duration and availability of subsidies for their agricultural activities are the major determinants of women farmer participation in agricultural extension activities. This study recommends that wealthy female farmers should be encouraged to participate in extension activities. Furthermore, they should be educated with more cost management strategies in allocating inputs in the production through extension activities.

*Keywords:* Agricultural extension activities, Female farmers participation, Poisson regression

**Migrants' Remittances and Expenditure Differences: A Study on Rural Households of Sri Lanka**

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By taking a nationally representative sample, this study examines the impact of remittances on the expenditure on rural households in Sri Lanka. The data were analyzed using descriptive statistical techniques and fractional logit model. The results suggest that there exists a significant difference in expenditures between households in receipt of internal and international remittances with respect to consumer and durable goods. The results of the fractional logit model reveal that households allocate less on education and more on ad hoc purchases, entertainment and transport with the receipt of internal remittances. Surprisingly, international migration does not have a significant effect on expenditure on rural households.

*Keywords:* Expenditure differences, Remittances, Rural Sector

**Intention of Non - Organic Tea Export Companies on Exportation of Ceylon Organic Tea**

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Although the organic tea is very popular among the consumers and it has a huge demand around the world, most of the tea export companies have not yet been involved in exporting Ceylon organic tea. Therefore, selecting 64 tea export companies in Sri Lanka, this study was conducted to explore the determinants of intention of non-organic tea export companies on exportation of Ceylon organic tea. Collected data through a questionnaire were analysed using descriptive statistics. The results suggest that most of the companies were willing to export Ceylon organic tea. Number of products, company experience and company category were significantly influenced to the intention on exportation of Ceylon organic tea. However most of the companies showed that a very few number of planters cultivate organic tea and therefore their availability is low in Sri Lanka. Thus, this study suggests the production of organic tea should be promoted in Sri Lanka by providing knowledge, funds and other supports. Therefore, it could be expected to increase the number of organic tea products that are exported to the foreign countries.

*Keywords:* Exportation, Intention, Non - Organic Tea Export Companies, Organic Tea

## **Development of a Mobile Application for Agricultural Extension Officers in Sri Lanka**

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The usage of Information and Communication Technology (ICT) in the service sector is unfathomable, as several key industries are interlinked and embedded into the system through ICT. Particularly, in the agricultural sector, the application of IT for extension services can be identified as a growing trend and this is successfully achieved through the usage of the mobile platform. In the present context, many tend to communicate with the mobile platform as it is uncomplicated, portable, and has the ability to handle multipurpose tasks. Furthermore, mobile app technology is cost effective in comparison to other devices utilized to access the internet. Thus, this research was carried out with the purpose of developing a mobile application for agriculture extension officers in Sri Lanka and creating a record keeping system for farmers subsequently developing a data base for agriculture instructors which can be updated on a regular basis. The design of the application was based on the development of five categories namely requirement gathering, designing, implementation, testing and review. Required data were obtained through Department of Agriculture, Sri Lanka. This programme was developed using the coding systems namely, HTML, CSS, Java Script, HTML, DOM, jQuery, PHP and SQL. “Lak-farmbook” mobile application serves several services such as developing a farmer database, developing a business plan, prediction of production and income of a selected crop, details about required cultural practices of crops and developing essential financial reports. Finally, the study was able to develop a mobile application that can be used to develop a farmer database and record keeping system and can be updated on regular basis and in the trail stage the application was found to be highly satisfying the agricultural instructors due to the user friendliness and knowledge gained through Lak-farmbook, the agro-tech driven service provider at any consumers fingertip.

*Keywords:* Agricultural extension, Extension officers, Mobile application

## **Popularity of Herbal based Face Washes Among Females in Colombo District of Sri Lanka**

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Herbal cosmetics sector is one of the key areas of promoting among females in Sri Lanka. Among them, the most popular item is herbal based face washes because they are free from chemicals and have relatively less side effects compared to synthetic face washes. Furthermore, Sri Lankan cosmetic companies tend to produce products using herbal plants and plant parts as main ingredients. Therefore, this research was conducted to determine the popularity among females for herbal based face washes by assessing the consumer preferences among females regarding face washes in Colombo district. To accomplish this objective a semi structured questionnaire was prepared and direct interviews were conducted with females who visited to the super markets in Colombo district. Popularity was measured using conjoint analysis. According to the results of the conjoint analysis, herbal face washes are more popular than synthetic ones. Among the attributes, product type was the most preferred attribute whereas the least preferred attribute is the volume of the product. Thus the study concludes that herbal face washes are more popular than synthetic face washes.

*Keywords:* Conjoint analysis, Herbal faces washes, Product attributes, Synthetic face washes



### **Determinants of Spice Exports from Sri Lanka: A Gravity Model Approach**

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Sri Lanka is very famous for production of valuable spices with unique and intrinsic quality characteristics, mainly due to existing favorable environmental conditions. Since the country's share for total spice exports is very low, it is important to identify plausible factors affecting to spice exports. Thus, the purpose of this study is to investigate the factors that determine spice exports from Sri Lanka. Cinnamon, Pepper, Ginger and Turmeric are the selected spices for the study as they are produced abundantly over the island with high quality. Gravity model analysis was done for the panel data set that covers the period from 2003 to 2015. The results of the study suggest that Sri Lankan GDP, Sri Lankan trade openness ratio and Real Effective Exchange Rates (REER) are the factors that affect the exportation of Ginger while Sri Lankan population and REER affect the Turmeric exports. GDP of importing country is the only factor that affects exportation of Cinnamon. The exportation of pepper is affected by distance, GDP of Sri Lanka, trade openness ratio of Sri Lanka, Sri Lankan REER, GDP of importing country, trade openness ratio of importing country and population of importing country. Based on the results, it can be concluded that, size of the economy of both countries, population that proxies demand of the importing country, distance that proxies transportation cost and Sri Lankan REER are the major factors that affect significantly the exportation of selected spices from Sri Lanka.

*Keywords:* Gravity model, Panel data, International trade, Sri Lankan exports

**Impact of Chronic Kidney Disease on Technical Efficiency of the Paddy Cultivation in Medawachchiya Division, Anuradhapura District**

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This study was conducted to identify the impact of Chronic Kidney Disease (CKD) on technical efficiency of the paddy cultivation in Medawachchiya Divisional Secretariat Division, Anuradhapura District. 150 farmers were randomly selected for the study. Among them, 87 farmers are non-CKD affected and 63 are CKD affected farmers. The technical efficiency was estimated using a stochastic frontier production function. Results suggest that mean technical efficiency of CKD affected paddy farmers is 59.6 %. Mean technical efficiency is 63.3 % for non-CKD affected farmers. According to the model estimates, land extent and amount of seed paddy increase the paddy yield while age, gender, farming experience, education, and number of family members increase the efficiency of the farmers. More importantly, severity of CKD, awareness of the CKD and number of days incapacitation due to the CKD increase the inefficiency of the farmers. Thus, results confirm that CKD has a negative impact on technical efficiency of the paddy cultivation.

*Keywords:* Chronic kidney disease, Cobb-Douglas production function, Paddy cultivation, Stochastic frontier analysis, Technical efficiency

### **Determinants of Value Added Ceylon Tea Exportation to Russian Market**

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Value addition in agriculture implies the changes made to primary agricultural products that increase the product's value. At present, about 40% of the total quantity of tea exports from Sri Lanka is in value added form. Russia is the number one market of Ceylon value added tea for several years. However, Ceylon value added tea market in Russia has been fluctuating for many years by causing instability in its position as one of the major markets. Therefore, the attempt of this study was to explore the determinants of value added Ceylon tea exportation to Russia. The sample of this study was the total number of tea companies which export value added to Russia. Data was gathered by using a structured questionnaire and interviewing with exporters. The data was analysed using a multiple linear regression model to achieve the objective of the study. According to the results, skilled labourers, market experience, new market approaches, ratio between Free On Board (FOB) prices of Value Added Tea and FOB of Bulk Tea, influence of bilateral agreement and influence of tariff and non-tariff barriers significantly affect the value added Ceylon tea exportation to Russia. Finally, this study suggests that the exporters should increase the value added Ceylon tea export volume to Russia by having more skilled labourers and by adopting new market approaches.

*Keywords:* Exportation, Russian tea market, Value added Ceylon tea

**Determinants Of Stock Market Development: With Special Reference To Colombo Stock Exchange)**

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The stock market plays a prominent role in shaping a country's economic and political development. The collapse of the stock market always tends to trigger a financial crisis and push the economy into recession. Well-developed stock markets should efficiently allocate capital to increase the economic growth, wealth and confidence of the investors. Although most of the growing economies are endowed with growing stock markets, Colombo Stock Exchange (CSE) remained underdeveloped during the pre-war and post war periods. However, the constraints for stock market development remain unclear. Thus, this study examined the determinants stock market development in Sri Lanka using a multiple regression analysis over the monthly data between 2005 and 2015. Data were gathered through monthly bulletins of CSE and central bank reports. According to the literature; remittances, private capital flow, financial intermediary development, political stability, stock market liquidity, institutional quality, and trade openness were identified as determinants of stock market development. Further, stock market capitalization was used as the proxy of stock market development. The results suggest that institutional quality, political stability, private capital flow and stock market liquidity significantly influence the stock market development. More precisely, those dimensions have curtailed the stock market development in Sri Lanka. Further, trade openness, political stability and private capital flow were identified as the most influencing factors to the stock market development in Sri Lanka. Accordingly, to develop CSE, policy makers can implement policies to stabilize political environment and to improve institutional quality. Further, it is necessary to provide facilities to undertake easier transactions and trade shares in the CSE as well as policies could be implemented to control private capital flow and to attract more foreign and local investors to CSE.

*Keywords:* Market capitalization, Sri Lanka, Stock market

**Future Potentials on Diversification of Rubber Processing by Smallholders in Non-Traditional Rubber Cultivating Areas**

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This is an attempt to identify the future potentials on diversification of rubber processing by smallholders in nontraditional rubber cultivating areas with special reference to Monaragala district where Ribbed Smoked Sheet (RSS) is the only processed type of rubber. The data used in this study were gathered through a field survey in a sample of 150 smallholders from eight district secretariat divisions in Monaragala district and the data were analyzed by employing descriptive statistics and multiple linear regression model. The results from descriptive statistics show that a majority of the smallholders produces RSS or sell raw field latex hence there is a potential to diversify the processing sector. The awareness of smallholders regarding rubber processing is at a fair state while the implementation of the processing standards is at a lower level and as a result the produced grade of RSS is also low. Many people are attracted more towards high cost group processing centers than processing RSS at household level by adopting techniques such as use of carpets for milling and chimney for smoke drying. The majority of the smallholders are not interested in the ceiled price due to the fact that they have a long way to travel to get it. In order to determine the impact of identified future potentials to the profit of the smallholders, a multiple linear regression model was estimated. According to the results, out of the identified potentials type of rubber produced, price of rubber, monthly cost of production, produced grade, monthly output and place of processing have a significant contribution on monthly profit while rubber grown land extent, labour cost, government subsidies and distance to nearest collection center do not have any significant impact on monthly profit from rubber processing. Hence it can be concluded that there is a potentials which has a significant impact on the profit for diversification of rubber processing in small holding sector in the Monaragala district.

*Keywords:* Alternative techniques, Rubber processing, Rubber smallholders, RSS

**Labour Migration Decision Making Behavior in Tea Estates  
(Special Reference to Nuwaraeliya District)**

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This study is an attempt to evaluate labor migration decision making behaviour of estate workers in tea estates of Nuwaraeliya district. The primary data was collected from 151 labourers from seven tea estates in Nuwaraeliya Divisional Secretariat Division. The theory of planned behaviour was used to accomplish the objectives of the study. Structured questionnaire was used to collect primary data from respondents. The questionnaire was formulated based on hedonic scale and each question contained positive and negative values of behavior and it consisted of questions related to attitude, subjective norm and perceived behavioural controls which are predictors of two multiple linear regression models used in the analysis. Two regression models were used to determine the extent to which the identified variable affects migration decision making behaviour and behaviour intention on migration. This study found that middle aged (35-40) labourers have more tendency towards migration. In addition, more females have willingness to migrate than males in tea estates. This study also found that attitude, subjective norm and perceived behavioural control have positive relationship on the intention on migration. Furthermore, behaviour intention has shown positive effect on ultimate behaviour while perceived behavioural control has no significant effect with decision making behaviour on migration of laborers in tea estates. Finally, the study concludes that overall outcome evaluation of migration, social pressure and labourers confidence on making decisions affect behaviour intention on migration. Labour migration decision making behaviour is determined only by outcome evaluation of migration and social pressure towards migration. Labourers confidence and knowledge on migration have no significant effect on decision making behaviour towards migration.

*Keywords:* Labour migration, Tea estates, Theory of Planned Behaviour

**Determinants of Willingness to Export: A Study of SMEs in Badulla Region**

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Small and Medium Enterprises (SMEs) are regarded as one of the main driving forces of economic development of all economies. Although several studies were conducted to identify the determinants of the export performance in SMEs, no studies had been conducted to identify the determinants of willingness to export in SMEs. The objective of the study was to determine the factors affecting the willingness to export of SMEs in Badulla region. Simple random sampling method was used to select the sample from target population. Binary Logistic Regression Analysis was used in the study to achieve the objective. The results of the analysis reveal that education level and gender of the owners of SMEs, number of laborers and income from the government sector were identified as the determinants of the willingness to export of SMEs in Badulla region.

*Keywords:* Badulla region, Small and medium enterprises, Willingness to export

## **Fertilizer allowance and Technical Efficiency of Tea Smallholders**

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Fertilizer is one of major inputs in tea cultivation and it incurs a higher cost for tea smallholders. Therefore, previous governments in Sri Lanka provided tea smallholders with fertilizer subsidy. However, the present government decided to convert the fertilizer subsidy to a cash allowance, under the 2016 budget. This cash allowance is allotted to tea small holders at regular intervals for the purchase of fertilizer from the open market. The governments intention of granting this allowance is to improve the tea productivity in tea smallholdings thereby to improve the quality of life of tea small holders. Therefore, this study was carried out to evaluate the technical efficiency of tea smallholders who utilize the fertilizer allowance to apply fertilizer for their tea lands. Primary data from 200 tea small holders in six subdivisions in Nivithigala Secretarial Division were gathered to estimate the technical efficiency using stochastic production frontier model. According to the Cobb-Douglas specification, the coefficients for the amount of fertilizer, land extend and total labour have a positive significant effect on tea yield. The inefficiency model indicated that age of household head, dependency ratio and dummy variables for occupation have a significant effect on decreasing inefficiency. The coefficient of amount of allowance has negative value and shown to decrease the inefficiency. Intercropping in the tea land and experience have positive values and shown to increase the inefficiency. The average technical efficiency of the smallholders who receive allowance in Niwithigala area is 81% and this is almost 7% higher than that of those who do not receive allowance. Overall findings suggest that the efficiency of green leaf production can be improved by providing fertilizer allowance to tea smallholders.

*Keywords:* Cobb-Douglas production function, Fertilizer allowance, Maximum likelihood estimate, Stochastic frontier, Technical efficiency



## **Investigation of Coffee Market Landscape In Sri Lanka**

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The global hot drinks industry is enjoying strong growth, as the expansion of specialist coffee shops and tea specialists familiarize consumers with premium coffee and tea offerings. The study aimed to analyze the market landscape of Sri Lankan coffee market, identifying the market elements and its evolution from the British colonial period. Rapid market chain analysis was adopted to investigate the coffee value chain. Market trend analysis was heavily based on secondary data and data providers were statistical abstracts of Department of Census and Statistics, national accounts data of Central Bank of Sri Lanka, Department of Agriculture, Department of Export Crops, and Export Development Board. Further, limited amount of primary data were gathered through the informal interviews with key industry stakeholders and customers. Nuwaraeliya, Badulla and Welimada were identified as the main coffee growing areas where there are dedicated teams of farmers striving to produce the finest coffees for the true flavour hunters. Product, price, place and promotion were the key marketing mix elements used to develop the coffee market landscape. Study identified a gradual increase in coffee production from 1981, and it had reached the highest position in 1996. The time period of 2011-2014 showed healthy production growth while the production extent was gradually increasing from 1980 to reach its highest extent at 1995. Though the performance of exports rebounded since 1972, due to the high recession at 1998 it never recovered the initial export values. Auction prices and farm gate prices seem to increase in line with international market. Local vs. global demand for Sri Lankan coffee showed a positive trend. As we revealed that coffee products have increased, exports were stagnant and local consumption has increased. Coffee farmers are needed to encourage for expanding their cultivations and establishing new cultivation. Coffee farmer reinforced programme is essential with value chain development. Hence the identification of global market niches and local profitable segments will help to boost the industry earnings.

*Keywords:* Coffee, Market landscape, Trends

**Black Pepper (*Piper nigrum L*) Market Landscape: A Case Study of Sri Lanka**

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Pepper is one of the most important spice grown in Sri Lanka & the study aims to investigate the pepper market & market landscape development in Sri Lanka. It will cater the demands of identifying the current nature of the pepper market for future decision making. Our approach dedicated to recognize the pepper market elements, design the market landscape & identify the market potentials. Market analysis was based on secondary data of Department of Export Agriculture, Research Stations, Department of Census & Statistics for production, cultivated extent, export quantity, prices & product type. Qualitative data from the industry stakeholders through key informant interviews were used to complete the market landscape. Market landscape was developed mainly concerning the product, price, place & promotion variables. Further, time series analysis provided the evolution of black pepper market in Sri Lanka. Study showed that pepper product varies from row black pepper to ready to use black & white pepper with different value added forms, brands, private labels, standards & certifications. Promotion efforts & strategies were varied according to market segment, brands, & market. Pricing methods & strategies varied with product types, brands, value addition, season, certification, labeling etc. Growth of ready to eat food industry & demand for functional food places huge demand on black pepper. The analysis of export quantity of pepper shows the increase in black pepper export over the time. Current global trends on functional food, anti-oxidants & growth of health concerned markets leads to develop more value added forms. Markets and distribution channels were varied from farmers markets to e-market.

*Keywords:* Market landscape, Pepper, Sri Lanka

### **Level of Adoption of Digital Marketing Methods in Domestic Tea industry**

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Digital marketing is the promotion of products or brands via one or more forms of electronic media such as internet and mobile phones. According to the world marketing statistics, most of the food and beverage companies are shifting from traditional market methods to digital marketing. As a leading tea producer in the world, Sri Lanka is also still using high cost advertisement methods instead of cost effective digital marketing methods. Therefore, this study was conducted with the primary objective of identifying the level of adoption of selected digital marketing methods by domestic tea brands (locally produce tea brands). Forty registered domestic tea brands were selected as the sample based on Tea Board statistics. Data were collected from the particular brand managers using a semi structured questionnaire. Multiple linear regression analysis was applied to identify the level of adoption of selected digital marketing methods. The regression results revealed that, number of years since establishment of the brand, Number of other marketing methods used currently by the brand, number of quality certificates obtained by the company, number of different products of the brand and percentage of advertising expenditure from total income of the company significantly affect the level of adoption. According to the descriptive analysis, most of tea brands use news-paper advertisements and posters as their main marketing methods. Further, it was revealed that social media is most widely used digital marketing method. According to the study, the level of adaption of digital marketing by domestic tea brands is still poor in Sri Lankan context. The study suggests that domestic tea brands could gain more benefits in terms of cost, by incorporating digital marketing methods with the traditional marketing methods.

*Keywords:* Digital marketing, Domestic tea brands, Adoption level

### **Brokers and Buyers Willingness to Sell Green Tea through Colombo Tea Auction**

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Public auction is the most popular marketing channel in tea industry. Black tea that is produced within the country is primarily marketed through the auction. Colombo tea auction is admired as the largest single origin and most professional tea auctions in the world. Although public auction is the most popular channel available for tea marketing, still green tea is sold through the private sales and direct sales. Buyers and brokers have different intention to trade green tea through the Colombo auction. Therefore, this study attempts to assess buyers and brokers willingness to sell green tea through the Colombo auction. Data were gathered using a structured questionnaire from randomly selected 40 Auctioneers and 69 buyers. Ordinal logistic regression was used to find out the relationship between the levels of willingness to sell green tea through Colombo auction. According to the result, bought tea quantity per month, green tea buying frequency, mostly practiced marketing channel, green tea importation, experience in tea auction and volume of the company are significant in buying sector. Experience in tea trade, number of green tea manufacturers deal with the company, green tea selling quantity per month are significant in brokering sector. It was also revealed that 62% brokers and 30% buyers are willing to sell green tea through the Colombo auction.

*Keywords:* Brokers, Buyers, Colombo tea auction, Green tea, Willingness

### **Effect of Performance Appraisal on Employee Motivation**

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Performance appraisal is a process of annual reviews, evaluate an employees skills, achievements and growth for assessing employee performance by way of comparing present performance with already established standards. Appraisals have power to motivate employees because appraisals demonstrate the need of improvement, help to meet psychological needs, build a sense of personal value and help to increase satisfaction. The ineffective practice of the performance appraisal can influence to the employee motivation within the organization. Therefore, the objective of this research was to study the effect of employee performance appraisal procedure on employee motivation. The study was conducted at one of herbal based cosmetic producing companies in Sri Lanka. A sample of 58 employees were selected through purposive sampling technique. A structured questionnaire was developed and administered on the individuals of the sample in order to measure the performance appraisal and motivation variables. Collected data through questionnaire were analysed using ordered logistic regression. The results of the study indicated that there is a positive and significant relationship between performance appraisal and motivation. The analysis of individual component of performance appraisal found that employee trust in appraiser, awareness about training program and provided feedback significantly predicted the motivation of employees. This study suggests that organization should develop a proper feedback system where the management frankly communicates the performance results to the employee and help identify the causes and solution for the negative deviation in performance. This will further strengthen the working relationship between the employee and employer.

*Keywords:* Performance appraisal, Motivation, Appraiser, Employee, Effectiveness

**Adoption Level of Livelihood Activities in Batticaloa District: Impact of an Agricultural Livelihood Project**

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Sustainable agricultural livelihood development projects play an important role in enhancing the livelihoods of the rural people. Such a project was implemented by the World Vision Lanka, a non-governmental organization in Manmunai South West Divisional Secretariat division of Batticaloa District during the period 2010 - 2015. Agricultural livelihood activities were channelled through four programmes; family development, goat village, cattle rearing and poultry development in all *Grama Niladhari* (GN) divisions. The present study was carried out with the objective to find out the adoption level of those livelihood activities by the project beneficiaries. Major five GN divisions based on the number of beneficiaries were selected for the study. Questionnaires were administered to a random sample of 100 project beneficiaries through personal interview in the selected five GN divisions. Collected data were analysed by SPSS. Descriptive statistics were used to interpret the results. The results of the study reveal that 82% of beneficiaries succeeded in their activities, especially in goat village programme and family development plan. As such, high level of adoption was observed in the goat village programme of the livelihood project. Furthermore, results on mean annual income received show that mean income earned by the goat village beneficiaries was high (Rs 80,166) compared to other activities of the project, whereas lowest mean income (Rs 37,800) received from chicken rearing. Overall impact of this livelihood project indicates a considerable progress in achieving its original objectives and enhancing the agricultural livelihood activities of the rural communities in the study area. Before the implementation of the project, high variation exists among the population in their annual household income. Moreover, the impact analysis of income generating activities show that their financial capital in terms of overall income received had increased; major increase observed from 6% to 35%, during the project implementation period. Overall, based on the tested livelihood indicators the study concludes that the general livelihood situation in the study area was on satisfactory level. The present situation in the area needs to be intensified further to sustain the livelihood of the rural communities. It is suggested that the relevant authorities; public or private, continue to assist the rural communities for their livelihood enhancement.

*Keywords:* Financial capital, Goat rearing, Income generating activities, Livelihood enhancement

**Determinants of Multiple Job Holdings Among Tea Small Holding Families in Nivithigala Secretarial Division**

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Tea small holders in Sri Lanka operates under many problems, such as labor shortage, high cost of production, uncertain weather and market conditions and low profit margins. Those conditions lead to create variation of income among tea smallholders. Therefore, they tend to diversity their income seeking and holding multiple jobs. However, in-depth analysis of what factors affect the decision to engage in multiple jobs is lacking in Sri Lanka. Therefore, this study attempts to find the determinants of multiple job holdings of tea small holders in Nivithigala Divisional Secretariat Division of Sri Lanka. Data for the study were gathered from 200 tea small holders using a structured questionnaire. The data were analyzed using bivariate probit model. The results suggest that the off-farm experience of household head, number of children, farm days, off far days, distance to major city, farm income, off farm income are the major determinants of multiple job holdings of household head. For spouse, number of children and off farm days are the only influencing factors.

*Keywords:* Bivariate probit, Determinants, Multiple job holdings, Nivithigala secretarial division, Tea smallholders





# **Entrepreneurship and Management**



**Entrepreneurial Orientation: A Skill Enhancement Strategy for Unemployed Youth Special Reference to Tamil Nadu, India**

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Intensify the level of entrepreneurial activity throughout the nations is vital for developing countries like India where the poverty and unemployment rate is mounting. The government of India introduced several schemes aimed at eradicating poverty by encouraging self-employment among youth. However the youth in India are scared to take up entrepreneurship as their career option due to increased sick units and failure in businesses. Hence principally, this study explores the level of Entrepreneurial Orientation (EO) among India's next generation of entrepreneurs in state of Tamil Nadu. For that the survey considers the final year postgraduate student population of different streams of study, in order to enhance the entrepreneurship related procedure among youth. The sample consisted of 818 postgraduate students from the colleges which represents 93% response rate from the total of 879 in the targeted fields of studies. In total, 50 per cent (410) were male, 50 per cent (408) female. A self-administered questionnaire was developed and used among youth in India. The answers are explored using statistical methods such as analysis of variance and structural equation modeling. They results of the survey demonstrate that the level of EO differs between academic programmes and between genders. The male students are significantly different and high on innovation and competitive aggressiveness dimensions of EO scale. On the other hand male and female students remain to be homogeneous on autonomy, risk-taking and pro-activeness dimensions of EO scale. Male student from the engineering and technology streams are significantly different and are high compared to female students from the engineering and technology, commerce and management and arts and science on autonomy, innovation dimensions of EO scale. The students from the commerce and management streams are significantly different and are high compared to engineering and technology and arts and science on risk-taking, competitive aggressiveness dimensions of EO scale. Further it was found that engineering and technology and commerce and management postgraduate students have satisfactory level of EO compare to arts and science postgraduate. However this level is not adequate to promote entrepreneurial activity. Societal value has a positive relationship and influence on autonomy, risk-taking, innovation, pro-activeness and competitive aggressiveness dimensions of EO scale. The study has managerial and policy implications, suggesting that nurturing the level of Entrepreneurial Orientation (EO) among youth provides an indicator of the requisite behavioural dispositions for a new venture entry which may help to reduce the issue of unemployment.

*Keywords:* Entrepreneurial orientation, Youth, unemployment, Societal value, Skill enhancement

## **Impact of Viral Marketing on Brand Preferences: Case on Fast-food Industry in Sri Lanka**

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The advancement of marketing tools created cost effective ways for marketers to promote their products and services. Accordingly, viral marketing can be identified as a popular direct marketing tool among marketers across the world. Further, there are relatively a few numbers of articles and journals published about the viral marketing and it has not yet been covered the impact of viral marketing on brand preferences. Moreover, fast food industry is one of the booming industries which is having high competitiveness all over the world. Hence, the intention of this paper is to fill the gap in the literature by examining the impact of viral marketing on brand preferences, ascertaining the relationship between viral marketing and brand preferences and identifying the most affecting factor to brand preferences in the fast food industry in Sri Lanka. In this study, viral marketing is conceptualized as multidimensional construct which depends on four dimensions such as informativeness, entertainment, irritation and source credibility. Primary data were gathered through distributing a self-administered questionnaire and 100 franchise fast food restaurants in Colombo district were selected by using multi stage sampling technique. Descriptive statistics, Correlation coefficient analysis and Regression analysis were used for the purpose of data analysis. The results suggest that all viral marketing dimensions except irritation influence the brand preferences in the fast food industry in Sri Lanka. Further, entertainment and informativeness were identified as the most influencing viral marketing dimensions to the brand preferences in the fast food industry. Accordingly, to develop fast food industry, marketers can use these findings to organize promotional campaigns in an efficient and effective.

*Keywords:* Brand Preferences, Fast Food Industry, Viral Marketing

## **A Study on Factors Influence on Consumers Leisure Shopping in Sri Lanka**

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Shopping is widely regarded as a major leisure time activity and entertainment aspect of the retail industry is increasingly being recognized as a key competitive tool. Therefore, retailers and shopping Centre developers are seeking ways to make shopping more of a leisure pursuit. While retailers are focusing more on entertainment, academic research is lagging in investigating the hedonic reasons people go shopping. This study is providing a clear background about how marketers adopt marketing strategies and designing appealing store environments to provide a better value to customers and helps academics to the diverse body of existing shopping experience literature. A sample of 400 shopping mall customers was empirically investigated with the aim of identifying the nature of leisure shopping behavior in shopping malls and to determine the factors influence consumers to go for leisure shopping in shopping malls. A structured questionnaire was used to collect data through mall intercept technique. The pilot study 49 shopping mall customers informed a high reliability level of the questionnaire. The Exploratory Factor Analysis identified that the consumers leisure shopping was influenced by the seven different hedonic factors. These are especially remarkable theoretical implications which should prompt one to reconsider categories of shopping motives as indicated by Tauber (1972). Based on the literature these factors are named as Learning about new trends, Diversion, social Interaction, Gratification, Emotional Bonding, Mental Stimulants and Pleasure in bargaining. The study revealed that consumers go for shopping not only to purchase the products or services but also for fun. Hedonic Shopping also tended to be very social in nature and was often enhanced by the presence of friends and the trend is most marked among younger adults. Shopping is a major source of relaxation as well as a household chore mainly associated with females in Sri Lankan shopping mall concept.

*Keywords:* Leisure shopping, Shopping malls, Hedonic shopping, Exploratory Factor analysis, Structured questionnaire.

**Retail Store Ambient Attributes and Purchase Intention in Cross Different Customer Profiles**

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This paper focuses on observing the causal relationship between ambient attributes in retail environment and purchase intention, and identify the differences in this relationship between different subgroups. In order to accomplish the competitive advantages over their competitors, for both manufactures and service providers is important to have proper understanding about the consumers behaviour, and the way of they select products and service and so on. Retail setting in a store has significantly influenced to customers future store choices and other responses. Moreover, consumer preferences for products and services and the items they selected can be varied based on different demographic factors. The sample was selected conveniently, based on demographic variables such as age, gender, and educational level. Its consisted with 200 respondents from both areas are concerned. The survey was employed as the tool to collect primary data and used self-administered questionnaire which was built up focusing on demographic factors as first part and the questions related to the purchase intention and ambient attributes as the second part of the questionnaire. The findings revealed that, colours in a retail environment makes significantly influence on purchase intention of females and customers in age 21-23 and 27-29. The future research implications have discussed.

*Keywords:* Purchase Intention, Ambient cues, Age, Gender and Residence place

**Study on Entrepreneurial Intention among Undergraduates and Graduates Specialized in Entrepreneurship; A case of Sri Lanka**

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Entrepreneurial intentions are considered as more accurate predictors of entrepreneurial behavior. Given the paucity of empirical evidence and the contradictory findings on entrepreneurial intention, this study identifies the determinants of entrepreneurial intention among Sri Lankan undergraduates and graduates specialized in entrepreneurship. A sample of 160 undergraduates and graduates of the four main entrepreneurship degree offering universities were selected in terms of systematic sampling. Primary data were collected by using a structured questionnaire. A descriptive, correlation and hierarchical regression analysis were employed to analyze data. Besides, attitudes towards behavior, perceived social norms and perceived behavioral control were served as the independent variables while entrepreneurial intention was the dependent variable. Also, the test was controlled for gender, nationality and education level. The results indicated that a majority of the sample possess a moderate level of entrepreneurial intention. Attitudes towards behavior, social norms and perceived behavioral control were found to be statistically significant determinants of entrepreneurial intention. Besides, perceived behavioral control creates the highest influence on the level of entrepreneurial intention. Further, male undergraduates and graduates tend to have a higher level of entrepreneurial intention than that of female. Nationality and the education level had no effect on the investigated link. Therefore, the curriculum of these degree programs should be improved to cultivate a higher sense of attitude towards behavior and perceived behavioral control. This study informs the researchers on the dynamics of entrepreneurial venture creation process.

*Keywords:* Attitudes towards Behavior, Entrepreneurial Intention, Perceived Behavioral Control, Perceived Social Norms, Theory of Planned Behavior

## **The Relationship between Celebrity Endorsements and Consumer Purchase Intention**

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Modern marketing attempts to attract more customers as to build up the profits and growth within the industry for the firm as the competitiveness from rivals is more tactful. Using celebrities on promotional campaigns is one of the strategies within the promotional strategy of the firm as this study investigates the relationship between celebrity endorsers and consumers' purchase intention. The objective is to find the relationship between celebrity endorsement and consumer purchase intention. This study investigates the attributes of the Celebrity Endorsement and relationship of each attribute towards the Purchase Intention, in relation with the skincare and hair care market in Sri Lankan context. Three celebrity endorsement dimensions; Expertise, Trustworthiness, and Attractiveness and consumer purchase intention has measured, both primary and secondary data has been collected and sample of hundred consumers has been randomly chosen from Western Province. Findings revealed that weak positive relationship between celebrity endorsements and consumer purchase intention and celebrity expertise has been identified as the most influential factor. Study recommends that consumer evokes the advertisement due to the attractiveness of the celebrity and influence of consumer behavior can be changed due to type of celebrity and product category. Further when selecting a celebrity the relevancy to the product to influence on consumers purchase intention and their qualifications or expertise on concerned products could identified as Managerial Implications.

*Keywords:* Celebrity endorsement, Attractiveness, Expertise, trustworthiness, Consumer purchase intension



**Factors Affecting on Female Consumers Purchasing Behavior. Study on  
Ayurvedic Skin Care Brands Made in Sri Lanka**

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The affluent industry of cosmetics and beauty care, with its verdant growth, has ensured that a colossal amount of money is penetrated to the world economy. A rising demand for skin care products is quite visible, captivating the attention of female consumers. Female purchasing power has increased predominantly, as they seek to enliven their lifestyle in an avid manner. Hence, this study was conducted to identify the factors affecting on female consumers purchasing behavior of skin care products containing Ayurvedic ingredients. Herbs such as aloe vera, cucumber, calumba wood, neem, turmeric and rose petals are contained in local products portraying the value of Ayurveda. The objectives of the study are; identification of the main factors affecting on female consumers purchasing behavior, the effect of *normative influences* on *purchase intention* and the effect of *purchase intention* on *purchasing behavior*. A novel model based on the *Theory of Reasoned Action* model was included in the conceptual framework. Sample consisted of 150 respondents from Colombo district. Simple random sampling and multi –stage sampling methods were adopted. A survey was conducted distributing structured questionnaires within supermarket premises. Data were analyzed thereafter, using *uni variation analysis*, *bi variation analysis* and *multivariate analysis* ingrained with *mediation effect* through SPSS. Findings depict *normative influences* having a positive effect on female *purchase intention*. Same applies for *purchase intention* on *purchasing behavior*. Moreover, female consumers are greatly influenced by family and friends to purchase such items. Widely purchased brand is 4ever and the product is cream. As managerial implications; acknowledging the possibilities of developing skin care brands catering to family needs with innovative product features and green/herbal brand extensions could be introduced.

**Keywords:** Mediation effect, purchase intention, purchasing behavior, normative influences

## **Impact of Brand Image towards Customer Retention in Mobile Telecommunication Industry**

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The service providers increasingly offer a better service to attract and retain the customers with the intense development of mobile telecommunication industry in Sri Lanka. However, service providers are facing huge problem in increasing their market share nevertheless the amount of subscribers has been growing rapidly. Therefore, service providers are adopting different strategies to face the aggressive competition in the industry. Past studies have revealed that brand image is one of the tools adopted by firms to enjoy competitive advantage. Thus, the objective of this study is to identify how brand image of service providers would impact on retaining customer in mobile telecommunication industry. This study has empirically evaluated three brand image dimensions namely mystery, sensuality and intimacy. The convenience sampling method was adopted to collect data from 100 mobile phone users in Western province. Hence, the self-administrated questionnaire was used to collect primary data. Descriptive analysis, correlation and regression analysis were used to analyze data. The result of correlation analysis revealed that there is a strong positive relationship between brand image and customer retention. Further, the result of multiple regression analysis shown that intimacy dimension of brand image is highly predicting customer retention in the industry. Accordingly, this study suggested the service providers to offer latest technology and provide quick solution for subscribers issues in order to retain their customers. Hence, focusing on advertising which caters for different groups of customers will help businesses to increase the level of customer retention.

*Keywords:* Brand Image, Customer Retention, Mystery, Sensuality, Intimacy

**A Study on Determinants of Commercialization Intention of the Inventors: Study of Sri Lankan Invention Award Winners**

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Commercialization of inventions is significantly contributing to the growth and development of economy. Statistics of Sri Lanka Inventors Commission revealed that 96 invention award winners have been identified in Sri Lanka during the period of 1994-1999. But only 16 of them were able to commercialize their inventions and which depicts that there is a possible gap between the number of viable inventions and the number of innovations introduced to the market. Moreover, there are many determining factors influencing the commercialization intention of the inventors and absence of these factors can be the reason for many un-commercialized inventions. Thus, this study attempted to identify the determinants and its impact on the commercialization intention of inventors. Self-administered questionnaire was adopted to collect primary data from 50 award winning inventors in Sri Lanka from a population of 293 invention award winners 1994-2012; sample was derived by using simple random sampling method. Descriptive, Pearson correlation and multiple regression analysis were used to analyse the data. Accordingly, this study has identified three broad determinants of commercialization intention of inventors, namely environmental factors, personal factors and technological factors respectively. Besides, the investigation revealed that there is positive relationship between each determinant and the commercialization intention of inventors. The study concluded that personal and environmental factors have significant impact on commercialization intention while, the impact of technological factors is not significant, as most of the frequent inventions are at higher technological level and are technologically advanced. The findings of this study suggested, Provision of personal support, motivation of inventors towards commercialization, increase of infrastructure, favourable financial and governmental policies will stimulate the inventors to commercialize their inventions.

*Keywords:* Commercialization intention of inventors, Environmental factors, Personal factors, Technological factors

**Assessing the Impact of Popular Melodies & Jingles in Advertising Special Reference to Brand Image on Food & Beverages**

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Organizations use advertising as an effective way of promoting products and services in mass media. Present competitive market place let the organizations to concern more on advertising strategy to memorize the product often in consumers minds as desperate ways of advertising are used with the collaboration of numerous elements. Music is considered as a highly preferred element which is used in majority of advertisements and used mainly in getting the viewers attention. The objective of the study is to assess the impact of popular melodies & jingles in advertising strategy in Food and Beverage sector (F&B). Sample of 192 respondents was investigated with the main aim of identifying the impact of popular melodies and jingles in advertisements on brand image and to find the relationship of the two variables. An online and offline questionnaire survey has been conducted to collect primary data from consumers in Western province. Popular melodies and jingles in advertisements and brand image were considered as independent and dependent variables respectively. Data were analyzed by Regression and correlation coefficient analysis techniques. The findings indicated the positive relationship between the popular melodies and jingles in advertisements and brand image and out of the three brand image dimensions, perceive benefits were identified as the most influencing dimension which effects on popular melodies and jingles. Study revealed that, advertisers should concern on specifying the brand name and the product name in order to avoid confusions and misidentification of brands among consumers as the brand name of the product play a significant role. As managerial implications, the advertising strategy should align with the popular melodies and jingles with the target group of consumers for the effectiveness of the message of the advertisement to maintain customer loyalty.

*Keywords:* Advertising, Melodies and Jingles, Brand Image, Perceive Benefits, Marketing

**The Study on Identifying the Green Gap and Factors Creating Green Gap: With special reference to Fast Moving Consumer Goods (FMCG) in Colombo District**

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Implementing green practices by consumers and companies are questionable and Literature suggests high level of environmental concern does not reflect the preoccupation of purchase behavior. Since the gap between green purchase intention and actual green purchase behavior (Green gap) has not yet been identified in Sri Lankan context, this research was conducted to explore whether there is an attitude behavior gap and if there is a gap, what factors have caused the green gap and the strategies to be applied to minimize the Green gap with reference to FMCG. This research was conducted in two parts. The first part was to identify the green gap by using the Theory of Planned Behavior. Data was collected using a questionnaire from randomly selected hundred consumers and analyzed using correlation technique. It revealed, there is a Green gap in Sri Lankan context. As the researcher identified a green gap, second part was conducted by selecting sixty consumers who had green purchase intention but did not demonstrate actual green purchase behavior and provided with a questionnaire to identify what factors have caused the green gap in Sri Lankan context. Factor analysis was used to analyze the data and results revealed that high price, low quality, economic rationality, narrow product range, difficulty in understanding green labels, lack of proper mass media and lack of in - store communication are the reasons for green gap. To reduce the green gap FMCG companies should reduce prices and improve quality of green products, and green labels should be printed in larger sizes so that consumers can easily identify labels. Consumers should be made aware about green products through mass media and proper in store communication about the availability of green products should be done. Further, green products should not be made available among conventional products, instead they should be made available in special stores or shelves in supermarkets and product range should be broadened.

*Keywords:* Green purchase intention, Green purchase behavior, Green gap, Fast Moving Consumer goods, Sri Lanka

## **Impact of Promotional Mix Elements on Buying Behaviour of Baby Care Products**

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The baby care is an industry where the market demand is everlasting as there is a tremendous growth and potentials in the global and local market due to novel technological aspects and innovations. Modern marketing strategies affirmed beyond producing good products, suitable pricing and easy access but an integrated marketing. Technological development, changes are proceeding rapidly in the industry as result customers are experiencing new features as well as new products continuously. The objective of this study is to identify the relationship between the promotional mix elements and customer buying behaviour of baby care products. Findings have been made through a questionnaire survey analysis which consisted of 200 baby care products customers in western province. Promotional mix elements; advertising, sales promotion, public relations, direct marketing and personal Selling were considered as the independent variable and customer buying behaviour was considered as the dependent variable. The data were analyzed via SPSS Statistical package using correlation coefficient analysis and Multiple Linear Regression analysis. Findings revealed the significant positive relationship between the promotional mix elements on customer buying behaviour and Advertising was originated to be the most critical factor on buying behaviour. As managerial implications its recommended to invest more on promotional mix elements of advertising and sales promotion rather than other promotional mix elements. Further the advertising strategy should align with the product theme, strong brand name and perceived quality of the buyer to become successful marketer in the industry is highlighted.

*Keywords:* Buyer behaviour, Promotional Mix, Baby Care product, Marketing, Advertising strategy

**Impact of Below the Line Advertising on Real Estate Industry Firm Performance in Sri Lanka(With Special Reference to Gampaha District)**

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Advertising is one of the most significant function practiced by individuals or firms in obtaining what they requisite through creating and offering products and services with others. Below-the-line marketing activities generally refer to flyer advertising, banners, word of mouth and point of sales. Those marketing practices which practice such methods for promotion of products and services that do not comprise of mass media. Real estate exceedingly emphasizes on below the line advertising, for instance, banners, newspapers rather than the online advertising and mass media which gives a sturdy promotion. Therefore, this study focus to examine why the real estate industry exceedingly concentrates on below the line advertising than other promotion methods. The objective is to identify the impact of BTL advertising on real estate industry firm performance. The model was constructed with BTL advertising as an independent variable with 5 dimensions and firm performance as dependent variable with 2 dimensions. The dimensions of BTL advertising were flyers advertising, billboards, word of mouth, banners and point of sales as well as the sales growth and profitability were the dimension of firm performance. Primary data have been collected and static sample consists of 45 real estate companies as respondents in Gampaha district and adopted correlation coefficient and Simple Linear Regression for analyze the data. According to the findings of the study, there is a strong positive association among the BTL advertising and firm performance. Moreover, the results of study further elaborate that flyers advertising, word of mouth advertising has significantly influenced on the firm performance than other BTL tools. Furthermore, these findings are assisted to the academics, policy makers and to Real estate company owners with respect to the decision making.

*Keywords:* BTL advertising, Real estate industry, firm performance, sales growth, profitability

## **Impact of Private Label Branding towards Consumer Buying Behaviour**

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Private label branding is a growing concept in Sri Lankan supermarket sector. Many terms are used to introduce forms of private labels, such as private brands, store brands, own brands, retailer brands, wholesale brands and distributors own brands. Private label products developed as low cost alternatives to national brands. The objectives of the study is to identify existing level of the private label branding influences to consumer buying behaviour and relationship between private label branding and consumer buying behaviour. Convenience sampling method adopted in order to choose the sample and obtained responses from 150 private label branding consumers in three divisional secretariats of Colombo, Kaduwela and Kesbawa in Colombo district. Self-developed questionnaire was used to collect primary data from private label branding consumers. As analysis methods, descriptive statistics applied to identify the existing level of private label branding and consumer buying behaviour while Correlation and Multiple Linear Regression analysis to identify the relationship between the two variables. Findings revealed the strong positive relationship between the private label branding such as generic branding, copycat branding and premium branding with consumer buying behaviour. Moreover, the private label branding consumers are highly intended to buy copycat brand products and premium branding products rather than generic brands. As recommendations, self-service stores and supermarket sector need to highly adapt visual appearance, advertisement styling, attractive packaging with necessary details and high quality of the private label branding products. As managerial implications, the focus need towards brand building strategies and premium brands by organizations would enhance the market share and profitability.

*Keywords:* Private label branding, Consumer buying behaviour, Generic branding, Copycat branding, Premium branding



**Assessing the Impact of Brand Equity on Purchase Intention with Special Reference to Franchised Fast Food Industry**

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In present context with modern lifestyle, franchised fast food has been highly popularized despite the fact that relatively small number of sellers in a local context. Fast food could be considered as most consumed foods in the Quick Service restaurant format due to its unique attributes such as convenience, taste and less price. The franchised fast food industry in Sri Lanka is yet to be defined, as there is no clear demarcated line to separate from the other fast food outlets, which is available in Sri Lanka. Apart from the purchasing power one may possess, this paper attempts to identify other factors that influence for individual choice of franchised fast food brands. The objective of the paper is to identify the areas that should be considered to develop purchase intention in the franchised fast food market. The convenient random sampling method has been adopted and 150 respondents in Colombo and Gampaha districts were investigated with the aim of identifying the impact of brand equity on purchase intention. A structured questionnaire administered to collect primary data. Descriptive statistics and Regression had been used as analysis methods. According to the findings, Brand awareness represents the highest mean value of the distribution and demonstrates the brand awareness as mostly influence on consumer purchase intention of the franchised fast food product. The regression model reflects 78.9% of R square value and confirmed brand equity is a strong predictor of purchase intention. As managerial implications, the study helps to identify the level at which each of selected brand equities is apparent to the customer at the customers point of view, thus enabling them to make evaluations with regard to the level to which the organizational communication is reflecting the brand equity and its effectiveness. Ultimately the management must cater more on strong brand building Strategies and communicating the positioning of the food products on the consumer's mind.

*Keywords:* Brand equity, Purchase intention, Perceived quality, Franchised fast food, Marketing

## **Green Supply Chain Management: Proposal of a Model to Transform Sri Lanka Tea Industry**

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Tea is a significant factor in the Sri Lankan economy and in the recent past sector faced numerous problems from the global competitors. The purpose of this conceptual review paper is to take an initial step in transforming Sri Lanka tea supply chain into green thus we proposed a model for green supply chain network for Sri Lanka tea industry. Thus, reviewed the literature based on an archival method which enables to structure the research and to build a reliable knowledge base to propose green supply chain model for Sri Lanka tea industry. Therefore this proposal entails to cater two main objectives, one is reaching the early mover advantage in the market by transforming into green and also provide solutions to stakeholder pressure of environmental degrade. Environmental pollution and waste emerging from industries which have resulted in an increase in implementation of policies and regulations by authorities and friendly environmental practices directing of reducing the rapid destruction to the non-renewables. Green supply chain management has its origins in both environment management and supply chain management literature. Adding the "green" factor into supply chain management connects the relationships between supply chain management and the environmental activities. In the proposed three folded model, green inbound logistics of the product design phase, recommends that selecting the raw materials that will make the product green and its packaging as green as possible. Designing products that support green manufacturing key to the second fold of the mode and finally on green transportation fulfils the green outbound logistics. Further, recommends that the green employee management techniques can also significantly impact the green supply chain model to reduce the industry environmental footprint. In this backdrop, the growing importance of green supply chain management is driven mainly by the escalating deterioration of the environment improvements and also good business outcomes such as higher profits. Thus the proposed model enhance reaching the early green moving competitive advantage for an economic growth for the industry and solutions for environmental degradation.

*Keywords:* Supply Chain Management, Green Supply Chain Management, Environmental Management

**Short-run Price Performance of IPOs and Corporate Governance Practices:  
Evidence from a Frontier Market**

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The short-run price performance of Initial Public Offerings (IPOs) indicates that the prices are often underpriced which is widely documented as a universal phenomenon. This phenomenon was first documented in the finance literature by Stoll and Curley (1970), Logue (1973) and Ibbotson (1975). To test the underpricing phenomenon, most researchers used the first listing day average return (Chan, Wang & Wei 2004; Chang et al. 2008; Dimovski & Brooks 2005; Finn & Higham 1988; Ibbotson, Sindelar & Ritter 1994; Lee, Taylor & Walter 1996; Loughran & Schultz 2006; Moshirian, Ng & Wu 2010; Omran 2005; Ritter 1987). Corporate governance refers to the set of systems, principles and processes by which a company is governed. Establishing good corporate governance system in an IPO company makes good decisions which attract more outside investors.. Therefore, this study examines whether there is any impact of corporate governance practices on short-run price performance of Sri Lankan IPOs. Study examined 44 fixed price IPOs which were listed on the Colombo Stock Exchange (CSE) during the period of 2003 January to 2015- December. Study measures the short-run price performance using the first listing day initial return (IR) and the impact of corporate governance practices on short-run price performance is identified using multiple regression models. Managerial ownership, block holder ownership, board size, non-executive directors in the board, non-executive independent directors in the board, CEO duality, family members in the board, family members in the audit committee, non-executive directors in the audit committee, family members in the audit committee, family member as CEO, directors experience, audit opinion and auditors reputation, were employed as independent variables to capture the governance impact. Further, controlling variables such as firm size, leverage, return on assets and asset tangibility were also used to understand the other impact. The study found that Sri Lankan IPOs underprice by 30% on IR, which is statistically significant at 5% level. Further, it found that block holder ownership (ownership concentration), CEO duality and existence of the non-executive directors in the board are positively related to the short-run underpricing, which are statistically significant at 5%. But, the board size has a significant negative impact on underpricing. These relationships are in line with the international literature, which confirms that the corporate governance practices have significant impact on short-run price performance of IPOs in Sri Lanka. These findings also support the agency and signaling theories.

*Keywords:* Underpricing, Sri Lankan IPOs, Corporate governance

## **A Case Study on Employee Readiness to Change and Employee Demography**

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The twenty-first-century business environment is highly competitive and rapidly changing. Business organisations have to survive and grow within this challenging environment. To face those challenges, many organisations are implementing a number of changes. Hence organisational change and development have become an avoidable requirement in an organisation. To make the change implementation success, determining employee readiness is essential because many change efforts had failed to achieve the desired outcomes due to lack of employee readiness. Since Sri Lanka is a developing country, it is vital to make the change efforts success unless the organisations have to bear a big sunk cost on change implementation. The objective of this research is to examine the differences in employee readiness for 5S implementation based on employee demographic characteristics. The study has done by using 4 major demographic factors such as gender, age, civil status and education. Standard and validated, self-administered questionnaire was used to collect the data. Based on census statistic method, all the executive level employees were taken for the study and it is 40 employees. Descriptive statistics is used to analyse data. The results concluded that female employees have more employee readiness than male employees. Also, more readiness is with unmarried respondents than married respondents. Graduates have more employee readiness than undergraduates and postgraduates. When employees are in their younger age (25 to 35) they have more readiness than the aged respondents. This research provides a supportive explanation regarding employee readiness based on four demographic factors and guidance to managers, change agents and practitioners in order to make the change implementation success.

*Keywords:* Employee Readiness, Change Management, Demography

## **A Critical Evaluation of the Reasons for Non-performing Business Loans in a Private Bank**

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Non-performing business loans (NPBL) are one of the major causes of the economic stagnation problems. From this point of view, the eradication of non-performing loans is a necessary condition to improve the economic status. The purpose of this project is to evaluate the current strategies and policies to prevent non-performing loans, analysing its problems, identify reasons for non-performing loans with the aim of developing appropriate strategies and policies for a leading Private Bank in Sri Lanka. A case study methodology was used to collect information. Secondary data includes annual reports of a leading Private Bank in Sri Lanka, Central Bank of Sri Lanka as well as relevant industry journals, magazines and newspapers. Primary data includes interviews with internal staff and surveys with customers. The same standardized open-ended questions were asked from all interviewees. This approach facilitated faster interviews, made analysis of data easy and comparison of results possible. Surveys were carried out to find external factors for NPBLs, effectiveness of the current strategy in recovery, strategies that could be adapted to improve the loan recovery process. The levels of success of the actions were also discovered to a range between very good and poor according to the respondents surveyed. Purposive sampling technique was used in this. Main factors contributing to NPBL loans were the national economic downturn, reduced buying ability of consumers, insider lending, inadequate procedures for credit risk assessment and credit management, misuse of the loan. The other factors included the bank clients starting new businesses in which they had no experience, the simultaneous operation of too many kinds of business and the inappropriate use of the loan. Actions bank managers have taken to deal with the causes of NPBL are improvement in credit risk assessment, improved credit management involvement without the firm financial policy formulation by government.

*Keywords:* Non performing business loans, Private bank, Economic, Non performing, Loans

**Influence of Internal Corporate Social Responsibility on Employee Retention with special reference to the Apparel Industry in Sri Lanka**

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Apparel industry in Sri Lanka is experiencing a high labour turnover ratio. Employee Retention is emerging as one of the most critical issues impact on the competitive advantage. Nowadays organizations have become aware in internal marketing strategies to ensure a lower turnover rate. Internal Corporate Social Responsibility (CSR) has been creating so much attention in the minds of the employees during the recent years which can be used in internal marketing of an organization. Thus, the study based on the three objectives; first, it explores the relationship between Internal CSR and employee retention. Second, study aims to identify how intrinsic motivation, mediate the relationship between internal CSR and employee retention. Finally, to determine the internal CSR activities which the apparel industry should pay more attention for better employee retention. Questionnaires were distributed by using convenience sampling method to collect primary data from 150 employees working in top three apparel giants in Sri Lanka. The data were analysed using correlation coefficient, Baron and Kenny mediator analysis method and Sobel test. The results of the study indicated that there is a positive relationship between Internal Corporate Social Responsibility and Employee Retention. Mediator analysis and the Sobel test identified that intrinsic motivation partially mediate the relationship between the Internal CSR and Employee Retention. The findings of the study support to the human resource managers of apparel industry to identify career development, Supportive working conditions, Individual benefits and working patterns as the internal CSR activities which the apparel industry should pay more attention to develop their retention programs in future.

*Keywords:* Corporate Social Responsibility, Employee retention, Intrinsic motivation and Competitive advantage

## **Impact of Self- Efficacy of Small & Medium Sized Enterprise Owners on Firm Performance**

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Self-efficacy is often an overlooked, but critical component to successfully completing a task in the workplace. The relationship between self-efficacy and performance is critical and lays the foundation for how each owner interacts with his work and what he is capable of achieving. Further, the level of self-efficacy of the individuals also can differ among individuals. Accordingly, past studies shown mix findings related to the self-efficacy of owners and firm performance relationship. The aim of this study is to investigate the impact of self-efficacy of Small and Medium business owners on firm performance. More specifically, study examined whether there is any variation in self-efficacy in terms of gender, age and educational level differences of the owners. The study investigated four major dimensions of self-efficacy namely vicarious experience, verbal persuasion, emotional arousal, and performance accomplishment. A sample consists of 80 owner managers from Badulla district and simple random sampling method was adopted to select the respondents. Further, this study employed self-administered questionnaire to collect primary data. Besides, the data were analyzed by using descriptive, correlation, multiple regression analysis and one-way ANOVA. Results significantly supported to conclude that self-efficacy is one of the strong predictors of firm performance and there is a strong positive relationship exists between self-efficacy and firm performance. Besides, the results revealed that the owners in Badulla district were highly possessing the emotional arousal compared to other dimensions of self-efficacy. Additionally, females are low self-efficacious than males and their performance is significantly low. However, there is no difference in the level of self-efficacy and firm performance in terms of age and education level. Finally, it was suggested that the owner managers should develop their talents, organize themselves to be effective and be motivated to perform better.

*Keywords:* Self-efficacy, Firm Performance, SMEs Owner Managers

**An Empirical Study on the Impact of Reward System on Employees Performance of Licensed Commercial Banks in Sri Lanka**

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Offering different types of rewards to employees have become an important strategy to enhance the employees performance. However, as the rewards offered to employees are cost to the organization it is worthwhile to explore the potentiality of improving employee performance through providing rewards. Hence this study explored the association between reward system and employees performance with especial reference to banking industry in Sri Lanka. The objectives of the study were; first to identify the relationship between reward system and employees performance, second to explore the relationship between monetary rewards and employees performance, then the relationship between non-monetary rewards and employees performance and finally to explore the best reward system out of monetary and non-monetary rewards that impact on employees performance in licensed commercial banks in Sri Lanka. The study was conducted using both primary and secondary data. The secondary data were collected from the reports of Central Bank of Sri Lanka and other published material of the respective banks while primary data were collected by self-developed questionnaire from 100 employees from both public and private sector banks in Colombo district. The descriptive statistics, correlation coefficient and regression analysis techniques were used to analyze the data. The results revealed that there is a strong positive relationship between reward system and employee performance. Further, it revealed that both the monetary and non-monetary rewards are having positive relationship with the employees performance. Moreover this study determined that the non-monetary rewards are the most significant type of reward that impact on employees performance. Based on these empirical findings the study recommended to the respective authorities to incorporate more non-monetary rewards into the rewards system while having adequate amount of monetary rewards in order to enhance the employees performance.

*Keywords:* Monetary Rewards, Non-Monetary Rewards, Employees Performance, Banking Sector



**Diversification Strategies and Intra - Regional Value Chains: A Framework for Textile and Clothing Industry in South Asia**

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Value chains describe the activities that are performed by organizations to bring a product or service from conceptual phase up to the end use. South Asian countries(SAC) such as India, Sri Lanka, Pakistan and Bangladesh are manufacturers of inputs, component products or final products in apparel value chain. SAC compete among themselves to increase the market share of Textile and Clothing (T&C) in the world market individually. Eventhough, regional intergration programmes such as SAFTA and SAARC are in action, regional integration among SAC for T&C stand at the lowest. Hence, objectives of the research were to identify the current position of apparel value chain in South Asia, potential of SAC to formulate Intra- regional value chains for T&C and to propose a model for intra regional value chains for South Asia related to T&C sector. The research was based on data collected from UN comtrade database. Iidentifying the current status of T&C and Intra-industry trade was analysed using weighted Grubel-Lloyd index for each Harmonized Code category ranging 50–63. Results revealed that products manufactured by SAC are exported to non-SAC and inputs required for production are imported from outside South Asia leading to lower intra regional integration. In analysing the specialization areas and competitive advantage each country receive through the production of T&C inputs, relative competitive advantage index was calculated. The results revealed that the value chains can be formed within the South Asian region as different countries are specialized for unique T&C items where demand and supply for same items exist within the South Asian region. Futher, demand and supply for T&C items were analysed and results revealed that India can export manmade filaments and staple fibres and woven of tufted fabric to Pakistan while exporting cotton, manmade filaments and staple fibres, carpets, other textile floor coverings, woven of tufted fabric and lace to Sri Lanka. Also, India possess the competitive advantage for exporting cotton, manmade filaments, and manmade staple fibres to Bangladesh. Sri Lanka can export wadding, felt, nonwoven yarn and twine for Bangladesh and vegetable textile fibres and paper yarn to Pakistan. Pakistan can export carpets, other textile floor coverings and cotton to Sri Lanka and enjoy competitive advantage.

*Keywords:* South Asia, Intra Regional value chains, Competitive advantage, Textile and clothing sector

**The Impact of Emotional Intelligence on Occupational Stress: A Study in the Healthcare Industry in Sri Lanka**

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Occupational Stress has been identified as one of the critical problems in healthcare industry in Sri Lanka. According to the current context of health care industry in Sri Lanka, minimizing the level of occupational stress is considered as one of the major issues since, the health care industry's performance effectively affects the state population health situation and economic development. In order to minimize the level of occupational stress in health care industry, emotional intelligence has been identified as one of the important factors. Accordingly, the purpose of the study is to investigate the relationship between occupational stress and emotional intelligence of government hospital nurses in Sri Lanka. Further, study also aimed to identify the variation of occupational stress and emotional intelligence based on the age, gender and marital status of nurses. Besides, this study focused on two types of emotional intelligence namely personal competencies and social competencies. The stratified random sampling method was used to collect data from 150 nurses in Colombo District Government Hospitals. Hence, the self-administered questionnaire was used to collect primary data. Descriptive analysis, Pearson correlation, hierarchical regression and one way ANOVA method were used to analyze the data. The result of correlation analysis revealed that there is a strong negative relationship between personal competencies and occupational stress while there is a strong negative relationship between social competencies and occupational stress. Further, one way ANOVA test and hierarchical multiple regression analysis investigation shown that there is a significant difference in emotional intelligence and occupational stress of nurses in terms of age, gender and marital status. Finally, study suggested to the management paying more attention on nurses' emotional intelligence will help to change the level of occupational stress.

*Keywords:* Occupational Stress, Emotional Intelligence, Personal Competencies, Social Competencies

**Effect of Corporate Social Responsibility on Organization Performance of Bank Industry in Sri Lanka**

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Nowadays, Corporate Social Responsibility (CSR) is the most significant factor for the organization and it is directly affected to performance of the organizations. CSR realizes the responsibility of organization to related parties and it helps to enhance competitive advantages of organizations and through that creates long term sustainability for organizations. CSR is one of a business strategy and that mitigate potential risks involving the organizations. This study aims to identify the effect of CSR on organization performance of the bank industry in Sri Lanka and thus the Objectives of the study are set to identify that effect. To achieve the objectives of the study, quantitative approach has been used with 72 respondents and the results indicate that there is a positive correlation between CSR and organization performance of the bank industry in Sri Lanka and also CSR positively impact on the organization performance of the bank industry in Sri Lanka.

*Keywords:* Corporate Social responsibility, Organization performance

**An Empirical Study of Micro Finance Activities on Living Standards of the Community (Special Reference to Badulla District)**

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Improving living standard of people in rural area has been an important development challenge over the decades. Microfinance is currently being promoted as a key development strategy for poverty reduction and empowerment of people economically towards achieving a high level of living standard of rural community. However the available literature shows contradictory findings on the relationship between micro finance activities and living standard of community. Hence this study investigated the impact of micro finance activities on living standard of people in Badulla district with the hypothesis that there is a positive relationship between microfinance activities and living standard of community. The study was conducted using primary data collected from a sample of 150 micro finance users in Badulla District. The data was collected using a questionnaire comprising both structured and open ended questions. Correlation coefficient and regression analysis techniques were used for statistical analysis. The results of the statistical analysis revealed that there is a positive but weak relationship between micro finance activities and living standard of rural community. With the in-depth discussions had with the respondents, the researcher further verified the findings of statistical analysis. Based on the empirical findings this study concluded that though micro finance activities shows a positive impact on living standards, providing micro finance facility along cannot highly improve the living standard of people as there are some other factors effects on it. Hence the researcher recommends initiating proper mechanism for utilizing the micro finance in effective manner whilst searching other means to improve the living standard of the rural community.

*Keywords:* Community, Living standards, Micro finance activities, Poverty reduction

**Impact of Work life conflict on Turnover intention: The Mediation Role of Job satisfaction**

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Apparel industry has been the Sri Lankas largest gross export earner since 1986 and it is considered as one of the biggest industries in Sri Lanka. However, longer working hours, tighter deadlines and changes in family structure increased the employee responsibilities. Therefore, balance of the work life and family life are an emerging challenge for employees in the apparel industry. Employees are assets to the organization and the organization always tries to avoid losing the key performers. Therefore, apparel companies are providing attractive benefits to the employees like attractive salary, transportation, medicine etc. However, employee turnover has become a critical problem for this industry. Thus, this study empirically evaluated the relationship between work life conflict and turnover intention. Further study also investigated the role of job satisfaction as the mediator between the work life conflict and turnover intention. Convenience sampling method was employed to select 100 operational level employees from 10 apparel companies in Katunayaka Export Processing Zone and primary data were gathered by using self-administered questionnaires. Besides, descriptive, correlation and simple regression analysis were performed to analyze the data and Baron and Kenny mediation analysis was performed to check the mediation effect. The analysis exposed that work life conflict is negatively related to job satisfaction. Further, job satisfaction is negatively related to turnover intention of employees. Besides, study found the strong positive relationship between work life conflict and turnover intention and it is partially mediated by the job satisfaction. Moreover, the study revealed that turnover intention varied with gender differences in apparel industry and females have high level of turnover intention than the males. Study suggested management to reduce the individual work load, define the employees tasks and duties clearly and implement the experience based benefits system for minimizing the turnover intention among employees.

*Keywords:* Work Life Conflict, Job Satisfaction, Turnover Intention

**Impact of Financial Literacy on Investors Decision Making (with Special Reference to Colombo Stock Exchange)**

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The role of the investors is imperative to the development of an economy. According to literature, Colombo Stock Exchange (CSE) has failed to attract sufficient number of investors due to its inherent weaknesses. Further, there is relatively a few number of articles and journals published about the financial literacy and it has not yet been covered the impact of financial literacy on investor decision making in Sri Lankan context. Hence, intention of this paper is to fill the gap in the literature by examining the impact of financial literacy on investor decision making, ascertaining the relationship between financial literacy and decision making and identifying the most affecting factor to investor decision making. In this study, financial literacy is conceptualized as multidimensional construct which depends on three dimensions such as financial knowledge, attitude and behavior. Primary data were gathered through distributing a self-administrative questionnaire and 100 investors were selected systematically. Descriptive statistics, Correlation coefficient analysis and Regression analysis were used for the purpose of data analysis. The research findings revealed that there is a strong positive correlation between financial knowledge and decision making while other two dimensions have a weak positive correlation. Further, financial knowledge was identified as highly affected factors to the investors decision making. Accordingly, to develop CSE, policy makers can implement policies to increase the financial knowledge of both local and foreign investors. Moreover, policies can be implemented to improve the financial literacy of the investors through the education system of the economy.

*Keywords:* Colombo Stock Exchange, Financial Literacy, Investors Decision Making

**Factors Affecting to Occupational Stress of Customer Service Officers in Banking Industry (With Special References to Colombo District)**

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Occupational stress has become almost globalized and has the tendency to affect all professions and workers. The banking industry in Sri Lanka is one of the growing sector in the economy. Bank employees suffer from numerous problems in their workplace and job environment which has serious consequences for employee performances. The studies mainly focused on identifying causes of the occupational stress regards to the customer service officers in the banking industry. Hence secondary objectives of researcher were to absorb the nature of occupational stress in the banking industry and the most influential factors affect to occupational stress in the banking industry. The sample consists of 300 customer service officers. A self-developed questionnaire was used to collect primary data. Descriptive statistics and factor analysis has been used to achieve research objectives. The study explores five factors that most influential factors affect to occupational stress in the banking industry. Those five factors were named as "Job requirements", "Career development", "Employee attitudes", "Work related social support" and "Work-load and responsibility". The above factors are highly determined as the most significant factors that affect to occupational stress in the banking industry. With considering the results of this current study, Management could consider that five factors in order to reduce the stress level of the banking employees. It is suggested that management should give a high priority for their employees requirements and maintain them for a long term returns of both organization and employees.

*Keywords:* Occupational stress, Job requirements, Career development, Employee attitudes, Work related social support, work-load, Responsibility

### **Impact of Self-construal on Job Engagement**

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Sri Lankan apparel industry has been playing a significant role in the country's growth and development. However, one of the considerable problems faced by the apparel industry is poor job engagement among employees. Additionally, organizational culture can change the level of job engagement of co-workers and self-construal of individuals has been identified as one of the significant factors which reflect the culture in workplaces. The two types of self-construal were empirically evaluated namely independent and interdependent self-construal. The purpose of this study is to investigate the relationship between self-construal and job engagement of apparel sector employees of Katunayaka export processing zone. Further, the study aimed to identify the variations of self-construal and job engagement based on age, gender, and experience level of employees. The simple random sampling method was adopted to collect primary data from 100 operational level employees in apparel firms, Katunayaka export processing zone. Self-administered questionnaire was used to collect primary data. Besides, Descriptive, Pearson Correlation, hierarchical regression analysis and One-way ANOVA method were used to analyze the data. The results of correlation analysis revealed that there is a strong positive relationship between interdependent self-construal and job engagement while there is a strong negative relationship between independent self-construal and job engagement. Further, the result of one-way ANOVA test and hierarchical multiple regression analysis proved that there is a significant difference in self-construal and job engagement of employees in terms of their age and experience level. But there is no significant difference found in self-construal and job engagement in terms of gender variations. Accordingly, the study suggested to the management that paying more attention on self-construal of employees will help to change the level of job engagement in apparel sector organizations.

*Keywords:* Self-Construal, Job engagement, Diversity factors, Apparel industry



**Study on Influence of Employee Non-Financial Incentives for Turnover Intention in Apparel Industry(With Special Reference to Operational Level Employees of Apparel Firms in Biyagama Export Processing Zone)**

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Turnover intention is a critical problem of apparel industry in Sri Lanka. According to current context of the apparel industry, diminishing the turnover intention is more important because the apparel sector is the highest industrial employment generator and the highest foreign exchange earner. The main objective of this study is to examine the influence of non-financial incentives on turnover intention through job satisfaction. For this purpose, this study empirically evaluated the three dimensions of non-financial incentives (Job Enrichment, Workers Participation in Management and Employee Recognition), job satisfaction and impact on the turnover intention. The sample consisted of 100 operational level employees working in apparel firms in the Biyagama Export Processing Zone in Sri Lanka. Data were gathered by using a convenience sampling technique through self-administering questionnaires. Descriptive statistical Analysis were used to analysis the existing situation of three dimensions. The strength of a linear relationship between two variables is measured by the Pearsons Correlation Coefficient analysis and the mediation effect of job satisfaction was assessed through Baron and Kenny mediation assessment technique. The analysis exposes that there is a strong negative relationship between employee non-financial incentives and turnover intention. Further it evident that job satisfaction partially mediates the relationship between non-financial incentives and turnover intention. Researchers discussed and suggested that the apparel sector companies should be taken the appropriate strategies to develop the competitive advantages and employee work life improvement.

*Keywords:* Non-financial Incentives, Job Satisfaction, Turnover Intention

**Assessing the Impact of Visual Merchandising Strategies on Consumer Purchase Intention through Consumer Emotional States**

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Visual merchandising is an emerging concept that encourages impulse buying of consumers by improving aesthetic aspects of store environment and fast fashion apparel retailing is an industry which practices it significantly. The main objective of the study is to assess the impact of visual merchandising strategies on purchase intention through the mediation of emotional states. Identify the relationship between visual merchandising strategies with emotional states and emotional states with purchase intention are the secondary objectives. The primary data was gathered through a survey and secondary data was gathered from literature. A sample of 200 was drawn from Colombo and Kandy and a structured questionnaire was administered to assess visual merchandising strategies over store exterior and interior factors while emotional states were measured by pleasure, arousal and dominance. Purchase intention was assessed through the consumer buying decisions, recommendation and willingness to pay more. Data analysed with Pearson correlation and regression analysis revealed the significant weak positive relationship between visual merchandising strategies and purchase intention while the relationships between visual merchandising strategies and emotional states as well as emotional states and purchase intention have been recorded to be strong positive. Baron and Kenny (1986) method has detected a partial mediation of emotional states on the link between visual merchandising strategies and purchase intention while Sobel test proved that the said mediation is extremely significant. As per the descriptive statistics, the fast fashion apparel retailers require improving visible visual strategies that stimulate pleasure and arousal of buyers while training the staff on effective use of them. As managerial implications, retailers could offer adequate information, display new trends, improve accessibility and parking spaces to draw more attraction as visual merchandising strategies.

*Keywords:* : Visual merchandising, Purchase intention, Emotional states, Fast fashion apparel

## **Influence of Conflict Handling Styles on Employees Job Satisfaction**

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Employees job satisfaction is one of the main valuable source of many succeeded business because it has the ability to deal with the overall performance of the organization. Further every organizations have to pay more attention on handling the conflict since it is unavoidable fact. The literature review found since the certain research area needed a clear study in Sri Lankan context. Therefore, this study an attempt was made to identify the influence of conflict handling styles on employees job satisfaction in top ten companies in Sri Lanka. The present study evaluated the conflict handling styles which are practiced in Sri Lanka according to Thomas-Kilmans conflict handling styles (Competing, Collaborating, Compromising, Avoiding and Accommodating) and the relationship of conflict handling styles on employees job satisfaction. Further it studied about moderating effect of demographic factors (Age, Gender, Education, and Experience) which were used to identify whether the demographic factors moderate the relationship of conflict handling style and employees job satisfaction. Top ten companies in Sri Lanka ("Business Today - 2015") were selected for the sample. Samples were taken for the convenience of analysis which were consisting of 50 managers and 250 employees by using convenient sampling technique. Primary data were gathered through providing two different set of structured questionnaires for both managers and employees of top ten companies in Sri Lanka. Questionnaires for managers and employees were used to measure the conflict handling styles and employees job satisfaction accordingly. SPSS-21 used for the data analysis. The descriptive analysis illustrates that the Accommodating and Collaborating conflict handling styles are mostly practiced by managers in Sri Lanka. Further the correlation analysis illustrates conflict handling styles and employees job satisfaction have a strong positive relationship. Therefore a proper conflict handling style may increase the employees job satisfaction. In additional Andrew F Hayes model illustrates the demographic factors (Age, Gender, Education, and Experience) are not moderate the relationship of Conflict handling styles and employees job satisfaction. The research findings are satisfied with existing scholars findings and also the study suggested certain area for the future studies.

*Keywords:* Conflict handling styles, Employees job satisfaction, Demographic factors

## **Impact of Customer Relationship Marketing on Customer Perception in Banking Sector**

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In present competitive business world, one of the most difficult and expensive activities for any business is acquire and retain customers. Customer Relationship Marketing (CRM) means creating long-term relationship with customers. It maintains customer loyalty by providing best products and services rather than trying to encourage one-time sale. Moreover banking sector is becoming more vital, because the volume of banking customers has increased over the last two decades with a wide range of preferences and favorable customer perception will add an advantage to the bank to face high competitiveness within the industry. Hence, intention of this paper is to identify the customer perception on existing CRM practices in banking sector, to ascertain the relationship between CRM and customer perception in banking sector and to identify the most significant CRM practice on customer perception in banking sector. In this study, CRM practices are conceptualized as multidimensional construct which depends on six dimensions such as trust, communication, bonding, shared value, empathy and reciprocity. Primary data were-gathered through distributing a self-administrative questionnaire and 100 SME owners in Colombo Division were selected by using systematic sampling technique. Descriptive statistics, Correlation coefficient and Regression analysis were used for the purpose of data analysis. The research findings revealed that there is a strong positive correlation between trust, communication, bonding and customer perception while other dimensions have a weak positive correlation. Further, trust and communication were identified as highly affected factors to the customer perception. These findings will help managers to build and maintain profitable customer relationship by delivering superior customer value, in order to enhance customer loyalty. Future researchers can investigate the impact of CRM practices on other factors such as market share, profitability and firm performance.

*Keywords:* : Customer Relationship Marketing (CRM), Customer perception, Small and Medium Enterprises (SMEs)

## **Insight to the Motivational Factors influence to Purchase of Luxurious Apparel Brands**

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Immense competitive market for apparel has identified Luxury fashion as one of the most contemporary inclination in the industry. Global competition tends to expand the luxury apparel market in Asian countries rather a world phenomenon. The storied iconic brands in the fashion industry, are synonymous with exceptional fashion clothing rely on Sri Lanka as their topmost apparel sourcing destination. The study aims to identify the motivational factors influencing on luxury apparel brands with regard to consumer purchase intention. The objective is to identify the most influencing factor towards purchasing luxurious apparel brands. By referring literature, the conceptual framework adopted from Dubois and Czellers (2001) six dimension model and study explores the motivational factors on purchase ; excellent quality, very high price, scarcity and uniqueness, aesthetic and poly-sensuality, ancestral heritage and personal history of the brand and superflouesness to purchase luxurious apparel brands in Sri Lankan context. Both primary and secondary data has been collected and sample consists of 200 respondents consume luxurious apparel in Colombo district and adopted correlation coefficient and Multiple Linear Regression for analyze the data. Findings revealed the weak positive relationship between motivational factors and consumer buying behaviour and excellent quality has been identified as the most significant factor. Since Sri Lanka is a tourist destination, more luxury fashion outlets can be established rather creating a novel market avenue. Design the aesthetic value in apparel, uniqueness and excellent quality could be identified as managerial implications and awareness on luxurious apparel brands is crucial excessively.

*Keywords:* Apparel brands, Luxurious Fashion, purchase intention, motivational factors, marketing

**Impact of Online and Offline Advertising on Purchase Intention (Evidence from Automobile Industry in Sri Lanka)**

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Online advertising has grown rapidly in the last decade. Online advertising is geared toward defining markets through unique and useful applications. On the other hand, offline advertising can be very effective, even for internet marketers promoting their websites, especially when one is targeting local public, but only few marketers are using this resource. Simply purchase intention mean what we think it will be bought. Further, purchase intention refers to a consumers intention to purchase a product, or to utilize a service firm. This study focuses on the impact of online and offline advertising on purchase intention of automobile industry since there is no preceding studies regarding the said topic on the automobile industry in Sri Lanka. The objective of this empirical study is to find the relationship between online advertising and automobile purchase intention as well as the relationship between offline advertising and automobile purchase intention. Further, this study aims at the relative contribution of each factor in online and offline advertising to purchase intention. In this study, primary data were gathered through a structured questionnaire and the sample consisted with 100 automobile consumers in Colombo district. The Probability sampling technique used to obtain preliminary first-hand information in a quick and inexpensive way. As per the results, there is a positive relationship in between both online and offline advertising method and purchase intention. This study helps automobile sellers to use their advertising strategies effectively by selecting the best method to promote their automobiles in the market.

*Keywords:* Advertising, Online Advertising, Offline Advertising, Purchase Intention, Automobile Industry

**An Empirical Study on the Factors Affecting the Selection of Mobile Telecommunication Service Provider in Sri Lanka.**

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Switching the customers from one service provider to another is a common problem faced by any organization operates in the telecommunication sector in Sri Lanka. As the Sri Lankan mobile telecommunication industry has number of service providers who are providing quite similar facilities to the customers, it is worth for them to identify the factors affecting on selection of such mobile telecommunication service provider. Such knowledge is highly required them to attract new customers and to retain their existing profitable customers. Hence this study was conducted with the objective of identifying the factors influencing on the selection of mobile telecommunication service provider in Sri Lanka. This study empirically evaluated three factors; customer loyalty, purchasing intention, and switching intention on selection of mobile telecommunication service provider in Sri Lanka. The sample consisted of hundred and fifty (150) mobile telecommunication facility users in Southern Province, Sri Lanka. This study used primary data collected through an adopted, five point Likert scale type questionnaire filled by the respondents. Descriptive statistics, correlation coefficient and regression analysis techniques were used for the statistical analysis. The results of the statistical analysis revealed that all three factors studied showed positive association with the selection of mobile telecommunication service provider in Sri Lanka while customer loyalty showed a highest positive association. Hence this study recommends the service providers to implement strategies to improve the customer loyalty while paying considerable attention on the existing customers when launching new service features to the market for attracting new customers. The benefits of the novelty features should not offer only to the new customers ignoring the existing customers.

*Keywords:* : Service provider selection, Customer loyalty, Purchasing intention, Switching intention.

**Influences of Corporate Brand Image on Customer Loyalty; the Mediation Role of Customer Perceived Value and Customer Satisfaction**

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Creating competitive advantage in the business domain is a key factor in enhancing the survival of businesses especially in globalized business environment. For defeating competitors, firms can use few strategic tools such as enhancing brand image and customer perception which results in improved customer loyalty. Besides, most of the studies have found the key antecedents of customer loyalty only. However, scholars have approached with new studies which focus on the mediation effect on customer loyalty. Accordingly, this study is conducted with the aim of examine the influences of corporate brand image on customer loyalty in food and beverage sector. Further to have the better understanding of interrelationship between brand image and customer loyalty, customer perceived value and customer satisfaction were utilized as mediators. Data were collected through a questionnaire filled by 150 consumers who purchase food and beverage products from self-service retail stores in Colombo district. Further, systematic sampling method was used to derive the sample. Correlation coefficient, Simple leaner regression analysis and the Sobel test were used for the statistical analysis of data. The results claimed that, there is a strong positive significant relationship between corporate brand image and customer loyalty where the correlation coefficient is 0.755 and R square Value of the regression analysis was 57%. Further, the mediator analysis concluded that there is a partial mediation effect of customer perceived value and customer satisfaction on the relationship between corporate brand image and customer loyalty. Hence this study recommended the Food and Beverage managers, practitioners and manufacturers to implement strategies to create brand image, customer perceived value and enhance the customer satisfaction which lead to improve the customer loyalty.

*Keywords:* : Corporate Brand Image, Customer Perceived Value, Customer Satisfaction, Customer Loyalty



**Factors Influencing Dining Experience on Customer Satisfaction and Customer Loyalty: With Special reference to Restaurant Industry in Star Class Hotels in Sri Lanka**

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It is highly important for restaurant industry to fully understand the quality of the services, which they have provided. The main purpose of this study is to investigate the factors affecting on customer satisfaction and customer loyalty of restaurant industry in star class hotels in Sri Lanka. Survey data were collected from 100 customers from restaurants in star class hotels located in Colombo, Sri Lanka by using self-administered questionnaires. Data were analyzed and hypotheses were tested by performing Partial least Structural Equation Model by using Smart PLS software. The obtained results from the analysis show that physical environment, food service, service quality of restaurant were significant determinants on customer loyalty of restaurant services. In addition the results conclude that customer satisfaction is mediating the effect on food service quality dimensions and customer loyalty. The proposed model and study findings will greatly help to the industrial practitioners and investors on restaurants to understand the complex relationships among foodservice quality (physical environment, food, and service), customer satisfaction, and customer loyalty in the restaurant industry.

*Keywords:* : : Customer satisfaction, Customer loyalty, Partial Least Squares Path Modeling, Restaurant industry, Star Class Hotels, Sri Lanka

**Impact of Advertising Appeals on Working Womens Buying Behavior with Special Reference to Face Skin care Brands in Sri Lanka**

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The cosmetic industry is competitively emergent since particular industry has become a more lucrative in Sri Lanka. Scholars came up with contradictory ideas regarding the effectiveness of these adverting appeals and buying behavior. By constructing visible empirical gap, this study attempts to measure the effect of advertising appeals adopted in television commercials on working womens buying behavior with reference to face skin care brands in Sri Lankan context. The Main objectives of the research are to recognize the relationship and most influencing advertising appeal towards customer buying behavior. Both primary and secondary data has been collected through self-administered questionnaire. One hundred fifty respondents who consume cosmetics in Colombo district were selected for the sample by using systematic sampling. The independent variable was the advertising appeals; rational, emotional and moral. Consumer buying behavior of face skin care products considered as the dependent variable and implemented correlation coefficient and multiple linear regression for analyze the data. Rational appeal has the most influential supremacy and there is a positive relationship between advertising appeals and consumer buying behavior. According to the statistics, cosmetic industry is rapidly growing and cosmetic products dealers should focus on the strategies which will make an impact on these two influential factors in order to attract and retain female working customers excessively. Results contributes acquaintance to cosmetic companies and assist to understand the buying habits of the consumers when arranging advertisements and promotional activities.

*Keywords:* : CWorking Women, Advertising Appeals, Buying Behavior, Face Skin Care Products



# **Environmental Science**



## **Long-term Change Detection and Trend Assessment in the Rainfall and Temperature of Ratnapura**

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Ratnapura is situated in the Kalu Ganga Basin of South Western Sri Lanka. This area located at the frontier between the Sabaragamuwa Mountain Range and the middle block of the Central Highland. The main objective of this study was to examine the long-term variation and trend assessment in the rainfall and temperature of Ratnapura. This study was based on monthly rainfall and monthly average temperature data for the period from 1869 to 2014. The data was obtained from the Ratnapura weather station of the Department of Meteorology. To identify long-term variation in rainfall and temperature, the data set was divided into two observation periods from 1869 to 1941 and 1942 to 2014. The trend was estimated from 1869 to 2014 using the time series and linear regression techniques. The Mann-Kendall statistical test was applied to identify significant and non-significant monotonic trends. The results revealed that the annual average rainfall in Ratnapura has been decreased by an amount of 79 mm (about 2%) during 1869 to 1941 period compared to 1942 to 2014 period. South West Monsoon (SWM) rainfall has been decreased by an amount of 114 mm (about 6%) and Second Inter-Monsoon (SIM) rainfall has been decreased by an amount of 13 mm (about 2%) during 1869 to 1941 period compared to 1942 to 2014 period. First Inter-Monsoon (FIM) rainfall has been increased by an amount of 38 mm (about 7%) and North East Monsoon (NEM) rainfall has been increased by an amount of 7 mm (about 1%) during 1869-1941 period compared to 1942-2014 period. The annual and seasonal rainfall time series do not show a significant trend from 1869 to 2014. Annual average temperature has been increased by an amount of 0.30 °C during 1869-1941 period compared to 1942-2014 period. NEM average temperature has been increased by an amount of 0.40 °C and an average temperature of other seasons have been increased by an amount of 0.30 °C during 1869-1941 period compared to 1942-2014 period. Annual and seasonal average temperatures have shown statistically significant ( $P < 0.05$ ) increasing trends during 1869-2014. The rate of increase of annual average temperature is in the order of 0.005 °C per year. The largest increasing trend of 0.007 °C per year was observed in NEM season. The study clearly revealed that the rainfall does not show a significant upward or downward trend, but the temperature shows a significant increasing trend during the last 146 years.

**Keywords:** Rainfall, Temperature, Trend, Variation, Significant

## **Screening of Aerobic Bacterial and Fungal Strains for Cellulose Biodegradability of Organic Wastes**

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Degradation of organic solid wastes by biological methods is environmental friendly and low cost. Cellulose in waste is more resist to degrade in the normal degradation processes. In this study, fungal and bacterial species were isolated from soil samples collected from garbage dump near Vincent Dias stadium and screened for cellulase production in Congo-Red agar medium. Culture medium pH was also measured. Screened five bacterial (B1, B6, B12, B15 and B24) and five fungal (F1- F5) strains were selected and used for waste degradability tests. Organic waste samples in three different degradation stages (one week old waste as Stage 1, two-three weeks old waste as Stage 2 and eight - nine weeks old waste as Stage 3) were collected from Vincent Dias garbage dump. Each sample (~20g) were placed in sterile petri dishes, treated with screened microbial inoculants (1 mL) and incubated under room temperature for 15 days. Sterile distilled water was used as the control. Three replicates of each sample were arranged according to CRD in the Laboratory. Cellulose degradability was tested by considering mass reduction, sugar production and analysis of polysaccharides by Fourier Transform Infrared Spectroscopy (FTIR). Data were analyzed by ANOVA. According to data, F5 and B1 showed the highest mass reduction out of fungal and bacterial species respectively. The significantly ( $p \leq 0.05$ ) high amount of simple sugars was observed in F5 and F4 over the other treatments. The amount of simple sugar production increased with the increment of incubation time. According to the FTIR data, absorbance in polysaccharide window ( $900-1200\text{ cm}^{-1}$ ) reduced under each treatment by showing the positive effects of microbial treatments for polysaccharide degradability. FTIR and sugar analysis proved the best action of microbial treatment on stage 1 waste samples. In conclusion, screened aerobic bacterial and fungal strains can be applied in degradation of solid organic wastes. Fungal strains are more efficient in degradation and F5 is the best. Microbial strains are yet to be identified.

*Keywords:* Bacteria, Fungi, Biodegradability, Cellulose, Solid waste

## **Growth Promotion of Strawberry (*Fragaria x ananassa*) Under the Application of Biofilmed Biofertilizers Combined with Organic Fertilizers**

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Growth and yield of strawberry requires application of high doses of chemical fertilizers which lead to critical environmental problems. The present study was conducted to assess the growth performance of strawberry under application of organic fertilizer combining with biofertilizer. Pre tested Biofilmed Biofertilizer (BFBFs, biofilm between *Aspergillus* and *Enterobactor*) for strawberry was separately combined with Press mud (PM+BFBF), Compost (CM+BFBF) and Cow dung (CD+BFBF) and used as fertilizer treatments for strawberry grown in pots. BFBF alone and 100% of Chemical fertilizers (CF) were used as reference treatments. Fertilizers were not used in the control. Five replicates for each treatment were arranged in a plant house by following completely randomized design. Pot experiment was conducted for three months. Plant height, number of leaves, leaf area, chlorophyll content, number of fruits, number of flowers and plant dry masses were recorded as vegetative data. Soil nutrients, NO<sub>3</sub><sup>-</sup>, NH<sub>4</sub><sup>+</sup> and PO<sub>4</sub><sup>3-</sup> were analyzed at the beginning and end of the experiment. Data were analyzed by ANOVA. According to the results plant height and chlorophyll content was not significantly ( $p > 0.05$ ) different among treatments. Leaf area was significant ( $p < 0.05$ ) in PM+BFBF over the control. Leaf count was highest in CM+BFBF. Flower count and fruit count was highest in PM+BFBF. All treatments and control showed a significantly higher ( $p < 0.05$ ) plant dry mass over the CD+BFBF. The highest dry mass was given by PM+BFBF. Available soil NO<sub>3</sub><sup>-</sup> and NH<sub>4</sub><sup>+</sup> significantly increased in PM+BFBF and CM+BFBF from week 1 to week 10. In week 10, soil NO<sub>3</sub><sup>-</sup> was significantly high in CM+BFBF whereas soil NH<sub>4</sub><sup>+</sup> was significantly high in PM+BFBF. All organic bio fertilizer combinations showed improved PO<sub>4</sub><sup>3-</sup> levels. When considering the growth performances, fruit production and soil nutrients, PM+BFBF and CM+BFBF were more suitable organic bio fertilizer combinations than CD+BFBF. CF showed poor growth and available nutrients in soil. This study supports the view that BFBFs combined with organic fertilizers have a capability to improve vegetative growth and fruit production in strawberry and reduce excessive use of chemical fertilizers.

**Keywords:** Strawberry, Biofilmed biofertilizer, Organic fertilizer



## Disinfection and Coagulation Abilities of Selected Plant Materials for Water Treatment

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In certain instances chemical compounds are used in water purification plants as disinfectants and coagulants which would cause adverse environmental and health issues. Present study aimed by finding a suitable plant materials as disinfectants and coagulants for both water and waste water treatment. In disinfection test, leaves of *Carica papaya*, *Azadirachta indica*, *Terminalia arjuna* and bark of *T. arjuna* were used. Plant powder (20 g) of each species was mixed in 70% ethanol (100 mL) separately and 2.5 mL of mixture was used to treat *E. coli* suspension. In control, *E. coli* suspension was treated by 2.5 mL of 70% ethanol. Treated suspensions were incubated (100 rpm, 15 hours), re-cultured in a Nutrient Agar, incubated for 24 hours and number of colonies were counted. In coagulation test, seed powder of *Zea mays*, *Moringa oleifera*, *C. papaya* and *Cicer arietinum* mixed in water (0.5 g, 1.0 g, and 1.5 g/100 mL) separately and added to 500 mL of raw water and jar test was performed. Turbidity, pH and conductivity were measured in treated water. Complete Randomized Design was followed in both experiments with three replicates. Data were analyzed by ANOVA. According to the results of disinfection test, all treatments showed the reduction of *E. coli* colony count in comparison to control. *C. papaya* showed the least colony count. Turbidity and pH of coagulated samples were significantly different ( $p < 0.05$ ) among treatments. The least turbidity was observed under *M. oleifera*. *Zea mays*, *M. oleifera* and *C. arietinum* maintained the pH of treated water around 7. *Carica papaya* maintained the basic water pH. Least conductivity was given by *C. papaya* but not significant ( $p > 0.05$ ). Effective concentration for turbidity and conductivity maintenance was 0.5 g /100 mL whereas pH was maintained with 1.5g/100 mL concentration. In conclusion, according to the results obtained from the study, the most effective disinfectant and coagulant was powder of *C. papaya* leaves and *M. oleifera* seeds respectively.

**Keywords:** Water purification, Disinfection, Coagulation, Plant materials

**Physio-chemical Stability of Suspended Particles in Peripheral Environments of Batticaloa Lagoon, Sri Lanka**

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The chemistry of Suspended Particulate Matters (SPM) and the physical parameters of water of the peripherals of the Batticaloa lagoon, Sri Lanka were determined to interpret the chemical stability of environmental concerning elements in distinct lagoon environment. X-ray fluorescence analysis was performed on filtered (>45 microns) sediments and concentrations were compared with upper continental crustal values. Pourbaix (Eh-pH) diagrams were used to interpret the chemical stability of each element. This study is important since SPM plays a major role in biogeochemical cycles. Results indicated oxic condition for anthropogenic impacted zones and anoxic conditions for natural vegetated zones. pH of the peripheral environments is neutral indicating the influences of inland flows. The SPM show minor enrichment in Cr, V, Ni and As (average 85.74, 189.65, 43.58, and 3.11 ppm, respectively) throughout the lagoon indicating the natural influence of the country rock. Higher enrichments observed in Cu, Zn and Sc (average 26.94, 90.93 and 15.2 ppm, respectively) with compared to the upper continental crust values in areas where human impact is high. Hence, study indicated both anthropogenic and natural factors govern the chemical variations of SPM. Eh-pH diagrams show the existence of soluble forms of Ni<sup>2+</sup>, more toxic form of As<sup>5+</sup>, Cr<sup>6+</sup>, Cu<sup>2+</sup> and Pb as in un-dissolved state. This study indicated the present status of the lagoon sedimentation is going to be polluted in near future. Spatial and temporal variations of chemistry of SPM should be further studied for comparison and monitoring.

*Keywords:* Suspended particulate matter, environmental concerning elements, Eh-pH diagrams, Batticaloa lagoon

## Potential Negative Impacts of Proposed Andha Dola Mini-hydropower Plant on Stream Ecosystem

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Small hydropower is defined as tapping the potential energy of running water to generate hydro-electricity of 10 megawatts or less. The estimated small hydro potential in Sri Lanka is about 400 megawatts of which nearly 90 percent has been already tapped establishing over 150 mini hydropower plants in headwater streams. A mini-hydropower plant with a capacity of 770 kilowatts has been partially constructed on Andha Dola, a tributary of the Gin Ganga draining Dellawa forest reserve. Presently, construction has been suspended due to objections of community and the Department of Irrigation. A study was conducted to determine whether there are any potential negative impacts of proposed mini-hydropower plant on aquatic fauna, hydrological network, and riparian community by analyzing, the Initial Environmental Examination report and rapid field surveys during September - November 2016. Analysis revealed that there were errors and miscalculations in the Initial Environmental Examination Report approved by the Project Approving Agency. Generation of 770 kilowatts is very unlikely if 300 liters/second is released as environmental flow and there was a reduction in flow volume towards the downstream according to available hydrological data. The study found 10 endemic fish species of which some of them were ranked as endangered (Ex: *Systemus pleurotaenia*, *Pethia nigrofasciata*, etc.). Fish breeding sites consisted of the specific bottom substrate were prominent at certain stream stretches. Nevertheless, eels were not observed during fish sampling although Andha Dola means a stream of eels according to folk legendry. The downstream flow of Andha Dola downstream is due to lateral loss and there are no influent streams between the weir and the tailrace outfall. Upstream movement of eelers has been regulated by the existing weir on Gin Ganga at lower Neluwa. The construction and operation of proposed mini-hydropower plant will certainly eliminate endemic aquatic fauna while there will be certain negative impacts on the riparian community.

**Keywords:** Andha Dola, Mini-hydro, Environmental Flow, Endemic Fish, Initial Environmental Examination

### **Acute Toxic Effects of Diazinon and Etofenprox on Zebrafish (*Danio rerio*) Embryos**

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Pesticides severely affect the balance in biodiversity, but are used worldwide for agriculture to control pests. The effect of this on the life in water bodies has been poorly investigated. The present study investigated the acute toxicity of two widely used pesticides; Diazinon ( $C_{12}H_{21}N_2O_3PS$ ) and Etofenprox ( $C_{25}H_{28}O_3$ ) on zebrafish (*Danio rerio*) embryos, since the sensitivity of toxicology testing of zebrafish reveals the permissible limits in toxicants to the ecosystem. Fertilized zebrafish embryos were exposed to a series of concentrations of pesticides (below  $100\text{ mg L}^{-1}$  for Etofenprox and below  $10\text{ mg L}^{-1}$  for Diazinon) which was prepared according to the results of the range finding test. Deionized water was used as internal plate control and negative control whilst 15% ethanol was used as positive control. Four apical observations of coagulation of fertilized eggs, lack of somite formation, lack of detachment of the tail bud from the yolk sac and lack of heartbeat at 24, 48, 72 and 96 hours were recorded as an indicator for lethality according to OECD / OCED 236; guideline for the test of chemicals, Fish Embryo Acute Toxicity (FET) test. Results indicated that the median lethal concentration (LC50) of Diazinon and Etofenprox at 96 hours for zebrafish embryos were  $1.975\text{ mg L}^{-1}$  and  $4.800\text{ mg L}^{-1}$  respectively. Growth retardation, shrinkage of chorion, scoliosis, yolk sac edema, hemorrhages, pericardial edema, lack of pigmentation were most potential sub lethal and teratogenic deformities in treated embryos with Diazinon and Etofenprox. An increasing trend of mortality rate with the pesticide concentration and the decreasing trend of LC50 with the exposure time were observed in the present study. Results revealed that exposing zebrafish embryos to minor concentrations of Diazinon ( $1.975\text{ mg L}^{-1}$ ) and of Etofenprox ( $4.800\text{ mg L}^{-1}$ ) can directly affect the survival and embryonic development of zebrafish, it can be used as a cost effective method to assess the hazard potential of pesticides in aquatic bodies.

**Keywords:** LC50, Toxicology, Sub lethal, Deformities

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**Diversity of Molluscs in Disturbed and Undisturbed areas in Intertidal Zone of Thambalagamuwa Bay-Trincomalee, Sri Lanka**

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Thambalagamuwa bay is an important marine ecosystem as well as good natural source of molluscs. Nowadays it is highly disturbed due to the rapid urbanization and destructive anthropogenic activities of the area. There are less number of studies regarding molluscan diversity for east coast belt. In this backdrop this study aimed to analyze the diversity of molluscs in response to anthropogenic disturbance of the intertidal zone of the bay as a preliminary study. Two different regimes (undisturbed/disturbed) were considered. Three sampling sites were selected for each regime considering the parameters such as number of waste water inlets present, number of polythene bags and plastic bottles present in unit area (1m<sup>2</sup>) and number of buildings close to the site. Disturbed area showed  $\geq 3$  for each parameter while undisturbed area showed  $\leq 1$ . Data collection was conducted using line-transect method along with quadrat sampling (quadrat size 0.36 m<sup>2</sup>). For each sample site 3 lines were placed perpendicular to the shore, so that cover the whole sample site. The length of the line was depended on the width of the intertidal region. The distance between two line was 50 m. In each line, six to fifteen quadrats were placed in accordance with the length of the line. Species identified using identification guides. Simpson index of dominance, Shannon index of diversity, Menhinick index for species richness and relative species abundance were calculated for disturbed and undisturbed regimes separately. Index of similarity was also calculated. Three bi-valve species and twelve gastropod species were found within study areas. Shannon index for entire undisturbed area was 0.7097613 disturbed area was 0.570156. Simpson index of dominance for disturbed area 0.5990114 and for undisturbed area 0.74775202. *Batillaria* sp. showed highest relative species abundance for both disturbed and undisturbed regimes. Index of similarity showed 0.909091. Collectively disturbed area showed higher value for Menhinick index (0.880705). In conclusion, value of similarity index trots out that anthropogenic disturbance has no any effect on molluscan population. Simpson, Shannon Weiner indices demonstrates that undisturbed area has high species diversity while Menhinick index demonstrates high species richness in disturbed area. *Batillaria* sp. was the dominant species among all studied molluscs inhabitants.

**Keywords:** Molluscan, Diversity, Disturbance, Thambalagamuwa bay

### **Evaluation of CKDu Parameters with Biofilm Biofertilizer Application**

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Chronic kidney disease of unknown etiology (CKDu) has become a very serious health problem in some parts of Sri Lanka. The causative factors and etiology of this disease therefore is still considered uncertain. Paddy cultivation is one of the key economic sectors in the areas where the CKDu has spread. Cadmium (Cd) contamination and high Fluoride (F) level are suspected to be some of the CKDu parameters in the disease. Chemical fertilizer (CF) is one of the major sources that add heavy metals and F into paddy soil. Cd traces naturally occur in phosphate, and have been shown to get into food through fertilizer application. Many consequences occurred due to excessive amounts of F, within the community of the dry zone Sri Lanka with the evidences of a significant difference of the interaction of fluoride with constituent ions, between endemic and non-endemic regions of CKDu. Biofertilizer is a good alternative to reduce chemical fertilizer application in rice fields. Biofilm -R is a biofilm biofertilizer product commercially available in Sri Lanka for rice. This research was conducted to evaluate CKDu parameters with the biofilm biofertilizer application for rice. Leaching tube experiment was carried out in a Completely Randomized Block design with four treatments, each with three replicates. Full amount (100%) of chemical fertilizers recommended by the Department of Agriculture (DOA), 50% of the chemical fertilizers with "Biofilm R" and "Biofilm R" were used as treatment and initial soil was used as the control. Cadmium acetate was used to spike the soil for the experiment. All crop management practices were done according to recommendations of DOA. Water soluble fluoride and leachate fluoride were determined by using ion selective electrode. Cd contents in soil, leachate and plant (in early vegetative growth) were determined by flame Atomic Absorption Spectrometer. Plant dry weight and height were also measured. Interestingly, the biofilm biofertilizer application showed reductions of fluoride and cadmium contents in leachate and plant, though they were not statistically significant at 5% probability level. Further studies are however necessary to evaluate these effects for a longer period.

*Keywords:* Cadmium, Fluoride, Paddy cultivation, Biofilm biofertilizer

**Prevalence of Parasitic *Sacculina* Species on Blue Swimming Crab (*Portunus pelagicus*) in Waters around Mannar, Jaffna and Trincomalee Districts**

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Blue Swimming Crab (*P. pelagicus*) is an ecologically and commercially important species which is mainly distributed from northwest to northeast coasts of Sri Lanka. Considerable infection of parasitic *Sacculina* species on the *P. pelagicus* resource is recorded. *Sacculina* is a *Rhizocephalan* parasite of order *Cirripedia*. It uses *Brachyuran* crabs including *P. pelagicus* as a host in their parasitic life cycle causing; cessation of moulting and mating, modification of secondary sexual characteristics and infertility. The objectives of present study are to study the prevalence of *Sacculina* infection around the waters of Mannar, Jaffna and Trincomalee districts, studying the locality and topography effect on the *Sacculina* infection and finding out the relationship between the infection and the size of crabs. Data collection was carried out at seven sites; Pelsalai, Paleimune and Illupakadavai of Mannar district, Mandathive of Jaffna district and Kokkilai, Irakkandi and Upparu of Trincomalee district. *P. pelagicus* samples were randomly collected from fishing boats at the landing sites. Carapace length and width, length and width of claws of each sample were measured by a vernier caliper. Samples were checked for infection by means of *externa* and the *scar*. There was no sign of parasitic infection in male samples of all sizes and all infected samples were females. Chi square value for the relationship between the size and the infection was 29.06 ( $P < 0.001$ ) indicating that there is a relationship between the size and the infection. Zero parasitic infection in males supports the sex reversal of infected males suggested in previous studies. Highest infection was observed among crabs of 99 mm to 138 mm carapace width. The infected crabs showed stunting which may be due to absorption of nourishment by the parasite. High prevalence (11.02%) of parasitic infection was observed in calm, sheltered and shallow waters of Palk Bay while zero prevalence was observed in comparatively rough eastern and north eastern waters.

**Keywords:** Crab, Rhizocephala, Occurrence

**Economic Viability of Exploiting Inland Sand Reserves on Flood Plains - with Special Reference to Kirindi Oya Basin**

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Sand is a type of sediment that is found all over the world and mostly consumed natural resource on the planet after fresh water. Recently sand has become a vital commodity for modern economies, as a dominant part of the construction industry. The annual sand requirement is approximately around 10 - 12 million cubic meters. The high demand for sand and escalating sand prizes draw masses into inland sand mining industry as an alternative for river sand. Rapid inland sand mining in the Kirindi Oya floodplain has caused serious problems to various sectors of natural and anthropogenic environments. This study aimed to identify and analyze the environment impact of sand mining at Kirindi Oya flood plain and availability of alternatives for inland sand. The damage caused to the environment has been visually estimated with basic measurements. The impact on the groundwater table has been assessed via geophysical measurements. Resistivity survey was done to assess the depth to the water table in the area and compare the change through public information. There was groundwater depletion due to direct damage to the aquifer caused by sand operations using heavy machinery. Major environmental hazards encountered in these fluvial environs due to over exploitation of inland sand were identified by physical damage observation. The fertile lands degrade into barren lands and the number of sand mined pits in the area remained unfilled, causing severe environmental hazards. The long term damage to fertile farm lands on the floodplains, damage to the semi-confined aquifer that hold enough water for the entire system become beyond repair. Therefore it is concluded that input of sufficient amount of river sand and alternatives to meet the demand shall scrub down the exploitation of inland sand reserves, which produce extensive damage to the environment and to communities.

*Keywords:* Inland Sand, Flood plain, Aquifer, Exploitation



## **Prevention of Upstream Salinity Intrusion and Groundwater Contamination by Kadupitiya Oya Regulatory Anicut on Karambalan Oya**

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A regulatory anicut was constructed in 1904 at 6.5 km upstream to divert the flow in Kadupitiya Oya, a tributary of Karambalan Oya into Tinipitiwewa. Stream water at 1.5 km upstream of the weir is being abstracted at present by National water Supply and Drainage Board as source water for drinking after conventional treatment. The area of the Kadupitiya Oya sub-watershed has been subjected to large-scale silica sand mining. The quality of stream water and groundwater was examined under the dry and wet weather during October and November with a view to determining the effectiveness of the anicut in preventing upstream salt water intrusion and possible groundwater contamination. Electrical conductivity of water samples collected from the Kadupitiya Oya from downstream of the regulatory to about several kilometers upstream and five shallow dug wells of the located in landward area of the right bank were determined under dry weather conditions. In addition, Electrical Conductivity, Total Dissolved Solids, pH, Turbidity, Colour, Sulphate ion, Total Hardness, Total Alkalinity, Chloride ion were determined with the onset of inter monsoonal rains. Shallow dug well water has extremely low Electrical Conductivity under the dry weather ( $178 \pm 106 \mu\text{S}$ ) and wet weather ( $120 \pm 71 \mu\text{S}$ ), which were not different from that of deep groundwater. The electrical conductivity of shallow dug wells located downstream of the regulatory anicut was little higher than that of the shallow ground water upstream of the weir. The mean water level of shallow groundwater levels has increased by about 0.6 m with the onset of second inter-monsoon rainfall in November. The brownish murky colour of the water was apparent in certain shallow dug wells during sampling, which is common over several decades according to the villagers. The depletion of groundwater level occurred in this area can be attributed to both massive silica sand mining and extremely dry weather conditions. The brownish colour water at certain locations is resulting from organic matter deposition during the mid-Holocene sea level rises. The lowest electrical conductivity, which is unique to the area is related to the geology of the overburden, which is mainly composed of silica sand. Regulator weir is an excellent prevent of upstream movement of tidal flow.

**Keywords:** Inland Sand, Flood plain, Aquifer, Exploitation

### **Treatment of Dandruff with Home Remedies-A Literary Review**

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Dandruff is a scalp disease & common complaint among young adults. Dandruff affects often causes itching, hair loss. Modern system of medicine has less effective remedies for dandruff. Most of the time a prophylactic antibacterial or antifungal treatment is initiated which reduces the symptoms, but does not prevent of recurrence. The term 'Home remedy' is a treatment to cure a disease at home or ailment that employs certain spices, some other medicinal plants or plants parts. The objective of this study was to collect the drugs mentioned in the siddha books and journals and to promote the use of home remedies which are used in day to day practice to treat dandruff. Data were collected from authentic home remedy siddha texts, scientific journals and bases such as pub med. There are some of home remedies which used to treat dandruff possesses anti fungal properties. Most of these remedies typically passed from generation to generation by layperson. By the way these home remedies can be a valuable source of information on medicinal plants. Some medicinal plants used as home remedies to treat dandruff such as *Artemisia vulgaris* leaves, *Melothria maderaspatana* leaves, *Ocimum sanctum* leaves and *Curcuma longa* rhizome and their efficacy have also been proven through scientific researches. It can be concluded that abundant home remedies are available to treat dandruff. Crush leaves mix with some other ingredients or can use it as raw. Apply it over the scalp directly or can boil with *Trigonella corniculata* and *Citrus aurantifolia* can apply.

**Keywords:** Dandruff, Home remedy, Medicinal plants, Anti-fungal



# **Food Science and Technology**



## Effect of Domestic and Commercial Level Processing on Proximate Composition of Six Commercially Important Sea Cucumber Species of Sri Lanka

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Market demand for dried sea cucumbers (*Blche-de-mer*) mainly depends on species and product quality which is governed by size, shape, colour, odour and moisture content. In Sri Lanka, sea cucumbers are processed into *Blche-de-mer* by both domestic and commercial level processors using similar processing steps. This study compares the proximate composition of six commercially important sea cucumber species (*Bohadschia marmorata*, *Stichopus chloronotus*, *Holothuria spinifera*, *Thelenota anax*, *Holothuria scabra*, *Bohadschia sp.* unidentified) processed by domestic and commercial level processors. Ten samples of each species processed by domestically and commercially were collected from the Northwest coast of Sri Lanka from October 2015 to May 2016 and analyzed for moisture and dry weight basis of ash, fat, crude protein and carbohydrate percentages. Domestically processed sea cucumber species always reported higher moisture percentages than the commercially processed species. Moisture percentage in commercially processed species varied from 16.64 to 32.95%, while in domestically processed species it ranged from 21.25 to 55.61%. Significantly higher moisture contents were reported in domestically processed *H. scabra* ( $55.62 \pm 7.28\%$ ) and *T. anax* ( $36.80 \pm 1.81\%$ ) than the commercially processed individuals of these species ( $P < 0.05$ ). The ash contents in domestically processed *B. marmorata*, *S. chloronotus*, *H. spinifera* and *T. anax* were significantly higher than those in commercially processed species ( $P < 0.05$ ). Fat contents were very low in all these species and values ranged from 1.2-2.0% in commercially processed species and 0.9 to 3.3% in domestically processed species. Among these species, *S. chloronotus* reported the highest fat content and domestically processed *S. chloronotus* ( $3.38 \pm 0.57\%$ ) had significantly higher fat content than the commercially processed individuals ( $2.12 \pm 0.59\%$ ,  $P < 0.05$ ). Protein contents in commercially processed species were higher than those in domestically processed species. Significantly high protein contents were reported in commercially processed *H. scabra*, *H. spinifera* and *T. anax* ( $P < 0.05$ ), and among them, *H. spinifera* ( $58.11 \pm 0.46\%$ ) reported the highest protein level. Significantly higher carbohydrate contents were recorded in domestically processed *H. scabra* ( $13.20 \pm 1.74\%$ ) and *Bohadschia spp.* than in commercially processed individuals ( $4.43 \pm 3.22\%$ ,  $P < 0.05$ ). However, the mean carbohydrate contents of commercially processed *B. marmorata*, *S. chloronotus* and *H. spinifera* were significantly higher than those in domestically processed individuals ( $P < 0.05$ ). This study revealed that domestically processed sea cucumbers have higher level of moisture and lower level of protein than the commercially processed individuals. As moisture is the key factor that determines the market demand of *Blche-de-mer*, improvements in domestic level processing must be considered.

**Keywords:** *Blche-de-mer*, Sea cucumbers, Processing practices, Proximate composition

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### **Optimization of Brewing Conditions for Different Green Tea Grades on Scientific Basis**

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Physiochemical properties of tea beverage totally depend on factors such as type of tea grade, brewing time and the temperature used. Use of a fixed brewing time and temperature combination in brewing of all tea types is not an effective method to prepare a good cup of tea having a fair liquor strength and quality. Therefore, the study was conducted to determine the optimal brewing methods and the contribution of time and temperature to extract full strength liquor characters to the tea cup as well as to correlate the chemical composition of tea infusions to their sensory properties. Different temperature levels (80, 70, 60 °C) and brewing times (1, 3, 5 min) were used to brew two leafy tea grades and two dust tea grades. Sensory evaluation was done by ten well trained tea tasters and data was collected using 5 point hedonic scale. The data was analyzed in MINITAB 16 software using Kruskal-Wallis non parametric ANOVA method to analyze sensory data while Conover-Inmann method and sensory profile were used for the selection of best treatment combination for the best sensory attributes. Two factor factorial design was used for chemical analysis in each tea type. According to the sensory analysis brewing tea at 80 °C for 3 minutes was selected as the best time and temperature combination for green tea brewing. High caffeine and antioxidant activities were observed at the same time and temperature combination. But, polyphenol extraction is encouraged by longer brewing time. Thus, the study suggested brewing green tea at 80 °C for three minutes is the best time temperature combination to obtain a quality green tea cup with optimum liquor characters.

*Keywords:* Green tea, Time, Temperature, Sensory properties, Chemical properties

## Development of a Functional Beverage Based on King Coconut Water

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Functional food can be considered as those whole, fortified, enriched or enhanced foods that provide health benefits beyond the provision of essential nutrients like carbohydrate, lipids proteins and minerals. The study was carried out with the objective of development of a Ready-To-Serve (RTS) functional beverage based on king coconut water. King coconut water, Banana extract, Matcha tea (Green tea), sugar and yogurt were used as main ingredients. Carboxymethyl cellulose (CMC) and Pectin were tested as thickening agents. Ascorbic acid was used as the acidifying agent. Final product was filled in to 200 ml glass bottles and did heat treatment for 15 minutes at 95 °C. Best combination of ingredients was selected via a sensory evaluation by using nine-point hedonic scale. Considered sensory attributes were colour, aroma, taste, texture and overall acceptability. Sample consists with king coconut water 80%, banana extract 4% and yogurt 16% were selected as the final product. Proximate composition and other physicochemical properties including pH, °Brix and percentage titratable acidity (%TA) of the developed product were analyzed. Microbial tests were done for Total plate count (TPC), Yeast and Mould count and *Escherichia coli*. Sensory data were analyzed by using nonparametric Friedman test and physicochemical properties were analyzed using ANOVA test with 95% confident interval by using MINITAB 17 statistical software. According to the proximate analysis final product contained carbohydrate 13.5%, protein 0.3%, ash 0.5%, fat 1%, Sodium 0.02% and potassium 0.2%. °Brix, pH and Percentage of TA of the final product were 14.1, 4.05 and 0.48 respectively. No significant changes were observed in these parameters during the storage period. TPC and Yeast and mould count were  $< 1.0 \times 10^1$  cfu/ml and *E. coli* was not detected after one month. Self-life evaluation was carried out for six weeks. The developed product can be safely stored at room temperature for one month.

**Keywords:** Functional food, Proximate composition, Ready-to-serve beverage, Sensory evaluation, Shelf life evaluation.



## **Determination of Major Causative Factors for Non-Vacuum Returns of Processed Meat Products**

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Processed meat products contribute a significant portion of human daily nutritional requirement. Due to higher level of nutrient content, these products are highly perishable. With the aim of increasing their shelf life, meat processors use different packaging techniques such as vacuum packaging. But, leakages in vacuum packed products are huge problem in this industry today and can occur during different stages of the production and distribution processes. The objective of this study is to identify the prevalence of non-vacuum returns and the major causative factors for them. Top four returned products with highest recorded sales in May, June and July, 2016, were selected separately in super market chain (modern trade) and retail chain (general trade) to conduct the study. A total of 10% from non-vacuum returns were daily examined for the conditions of vacuum leakage, age of the return packets, gauge and the thinning percentage of the packaging material. A parallel analysis on cold chain condition of five primary and secondary distributors was conducted to check the handling condition and freezer conditions. From whole product range top five returned products due to non-vacuum condition were Party Pack Sausages (500 g); (13.30%), Chicken Sausage (250g); (9.57%), Catering Sausages (450 g); (3.44%), Meat Balls (200 g); (2.13%) and Meat Balls (500 g); (0.86%). Results further showed that the percentage of physical damages in both general and modern trade products were higher (general trade-43.45%, modern trade-54.47%) than micro holes and seems like non vacuum packets. Freezer truck temperatures maintained in the distribution chain were found to be lesser than the recommended level (-18 °C). Hence, it was suggested to strictly maintain the cold chain management and post-processing handling practices at high standards to reduce incidences of non-vacuum returns in processed meat industry as they were the identified most critical factors for non-vacuuming of products.

*Keywords:* Cold chain, Gauge, Non-vacuum returns, Processed meat, Vacuum packaging

## Comparative Nutritional Analysis of Fresh and Preserved Palmyrah Young Fruit Kernel (Ice Apple)

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The study aims to compare the nutritional characteristics of fresh and preserved young fruit kernel of palmyrah and to determine the nutritional characteristics of preserved young fruit kernel with the time. Young fruits of palmyrah which are similar in size and at the same maturity were selected and divided into two portions. The nutrient analysis was done for one portion as a control. The other portion was immersed in palmyrah sweet sap of which the pH and brix values were adjusted to 4 and 25, respectively. The nutrient analysis was conducted for two months consecutively. The results were analyzed by one way ANOVA using MINITAB 17. Preserved young fruit kernel showed significantly ( $P < 0.05$ ) higher fat content [ $0.083(\pm 0.002)$ ] g/100g and ash content [ $0.4250(\pm 0.006)$ ] g/100g than fresh young fruit kernel. Moisture [ $89.270(\pm 0.241)$ ] g/100g, protein [ $0.8375(\pm 0.007)$ ] g/100g and vitamin C [ $4.9382(\pm 0.0905)$ ] mg/100g content were significantly high in fresh young fruit kernel compared to those in preserved young fruit kernel. Total sugar [ $13.8438(\pm 0.054)$ ] g 100g<sup>-1</sup>, reducing sugar [ $3.4632(\pm 0.191)$ ] g 100g<sup>-1</sup> and minerals such as Ca, Na, K and P were significantly high in preserved young fruit kernel compared to those values of fresh young fruit kernel. There were no significant ( $P > 0.05$ ) differences in all the parameters except dietary fiber [ $0.8709(\pm 0.010)$ ] g 100g<sup>-1</sup> and total phenol content [ $0.0578(\pm 0.0006)$ ] g/100g of fresh and preserved palmyrah young fruit kernel. Furthermore, the abundance of the moisture, total ash, protein, total fat, vitamin C, total sugar, reducing sugar, non reducing sugar, dietary fiber, total phenol content, and minerals remained stable throughout the study which lasted for two months. Based on the result, it can be concluded that the sweet sap preservation method significantly changes the nutrient characters it is compared with fresh young fruit kernel. Therefore further studies are required to identify a better preservation technique.

**Keywords:** Palmyrah sweet sap, Palmyrah young fruit kernel, Preservation

**Comparative Study on Sensory Attributes of a Stirred Yoghurt Incorporated with Watermelon (*Citrallus lanatus*) Seed Powder**

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Popularity of yoghurt has increased due to its perceived health benefits. Watermelon (*Citrallus lanatus*) is a fruit crop, is an herbaceous creeping plant belonging to the family cucurbitaceae. Watermelon seeds are often discarded while the fruit is eaten. It is known to be low in calories but highly nutritious and thirst quenching. The aim of this study was to evaluate the consumer preference for yoghurt incorporated with watermelon seed powder. There were two types of watermelon (var. crimson sweet) seed powder obtained through sun drying and oven drying methods. Stirred yoghurts were prepared by incorporating 0, 1, 2 and 3 of seed powder from two different drying methods. Treatments were subjected to a sensory evaluation for colour, texture, flavor and aroma, mouthfeel and overall acceptability sensory attributes, in five point hedonic scale using 30 untrained panelists. Sensory analysis data were analyzed using friedman non parametric test using minitab 17 software. Comparatively, there were no significant difference ( $P < 0.05$ ) between all the treatments. However, scores for flavor and aroma and mouthfeel showed high scores as 98.5, 95.0, respectively. Sun dried watermelon seed powder incorporated stirred yoghurt showed higher preference by the consumer compared to oven dried watermelon seed powder incorporated stirred yoghurt.

**Keywords:** Stirred yoghurt, Watermelon seed, Sun drying, Oven drying

## Evaluation of Histamine Concentrations in Different Export Categories of Yellowfin Tuna (*Thunnus albacares*) Received at Dikkowita Fishery Harbor from Multi-Day Boats

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Histamine (C<sub>5</sub>H<sub>9</sub>N<sub>3</sub>) is a biogenic amine and can be produced during storage and processing of certain fish species, especially tuna and tuna like fish, usually by the action of spoilage bacteria. This process starts soon after the death of the fish by the conversion of histidine into histamine, which can ultimately add a detrimental effect on the final product quality. Histamine concentration is of great concern as a critical parameter in the seafood exportation trade. Dikkowita fishery harbor, Western province, Sri Lanka is renowned for receiving the highest quantities of export quality yellowfin tuna (*Thunnus albacares*) by multi-day boats. The quality of yellowfin tuna can be graded into five quality categories (grade AAA, AA, A, B and reject-grade) based on the on-site sensory evaluation of core samples of flesh obtained by plugging a stainless-steel probe into the fish. In the present study, the core samples of yellowfin tuna flesh were randomly collected from all five quality categories, as 10 from each grade, and those were analyzed for the histamine concentrations using rapid colorimetric method. Grades AAA, AA, A, B and reject-grade contained  $5.18 \pm 3.26$ ,  $7.83 \pm 4.35$ ,  $9.29 \pm 5.23$ ,  $9.44 \pm 3.83$  &  $16.16 \pm 13.16$  (mg/100 g<sup>-1</sup>) levels of mean histamine concentrations, respectively. Fish samples of AAA, AA and A categories showed low mean histamine levels compared to the reference levels (10 mg/100 g<sup>-1</sup>) as stipulated by the European Union and Sri Lankan guidelines for food fish exportation. The mean histamine levels of grade B and reject-grade exceeded the reference level in 60 and 70%, respectively, from the analyzed 10 fish samples of each category. By applying good handling practices and improving the storage conditions, the post-harvest quality loss that is resulted due to increase of histamine concentration can be minimized, especially in low quality grades (B and reject-grade). This can lead to secure more profits by the exportation of good quality yellowfin tuna fish.

**Keywords:** Histamine, Yellowfin tuna (*Thunnus albacares*), Dikkowita fishery harbor, Export categories, Multi-day boats

### **Development of Fruit Incorporated Nutritionally Rich Rice Milk Shake**

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Rice milk which is grain milk made from rice, does not contain lactose or cholesterol. It can be used as a dairy substitute for vegans. This study was carried out to formulate nutritionally rich rice milk shakes with preferable sensory qualities by using both high amylose and low amylose containing rice. Four white pericarp rice varieties- (At 309, At 405, Bg 300 and Bg 360) were used for the preliminary studies and variety At 309 was selected through a sensory evaluation. The rice milk shake base was prepared using At 309 variety rice flour (3.5%), sugar (8.76%), salt (0.17%) and water (87.57%). Pineapple and wood apple fruit pulp into 10, 15, 20 and 25 ratios and rice bran obtained from rice variety At 362 (1, 2, 3 and 4 ratios) were incorporated with the base of the rice milk shake. Sensory evaluation was done in order to select the best treatment using 9-point hedonic scale. Pineapple, wood apple and wood apple with rice bran added rice milk shakes were prepared as the final products. These final products were packaged in 190 ML glass bottles and stored at room temperature after water sterilized them. Quality of the final product and shelf life were evaluated in once a fortnight by using brix value, acidity, pH value like physicochemical properties, total plate count and yeast and mould count like microbial properties and sensory properties. The results of proximate analysis revealed that wood apple with rice bran added rice milk shake had higher nutritional value than others. Any significant differences among high (Bg 300, Bg 360) and low (At 309, At 405) amylose content rice varieties were not observed. No significant differences were observed in physicochemical properties during the storage period. The product can be safely stored for 1 month period at ambient temperature. Rice milk shake is a good way to add value to the *Oryza sativa indica* sub species.

**Keywords:** Nutritionally rich, Pineapple, Rice bran, Rice milk shake, Wood apple

## Effect of Combustion Material on Chemical and Sensory Properties of Smoke-Dried *Catla catla* (Catla)

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Fish is considered as a nutritious but highly perishable food. For the purpose of ensuring long shelf life, it is preserved in many methods. Smoking is considered as one of the traditional yet highly used method to preserve fish commercially. But, no such conditions have been developed for catla in Sri Lanka. This study was conducted to select best smoking condition with least cost and higher keeping quality for *Catla catla* (Catla). Medium size (6-8 kg) male fish were collected from a local reservoir in Monaragala. All treatments were done at 45 °C for 2 to 4 hours. Albizia, cinnamon, mahogany and straw were selected as the combustion materials as with availability and cost. Quality of smoked fish in each treatments was evaluated for sensory parameters by 7 point hedonic scale using 30 untrained panelist in the age of 21-25 years in both sex. According to the sensory results, paddy straw was selected as the most suitable main combustion material (P <0.05). Then, combinations of paddy straw and other materials were evaluated (Albizia, Cinnamon and Mahogany with 0, 5, 10, 15, and 20%). According to the sensory data, 10% (w/w) cinnamon and 15% (w/w) Mahogany was selected and in final sensory evaluation revealed 15% (w/w) Mahogany as the best (P <0.05). Smoke generated in selected treatments were collected directly from smoking chamber as gaseous form and analyzed for volatile compounds under GC-MS. As biochemical parameters, anti-oxidants and pH were analyzed for selected smoked product. Contamination of *Escherichia coli* spp. *E. coli* and *Salmonella* spp. were examined in 25g of sample as the bacterial parameters. GC-MS data showed the smoke generated contain furans, acetic and propanoic acids, ketones, phenols and D-glucopyranose which may have improved the flavour, colour, texture and the keeping quality of the final smoked product. pH of the product varies from 5.87 ± 0.19 to 6.22 ± 0.24 while oxidation results (TBARS and DPPH assay) reveals the product can be stored for 14 days under -18 °C under LDPA normal sealed packaging conditions. Microbiology data confirmed the product is free from *E. coli* and *Salmonella* spp. However further improvements can be done with different packaging conditions and combination with different spices to the final product.

**Keywords:** Smoked fish, Catla, Chemical properties, Sensory properties

**Effect of Pretreatments on Quality Parameters of Minimally Processed  
*Dioscorea alata***

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Time consuming preparations and browning on cut surfaces of *D. alata* develop a reluctant feeling on consumers regardless of its high nutritive value. In present study, *D. alata* cubes (2x2x2 cm<sup>3</sup>) were treated separately with 3% ascorbic acid (T1), 3% citric acid (T2), 2% calcium chloride (T3), Distilled water (T4, control), edible coat (T5, *D. alata* endophytic bacterial exudates in Nutrient Broth), and Nutrient Broth (T6) for 5 minutes, drained, sealed in Low Density Polyethylene packages and stored at 5-7 °C for 7 days following the Completely Randomized Design with three replicates for each pretreatment. Quality of treated samples were assessed for weight loss, moisture content, Total Soluble Solids (TSS), pH, Titratable Acidity (TA), ascorbic acid, bacterial count, *Escherichia coli* contamination and degree of browning on 0<sup>th</sup>, 3<sup>rd</sup> and 7<sup>th</sup> day, nutrient profiles were analyzed by Fourier Transform Infrared Spectroscopy (FTIR) and sensory evaluation of samples was done using 30 untrained panelists, providing a seven point ranking system for minimally processed raw product. Data were analyzed by ANOVA and Kruskal Wallis test. The percentage weight loss was significantly less ( $p \leq 0.05$ ) in T3. Moisture content was significantly high ( $p \leq 0.05$ ) in T1, T2, T3 and T6 compared to control. TSS was gradually increased with storage time for T2 and T6. Ascorbic acid content and pH were highest in T5 compared with rest and TA was significant ( $p \leq 0.05$ ) in T2 on 7<sup>th</sup> day. T3 and T5 obtained high ranks for sensory properties (appearance, colour, odour and overall acceptability) and were the best in retardation of enzymatic browning. The bacterial counts were within safe-to-consume limit and *E. coli* was not detected for all treatments. Nutrient profiles (total carbohydrates, fatty acids and amides) were not significantly differed among treatments indicating the absence of chemical compositional alteration. According to the results, Calcium chloride (T3) and exudates of *D. alata* endophytic bacteria (T5) were the most compatible pretreatments in maintaining quality of minimally processed *D. alata* under cold storage for 7 days.

**Keywords:** Minimal processing, *Dioscorea alata*, Pretreatments, Sensory properties, Enzymatic browning.

## **A Feasibility Study on Implementing Total Quality Management for Secondary Tea Manufacturing Factory**

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Tea is internationally consumed agricultural commodities that increase foreign earnings to the Sri Lankan economy with a global reputation as "Quality Ceylon Tea". Tea manufacturers need to assure consumers health and safety while reaching zero defects. Among the quality standards, HACCP focuses on hazards present in the final product and Total Quality Management (TQM) focuses on overall quality of the final product. Therefore it is important to identify the significant gaps between existing HACCP over TQM to the secondary tea manufacturing firm. This study was carried out to identify the gaps between HACCP and TQM and to fill the gaps in secondary tea manufacturing firm to implement TQM. Gaps were identified with observing the existing data and interviewing the people involved. Thirty applicable solutions were suggested to fill the identified gaps. Cluster analysis and Friedman test were done to split the suggested solutions into three clusters with a Grand median of 1.77, 1.68 and 1.10 and to prioritize each cluster separately based on these values on implementation TQM respectively. Further, the most effective solutions were selected based on Sum of Ranks values (best solutions as 01). Accordingly solutions are prioritized as, providing easy access to the factory and fire extinguishers (58.5), advising workers to use safety measures (72.5), maintaining clean environment in production area (80.5) and removing unnecessary foreign particles accumulations in production area (83.5). Prioritization is done according to these values and solution with least value is considered as most important solution for implementing TQM. Therefore the implementation of these solutions will increase the quality of tea products assuring the food safety and consumer security while building loyal customers, reducing cost of production and uplifting the reputation of business entities in quality context.

*Keywords:* Food quality, HACCP, clusters, gap analysis



### **Identification of Minimum Ethrel Concentration and Exposure Time on Induce Ripening of "Embul" Banana (*Musa spp*)**

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Climacteric fruits, including bananas are frequently harvested at 'commercial maturity' stage and are subsequently allowed to ripen naturally or artificially. To induce the ripening process, the use of ethylene gas is the most suitable way as that results high quality fruits. Ethylene released from ethrel could be used as a ripening agent in 'embul' banana. To minimize the chemical exposure to the fruits, this study was carried out to examine the ripening index of 'embul' banana under low concentration and low exposure time than the existing recommended concentration ( $1 \text{ mL L}^{-1}$ ) and exposure time (24 hours) of ethephon ( $480 \text{ g L}^{-1}$ ) on induced ripening of 'embul' banana. In this study, two different concentrations of ethrel as  $0.5 \text{ mL L}^{-1}$  and  $1 \text{ mL L}^{-1}$  and two different exposure times as 12 hours and 24 hours were tested. After the subjected bananas attained the table ripening stage the quality parameters were tested. The tested quality parameters were percentage weight loss, firmness, peel colour, odour, disease index (DI), visual quality rate (VQR), total soluble solids (TSS) /<sup>o</sup>Brix value, pH, percentage titrable acidity (TA) and Vitamin C content. By giving equal values to all the above parameters which were analysed separately in "Embul" bananas at table ripening stage, the ripening index was calculated. Using this ripening index the overall quality of banana was analysed separately for each and every treatment. According to the results there was a significant difference in the total ripening index with treatments. The highest mean value of overall ripening index (73.667) was resulted for the  $0.5 \text{ mL L}^{-1}$  ethrel concentration with 24 hours exposure time. According to the results, favourable quality of ripen banana was observed for the  $0.5 \text{ mL L}^{-1}$  ethrel concentration with 24 hours exposure time. To minimize the chemical exposure to the fruits and for the commercial optimization of the storage life, the  $0.5 \text{ mL L}^{-1}$  ethrel concentration with 24 hours treatment should be favourable.

**Keywords:** Banana, Chemical exposure, Ethrel, Induced ripening, Ripening Index

## **Study on Sensory Attributes of Value Added Ready to Serve Canned Chicken Soup**

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Canning is a preservation method in which the food contents are processed and sealed in an airtight container. People have increased the consumption of ready to serve food products due to the change in lifestyle. Hence, the present study was conducted with the aim to develop and assess the sensory quality of a value added ready to serve canned chicken soup. Canned chicken soup was prepared using 65% deboned chicken meat, 5% green onion, 4.7% carrot pieces, 4% corn starch, 4% black pepper, 4% bell pepper, 4 coconut oil, 3.5% potable water, 2.2 soy sauce and 1.6% vinegar. Sensory evaluation I was conducted to find out the best salt level among 0, 2, 2.4 and 2.8%. Sensory evaluation II was conducted to adjust suitable salt:sweet flavor ratio by incorporating kithul treacle as 2:0, 2:1, 2:2 and 2:3% (w/v). Treatment with 2:0 salt:kithul treacle served as control. Cans were subjected to heat treatment at 121<sup>0</sup>C for 90 minutes. Treatments were evaluated using 30 untrained panelists for sensory attributes as color, flavor, texture, taste, smell and overall acceptability at room temperature. Sensory data were analyzed by Friedman non parametric test and data of physicochemical parameters analyzed using t-test using MINITAB 16 statistical package. According to sensory evaluation I results, 2% of salt level was selected and there was significant difference ( $P < 0.05$ ) with respect to color, flavor, texture, taste, smell and overall acceptability while based on sensory evaluation II, 2:1 of salt:kithul treacle level was selected and there was significant difference ( $P < 0.05$ ) with respect to colour. Chicken soup contained 2% salt and 1% kithul treacle showed highest overall acceptability scores (84.5) compared to the control. There was no significant difference ( $P < 0.05$ ) with respect to moisture content, ash content, water holding capacity and pH compared to control.

*Keywords:* Canned chicken soup, Ready to serve, Kithul treacle

**Effect of Cooking on Antioxidant Properties in Selected Rice Varieties  
(*Oryza sativa* L.) Popular in Sri Lanka**

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This study was carried out to investigate the variation of antioxidant activity (AOA) and total phenolic content (TPC) in twelve Sri Lankan rice varieties under different cooking treatments (raw, cooked raw rice, parboiled rice, cooked parboiled rice and extraction at gelatinization temperature). Eight improved varieties: Bw 272-6b, Bg 300, Bg 360, Bg 94/1, Bg 352, At 362, At 311 and Bw 367 and four traditional varieties: Sudu Heenati, Kalu Heenati, Madathawalu, Suwandal were collected from Rice Research and Development Institute, Bathalagoda. AOA was determined by using 2,2-diphenyl-1-picrylhydrazyl (DPPH) method and TPC was analyzed by using Folin Ciocalteu method. Data were analyzed using the Minitab 17 statistical software. Significant differences were observed in the AOA and TPC among different varieties with different cooking treatments ( $p < 0.05$ ). Positive correlation was found between AOA and TPC. Highest AOA and TPC had in the raw form of rice. Bw 272-6b and Madathawalu recorded the highest antioxidant activity ( $84.59 \pm 2.46$  and  $84.43 \pm 2.93\%$  respectively) and the highest total phenolic content ( $141.62 \pm 5.33$  and  $129.59 \pm 7.11$  mg GAE  $100 \text{ g}^{-1}$  DW, respectively). Based on the antioxidant activity, raw rice varieties could be clearly categorized into three significantly different groups: group I, group II and III ( $P < 0.05$ ). Antioxidant activity of the groups I, II and III varied between 84.59 - 76.68, 31.93 - 64.34 and less than 29.02%. Parboiling reduced the antioxidant properties in the grains and in a similar way, cooking also reduced the antioxidant properties in raw rice and parboiled rice due to the thermal reduction. After cooking, reduction of antioxidant in raw rice is higher than parboiled rice. Extraction at gelatinization temperature had less antioxidant reduction. Therefore, it could be concluded that the antioxidant properties shows high diversity among different rice varieties under different cooking treatments.

**Keywords:** Antioxidant activity, Cooking treatments, Polyphenol, Rice

## **Study of Increment of the Cooling Efficiency of Raw Milk Using Standard Deep Freezers**

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This study was carried out to develop a method to increase the cooling efficiency of raw milk in standard deep freezers, utilizing a brine solution and an agitation method. Four types of steel milk cans of 5, 10, 20, and 40 L were used in the study. NaCl solution was used as the test brine medium and steel cans were arranged to be dipped in brine medium while cooling. The agitation method was designed by modifying the lid of the steel cans. The effect of three different strengths of NaCl solution (20, 23, and 25%w/w) and two agitation speeds (10 and 20 rpm) on decrease of temperature of raw milk to 4 °C in a standard deep freezer was evaluated. Milk can without surrounding brine medium and without agitation method was used as the control. Three temperature data loggers were placed at the bottom, center, and side of the milk can in order to identify the temperature differences of the specific areas of the cans while cooling. The effect of the brine medium and the agitation method on increment of the cooling efficiency was evaluated by comparing the cooling rates of treatments with control. Total plate count of milk was evaluated before starting of cooling, middle of cooling and at the end of cooling to evaluate the decrement of microbial growth while cooling. Statistical analysis was done by using completely randomized design and Minitab16 software. The best brine solution and best agitation method, which gave highest cooling efficiency in 5, 10, 20, and 40 L cans were 23% w/w NaCl and 20 rpm, respectively. According to the statistical analysis, the cooling efficiency is significantly higher ( $P < 0.05$ ) in brine solution surrounded milk can compared to the control. Also, the cooling efficiency is significantly higher ( $P < 0.05$ ) in agitated milk can compared to the control.

*Keywords:* Raw milk , Standard Deep Freezer, Agitation, Temperature, Milk Can

## Comparative Study on Processing of Maldives Fish Using Selected Freshwater and Marine Fish Species

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Current study focused on assessing the potential of processing maldivian fish using commonly available freshwater and marine fishery resources in the local market to identify alternative fish varieties which are suitable for maldivian fish production in Sri Lanka. Two treatments were used in the current study and equal portions of *Auxis thazard* (Frigate tuna), *Euthynnus affinis* (Kawakawa), *Amblygaster sirm* (Spotted sardinella), *Labeo rohita* (Rohu) and *Channa striata* (Striped snakehead) were subjected to 2 treatments (treatment 1: conventional boiling, treatment 2: non-boiling with addition of fish: spices in 10:1 (w/w) ratio). All treatments were assessed for organoleptic, nutritional, chemical and biological parameters to identify the most acceptable products. All maldivian fish products were in the acidic range (pH value: 4.94 - 6.42) and negative for *Escherichia coli* test. Least consumer preference (Estimated median:3.00 - 3.10) was given for freshwater fishery resources, signifying non-suitability for maldivian fish production. Final product processed using *Euthynnus affinis* subjected to boiling was the best product with highest (Estimated median:4.50) consumer acceptability. Relatively higher protein level was recorded for the maldivian fish of *Euthynnus affinis* (52.58 %), while maldivian fish of *Labeo rohita*(43.53 %) had the lowest protein levels. *Euthynnus affinis* was identified as the most appropriate alternative fish source, for maldivian fish production, based on overall sensory and nutritional qualities. Boiling method without addition of spices is highly acceptable processing method compared to the non-boiling method, as boiling enhance the organoleptic properties in the final product. Results of the current study would be important for enhancing maldivian fish production using different kind of selected alternative fishery resources in Sri Lanka.

**Keywords:** *Euthynnus affinis*, Organoleptic parameters, Nutritional quality, Freshwater fish, Marine fish

## **Performance Analysis of Prototype Far-infrared Tea Dryer in Black Tea Manufacturing**

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Sri Lanka and most of other countries are still using conventional type, Endless Chain Pressure Dryers and Fluidized Bed Dryers, which are energy inefficient. In addition to that, dendro-thermal power is used in these dryers, which causes environmental pollution and have many other limitations. Far infrared dryers are unavailable for industrial use at present. Therefore, this study was conducted with an objective of identifying the essentials for developing a prototype dryer using far-infrared radiation for black tea manufacturing. Further, the performance of the developed dryer and the quality of black tea dried using this dryer were assessed. Fermented tea dhool were dried by four 600W infrared panels, changing the combination of far infrared radiation temperatures (255 °C, 220 °C, 200 °C, 185 °C and 170 °C) and exposure times (1 , 1.5 , 2 , 2.5 , 3 and 3.5 min) with the design of two factor factorial design replicating each three times. A K-type thermocouple thermometer was used to measure the temperature. The results revealed that, total polyphenol content of dried tea decreases with the exposure time in all temperature levels. Specific energy consumption showed inversely proportional relationship with the temperature. The liquid flavor, liquid aroma and infused leaf colour were almost similar for the tea samples dried using prototype drier and normal factory dried tea samples. However, the optimum combination of temperature and exposure time of dhool was found to be 185 °C and 2.5 min for sample 22. Further sample 22 showed better estimated median value for liquor colour, dry leaf colour and dry leaf appearance too. Therefore, it can be concluded that, far-infrared has high potential as a source for drying the fermented tea dhools. Further studies should be conducted to improve the precision temperature control which could possibly make to utilize the high- temperature region of far-infrared.

**Keywords:** Far-infrared radiation, Dryer performance, Black tea manufacturing, Specific energy consumption, Sensory evaluation

## **Effect of Temperature and Drying Time on the Quality Characteristics of Vacuum Dehydrated Tomato Flakes**

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Tomatoes are one of the most widely consumed vegetables in the world and are rich source of lycopene, polyphenols, anti-oxidants and vitamin C. However, tomatoes are not properly utilized during the peak production season and it is estimated about 40-60% of the harvested tomatoes are wasted annually world-wide. Dehydration of tomatoes into flakes is an effective method of prolonging the shelf life. Therefore, a study was conducted to develop dehydrated tomato flakes and to assess its quality characteristics. Ripe tomatoes were cut into 5mm thick slices and dipped into the 0.02% potassium metabisulphite solution for 5 minutes. These slices were dried in a vacuum oven at 0.045 atm at the time-temperature combinations of 50 °C for 15 hrs, 60 °C for 12 hrs, 70 °C for 10 hrs and 80 °C for 8 hrs. Physico-chemical parameters such as moisture, titratable acidity and ascorbic acid were estimated in the tomato flakes using standard methods. The results revealed that there were significant differences ( $p < 0.05$ ) among the different temperatures used for dehydration. The moisture content of the tomato flakes ranged from 2.14-5.43% on dry weight basis. The titratable acidity of dehydrated tomato flakes was lower than the fresh tomato. This is due to the evaporative losses of volatile acids during dehydration. There were substantial reductions in ascorbic acid content from 58.2mg/100g in fresh ripen tomato to 17.6 mg/100g in tomatoes dried at 80 °C for 8 hrs. The reduction may be due to the oxidative losses of ascorbic acid during dehydration at high temperatures. The total plate counts ranged from 9-15 cfu/ml in the dried tomatoes flakes which were within the recommended safe limit of  $\leq 30$  cfu/ml for dehydrated foods. A seven-point hedonic scale was used to assess the organoleptic characteristics of the tomato juice prepared from the tomato flakes. The results revealed that there were no significant differences ( $p > 0.05$ ) between the acceptability of the fresh tomato juice and the reconstituted tomato powder dehydrated at 60 °C for 12 hrs with regard to flavour, taste, colour, absence of off-flavour and overall acceptability. The findings of this research revealed that the vacuum-dehydrated tomato flakes developed from the tomatoes dried at 60 °C for 12 hrs had the highest overall quality in terms of physico-chemical, microbial and organoleptic characteristics.

**Keywords:** Ascorbic acid, quality evaluation, tomato flakes, vacuum dehydration

## Comparison of Different Enzymatic Inactivation Methods for Ovalbumin and the Functional Properties of Peptides Derived.

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Ovalbumin is the predominant protein in egg white, which contributes more than 50% of the total egg white proteins. Peptides derived from ovalbumin showed many functional properties. However, no research has been carried out to check the effect on peptides derived from the inactivation methods used. The objectives of this study were 1). to compare peptides derived from ovalbumin using heat and pH inactivation methods and 2). to compare the functional properties of the peptides in the hydrolysates. Ovalbumin (20mg/ML) was hydrolysed using protease from *Bacillus licheniformis* ( $>2.4$  U/mg) as 1:100 with different incubation time as 0, 3, 6, 9, 12, 24 hours for 37 °C. As inactivation methods, heating for 100 °C for 15minutes (HT) and adjusting the pH to 10.0 (PT) were used. Peptides derived from two treatments were checked with 15% SDS-PAGE. Locally isolated *Salmonella* spp. and *Escherichia coli* were used to check the antimicrobial activity of the peptides derived, with Augmentin<sup>XR</sup> (0.001 ppm) and distilled water as a positive and a negative control, respectively. Iron and copper chelating activities were used for their metal chelating activities. The results indicated that both HT and PT had no antimicrobial effects on either of the microbes at any given time period. However, HT showed high iron chelating activity (70 - 80%) and no significance difference was observed ( $P > 0.05$ ) between 0 to 24 hours incubation time. With HT, the iron chelating activity was decreasing with the time. a significant  $P < 0.05$  difference was observed in copper chelating activity between PT and HT. All treatments in PT showed negative values, indicating the release of  $\text{Cu}^{2+}$ . However, with HT treatment, 60% copper binding ability was observed in sample incubated for 3 hours, but the values decreased with the time. The results indicated that the peptides derived from two inactivation methods were different. However, further studies are needed to confirm these results by analysing the peptides and their structure.

**Keywords:** Ovalbumin, Enzymes hydrolysates, Antimicrobial, Metal chelating



### **Effect of Two Packaging Materialson Shelf Life of UHT Milk**

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Ultra High Temperature (UHT) treated milk is a long shelf life milk product which is packaged in different packaging materials and intended to be stored without refrigeration for 3-6 months. However, some UHT manufacturers have a problem of limited shelf life in their UHT product. Packaging material is an important factor limiting the shelf life of UHT milk products. The study tests the effect of two different packaging materials on shelf life of UHT milk. UHT milk were produced and packaged in two different packaging materials as three layer film and five layer film and stored at room temperature for 2 months. Physiochemical parameters including pH, Titrable Acidity(TA), Fat and Solid Non Fat(SNF) and, microbiological parameters including Total Colony Count(TCC), Thermophilic Bacteria(TB), *Escherichiacoli* (E.coli) were determined using standard methods at weekly intervals during the 2 months storage period. Sensory analyses were carried out at weekly interval during shelf life using 9-point hedonic scale to evaluate colour & appearance, mouthfeel, taste, flavor and overall acceptability. Data were analyzed using one way ANOVA with  $P < 0.05$  significant level and general linear model by Minitab 17. Friedman test was performed to compare the mean values of sensory parameters. TA of UHT milk packaged in 5 layer film was significantly lower compared to the UHT milk packaged in 3 layer film. Flavor, Mouth feel and overall acceptability of UHT milk were significantly higher in 5 layer packaged product compared to 3 layer packaged product starting from week 2. TCC, TB and E.coli were zero until 6 weeks of shelf life in both 3 & 5 layer film packaged UHT milk. After 6 weeks TCC were significantly increased in 3 layer film packaged UHT milk compared to 5 layer film packaged UHT milk. There was an increase in acidity but fat and SNF decreased in both sample during storage period. pH of the milk packed in 3 layer film was significantly lower from 6<sup>th</sup> week compared to the 5 layer film packaged product. The 5 layer film increased the shelf life of UHT milk in comparison to 3 layer film according to physiochemical, biological and sensory parameters analyzed.

**Keywords:** Physiochemical, Thermophilic bacteria, Total Colony Count(TCC)

## **Isolation of Commonly Found Foodborne Pathogens in University Cafeteria using Outbreaks in 2016 and Possible Remedies to Minimize the Contamination**

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Fresh vegetables bring high risk of contamination of foodborne pathogens. Due to minimally processed nature, it poses high risk of foodborne outbreaks. Among those pathogens, *Escherichia coli* is one of the most common food borne pathogens. Presence of *E. coli* indicates fecal matter contamination in food and make risk due to pathogenicity of strains like *E. coli* O157:H7. This study was carried out to identify the contamination sources of microbes which caused acute diarrhea conditions in Uva Wellassa University, Badulla from April to November in the year 2016. Due to high number of disease recordings, water samples, including fresh and processed vegetables; cooked rice, meat and fish from both cafeterias were analyzed. Plate count agar was used as the preliminary media and EMB (Eosin Methylene Blue) Agar and MacConkey agar media were used for straining out the pathogens. As with the observed results, fresh green leaves were positive for *E. coli* contamination. For the confirmation of *E. coli*, Indole test, Methyl Red test, Voges-Proskauer (VP) test, Citric Utilization test and gram staining were done. According to the observations, identified strain were rod shaped and Gram negative. Results showed positive for Indole and Methyl Red tests while negative for Citrate and VP tests. In order to identify the root of contamination, leafy vegetable samples were checked from farm to cafeteria. According to the observation, samples were contaminated from the field by manure used by the farmers and water applied. To minimize similar incidence, applying Good Agricultural Practices (GAP) in to the farm will be benefitted. Also, advising the farmers as well as distributors, food handlers in the cafeteria will help to minimize the occurrence of cross contaminations to the final food consumed.

**Keywords:** *E. coli*, Foodborne pathogens, Good Agricultural Practices(GAP)

## **Development of a Vegetable Salad Dressing and Evaluation of its Nutritional, Physicochemical and Sensory Properties**

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Fat soluble vitamins contained in edible vegetables play important roles in promoting overall health. Absorption of fat soluble nutrients from salads can be increased by addition of oil based salad dressing. The study was carried out with the objectives of formulation and development of a vegetable salad dressing for Sri Lankan origin. Four oil types were used for the preliminary studies. They were vegetable oil, sesame oil, soy bean oil and, olive oil. Vinegar, wheat flour, curry leaf powder, pepper, salt, sugar, carboxymethyl cellulose (CMC) vitamin E, and egg yolk were used as other ingredients. Best recipe was selected by conducting a sensory evaluation using nine point hedonic scale. Vegetable salad dressing incorporated with vegetable oil was selected as the best recipe out of four recipes. The total soluble solids (TSS), percentage titratable acidity (%TA), pH and microbiological properties (including total plate counts and *Escherichia coli*) were analysed using standard methods. Sensory parameters including colour, aroma, taste, texture and overall acceptability were evaluated using 10 panelists for the selected product for five weeks of storage period at two weeks interval. Sensory data were analysed using MINITAB 17 statistical software by Friedman non parametric test and the shelf life data were analysed with one way ANOVA test with 95% confidence level. Final product contains 55.2% moisture, 23.3% fat, 8.3% ash, 2.1% crude fiber and 5.7% crude protein. TSS, %TA and pH of the final product were determined as 18, 0.33% and 4.08 respectively. No significant changes were observed in TSS, %TA and pH up to the 5<sup>th</sup> week of the storage period. Microbial counts were less than the standard minimum limits. Highest consumer preference was observed in the 3<sup>rd</sup> week after preparation. According to the results, the developed vegetable salad dressing can be safely stored under room temperature for five weeks.

**Keywords:** Physicochemical properties, Salad dressing, Sensory evaluation, Shelf life

## **Determining the Functional Properties of Hydrolyzed Ovalbumin Incorporated Fish Cake Produced from Catla (*Catla catla*)**

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Fish cake contains higher amount of essential proteins, lipids and minerals. Ovalbumin is the major protein in egg white and can be used to produce bioactive peptides with various functional properties which can be used in food industry. Objective of this study was to determine the functional properties of hydrolysates of ovalbumin once it is incorporated in fish cake. Ovalbumin (20 mg/ML) was hydrolyzed with 1% pepsin (1:100) for 0 hours (0 h incubation refers to immediately after the addition of enzyme) and followed with heat inactivation at 100<sup>0</sup>C for 15 min. Fish cakes were produced using nitrite: hydrolysates in ratio of 100:0 (125 ppm nitrite as positive control), 0:100 (Tr<sub>1</sub>), 50:50 (Tr<sub>2</sub>) and 125 ppm of ovalbumin as negative control and incorporating fish (64 %), bread crumble (17 %), ice (12 %), vegetable oil (4 %), salt (2 %), chili (0.5 %), black pepper (600 ppm), MSG (10 ppm), cardamom (7 ppm), sugar (200 ppm), milk powder (10 ppm). Samples were cooked at 80 <sup>0</sup>C to a core temperature of 72 <sup>0</sup>C and cooled in cold water to 20 –25 <sup>0</sup>C All samples were sealed in polyethylene and stored in a freezer (-18 <sup>0</sup>C) for 21 days for analysis. Antimicrobial studies were conducted for *Escherichia coli* and *Salmonella* on 0, 3, 6 and 9 day of storage and all samples were negative for both microbes throughout the study. Keeping quality studies were done with antioxidant activity with TBARS value as concentration of malanaldehyde (mg/Kg) at 03 days interval up to 21 days and DPPH assay and pH values were determined at 03 days interval up to 21 days. As with TBARS, DPPH and pH values of the product were within the range of acceptable levels. As with metal chelating, Fe<sup>2+</sup> was bound to the fish cake while Cu<sup>2+</sup> was not in Tr<sub>1</sub> and Tr<sub>2</sub>. However, no significant difference was seen in Tr<sub>1</sub> and Tr<sub>2</sub> (P >0.05) in metal chelating. But, in positive and negative treatments could not observe such effect in metal chelating. As conclusion hydrolyzed ovalbumin can be a good replacer for the nitrite in fish cake production as it has many functional activities.

**Keywords:** Antimicrobial, Antioxidant, Fish cake, Hydrolyzed ovalbumin, Metal chelating

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### Comparison of Hydrolyzing Rates and Granule Morphology of Starches Available in Sri Lanka

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The Asian region is currently in the midst of a diabetic pandemic, and it is believed that dietary patterns are partly responsible for this phenomena. Rice is the principal staple of the Asian diet, and high consumption of white rice is thought to increase the incidence and prevalence of diabetes. The objective of this study was to analyse the hydrolyzing rates and the granule morphology of 16 starches available in Sri Lanka. The Selected samples were Atta, Chickpea, Corn, Kithul, Kurakkan, Mandu, Oats, Olu, Palmira, Raw Red Rice, Red Basmati, Soy, Undu, Wheat, White Basmati, White Raw Rice and obtained 100 - 180  $\mu\text{m}$  particle sized dry powder for analysis. The hydrolyzing rate was determined through enzymatic digestion with amyloglucosidase and  $\alpha$ -amylase using the GOD method and the granule morphology of the starches was determined using Scanning Electron Microscopy (SEM). Hydrolyzing rates of the starches for amyloglucosidase and -amylase ranged from  $2.10 \pm 1.25 - 174.37 \pm 9.96 \mu\text{Mmaltose/min}$  and  $4.78 \pm 3.04 - 85.69 \pm 8.18 \mu\text{Mglucose/min}$  respectively. The highest maltose and glucose releasing rates were observed respectively in Palmyra and Oats while the least rate was observed in Soy on both occasions. The average granule size of the starches ranged from 12.22 - 1457.20  $\mu\text{m}^2$ . Largest granule sizes were found in Mandu, Kithul, Chickpea and Oats while White Basmati, White Raw Rice and Red Basmati had markedly smaller granule sizes. An inverse relationship between granule size and the hydrolyzing rate was observed. Anyhow, further studies are required to confirm this observation.

**Keywords:** Diabetes, Hydrolyzing rate, Granule morphology, Amyloglucosidase, -amylase

**Effect of Cooking on Ascorbic Acid Content, Total Polyphenol Content and Antioxidant Activity of Selected Vegetables**

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The present study was carried out to determine the effect of cooking on ascorbic acid content (AAC), total polyphenol content (TPC) and antioxidant activity (AA) of selected vegetables. Vegetables: Beetroot, Cabbage, Eggplant, Green bean, Onion and Spinach obtained from local market of Sri Lanka were subjected to cook for 7 minutes at  $78 \pm 2^{\circ}\text{C}$ . AAC and TPC of water base vegetable extracts were determined using 2, 6- Dichlorophenol-Indophenol Visual Titration method and Folin-Ciocalteu method respectively. AA of ethanol base vegetable extracts were measured using DPPH radical scavenging assay and expressed as IC50 values. AAC varied widely among the raw vegetables from  $42.40 \text{ mg ML}^{-1}$  to  $7.07 \text{ mg ML}^{-1}$  and AAC in the all selected vegetables were drastically reduced with the effect of cooking. TPC in raw vegetables showed both positive and negative relationship with the cooking. TPC of Beetroot, Cabbage and Eggplant were increased with cooking by 12.28, 16.54 and 19.48% respectively. AA of Eggplant was increased after cooking by 22.08% with the liberation of high amounts of antioxidant components due to the thermal destruction of cell walls and sub cellular compartments. All other selected vegetables were reduced their AA under the same conditions by showing negative effect of cooking on AA. Selected vegetables; Beetroot, Cabbage, Eggplant, Green bean, Onion and Spinach were showed IC50 values as 0.128, 0.161, 0.048, 0.055, 0.950, 0.072 in  $\text{mgML}^{-1}$  respectively. All tested data shown IC50 values less than 1 mg/ mL and that facilitate to categorize these selected vegetables as an extremely high antioxidant sources according to literature. Resulted data showed both positive and negative effect of cooking on AA of selected vegetables. This finding is important to utilize maximum amount of natural antioxidants present in the vegetables through the domestic cooking practices in order to gain more health benefits.

*Keywords:* Ascorbic acid content, Total polyphenol content, Antioxidant activity, Cooking, Vegetables

## Development of Palmyrah (*Borrassus flabellifer* L.) Fruit Pulp Incorporated Ice Cream

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Incorporation of fruits into the ice cream is one of the choices to increase the nutrition value of the product, flavor and palatability. Ice-cream is normally as a frozen mixture of milk components, sweeteners, stabilizers, emulsifiers and flavorings. Therefore study was focused to formulate a nutritionally rich ice cream by incorporating Palmyrah fruit pulp. Palmyrah fruit pulp was extracted by adding water and squeezed. It was pasteurized for eliminate the microbes and bitter part, also the total soluble solid value (TSS) was maintained as 14. Five levels of Palmyrah pulp (0, 9, 12, 15 and 18%) were tested for the formulation by 30 semi trained sensory panelists using 5-point hedonic scale. Results of the sensory evaluations revealed that 15% Palmyrah fruit pulp as the best incorporation level. Proximate composition and other nutrients of the selected sample were analyzed by AOAC method (2000). Microbiological quality was evaluated using Total aerobic plate count, yeast and mold count, Coliforms and Salmonella counts of the selected product with 2 weeks interval. Accordingly selected Palmyrah fruit pulp ice cream contained 66.01±0.01% moisture, 9.89±0.08% fat, 1±0.02% ash content, 0.77±0.15% dietary fiber, 21.36±0.41% total sugar, 4.3±0.37% reducing sugar, 17.38±0.47% Non-reducing sugar, 101.50±12.02 mg per 100g Vitamin C, 49.75±6.29 mg/100g Calcium, 36.74±0.09 mg/100g Sodium, and 183.67±0.65 mg / 100g<sup>-1</sup> Potassium. The product was complied with Sri Lanka Standards in all recommended parameters and was safe for consumption up to 10 weeks at -18 °C without any artificial preservative. In conclusion, ice cream with acceptable consumer preference can be developed by using Palmyrah fruit pulp. Future studies are needed to analysis of antioxidant activity of developed ice cream and increase the storage period.

**Keywords:** Microbial analysis, Nutritional analysis, Sensory evaluation, Value addition

### **Comparative Nutrient Analysis of Palmyrah Fruit Pulp with and without Artificial Preservative**

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The study presents the results of a preliminary research carried out to examine the effect of the chemical preservative, sodium metabisulphite (SMS) on the nutritional characteristics of the palmyrah fruit pulp with time. Palmyrah fruits of same variety, maturity and size from the same palm were subjected to manual extraction of pulp. pH of the pulp was measured and it was adjusted to 3.8 using food grade citric acid. The pH adjusted pulp was heated to 90<sup>0</sup>C for 30 minutes and was allowed to cool down to 60<sup>0</sup>C. Food grade SMS was added to one portion of the pulp in the ratio of 0.4 gL<sup>-1</sup> and the other portion of the pulp was not mixed with SMS. Both were hot filled into sterilized glass bottles and stored at 4<sup>0</sup>C in a refrigerator. Analysis of fat, protein, reducing sugar, total sugar, vitamin C, and the physicochemical properties such as pH, brix, total phenolic content, titrable acidity and the total plate count were carried out and the results were subjected to two way ANOVA using Minitab 16. The study exhibits that there is a decline in titrable acidity, Na level, moisture level during two months and there is a rise in pH in the pulp with SMS. Sugars, protein, fat and K level remained stable for two months. In the pulp without SMS, there is an increase of reducing sugars and titrable acidity and a decline in pH, and total soluble solids levels with time and the differences between the values obtained periodically were significant. The microbial colony count shows that the chemical preservation treatment is effective since the colony count is zero in the pulp with SMS at the end of the 2<sup>nd</sup> month whereas pulp without SMS shows prominent growth of microorganisms and the total plate count here is 55CFU/ml at the end of the 2<sup>nd</sup> month. Based on the results of this study there is no adverse effect of SMS on the nutritional composition of the pulp. Addition of SMS shows a strong preservation activity when combined with refrigeration whereas refrigeration alone can be employed to preserve the pulp for up to one month.

*Keywords:* Preservation, Physicochemical properties



## **Determination of the Functional properties of the Peptide Derived from Ovalbumin Incorporated Breakfast Cereal**

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Ovalbumin is the main protein in egg white and its hydrolysates can be used to produce many foods with various functional properties. This study was carried out to determine the functional properties of peptides derived from ovalbumin-incorporated breakfast to increase the nutrition and keeping qualities. Ovalbumin (20 mg/ml) was hydrolyzed with 1% (1:100) of pepsin for 0 hours as a single treatment and 1% of trypsin (37 °C) followed with 1% protease (37 °C) for 3 hours as a combination treatment. The enzymes were heat inactivated at 100 °C for 15 min. Breakfast cereal contained 20% rice, 6.67% corn, 6.67% green grams, 6.67% cow pea, 12% chick pea, 3.34% skim milk powder, 6.67% sugar, 0.67% salt, 0.67% vanilla, and 33.3% water. The mixture was steamed at 100 °C for 40 min and oven dried at 150 °C for 15 min. Treatments were prepared by adding ovalbumin 3.34% (T<sub>1</sub>), hydrolysates 3.34% (1% pepsin) (T<sub>2</sub>) or hydrolysates 3.34% (1% of trypsin and protease) (T<sub>3</sub>) to the cereal formula. All samples were sealed in polyethylene bags and stored in a refrigerator (-18 °C) for 21 days until analyzed. Total plate count was used to detect antimicrobial activity. No microbial activity was found in (T<sub>1</sub>), (T<sub>2</sub>) and (T<sub>3</sub>) during the first 2 weeks and the microbial growth after 3<sup>rd</sup> week was within acceptable level (10 cfu/g<sup>-1</sup>). However, no significant difference (p > 0.05) was seen in any of the treatments. Keeping quality studies were done with antioxidant activity with TBARS value as the concentration of malanaldehyde (mg/Kg<sup>-1</sup>) and pH at 3-day interval up to 21 days. As with TBARS and pH values, the T<sub>1</sub> and T<sub>2</sub> were within the range of acceptable levels but rate of oxidation in T<sub>3</sub> was increased after 14 days. As with metal-chelating, Fe<sup>2+</sup> was bound in T<sub>1</sub> and T<sub>2</sub>, but not in T<sub>3</sub>. Cu<sup>2+</sup> was not bound in any treatments and releasing of bound Cu<sup>2+</sup> to the solution was observed. In conclusion, hydrolysates from 1% (1:100) pepsin can be a good replacer for the synthetic materials in breakfast cereals since it has several functional activities and cost effective.

**Keywords:** Breakfast cereal, Hydrolyzed ovalbumin, Antimicrobial, Antioxidant, Metal-chelating

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### **Comparative Study on Quality Characteristics and Antioxidant Activities of Different Types of Palm Treacle**

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Treacle is any uncrystallized syrup made during the production of sugar. The most common forms of treacle are golden syrup, a pale variety, and a darker variety known as black treacle. Black treacle or molasses has a typically strong, slightly bitter flavour, and a richer colour than golden syrup. Black treacle is obtained from palm such as palmyrah, coconut and kithul, which are available from Jaffna market used as the main sweetening agents for cake, curd, tea and coffee. There is a competition for the customerstothe selection of nutritionally best treacle. Therefore this research was designed to evaluate the best treacle this contained good physicochemical and nutritional characteristics. Triplicate treacle samples of palmyrah, coconut and kithul were obtained from one batch of respective production centers and used for the analysis. All types of treacle were in compliance with SLS specifications while there were significant different among the tested parameters. Significantly higher( $P < 0.05$ ) total sugar (63.90%) and ash content [ $0.075(\pm 0.002)$ ] %was obtained for palmyrah treacle, while protein content was significantly highest for coconut [ $0.410 (\pm 0.0040)$ ] than kithul [ $0.570 (\pm 0.0120)$ ] and palmyrah [ $0.028 (\pm 0.0070)$ ] %.Total phenolic content was significantly highest for coconut [ $0.807 (\pm 0.004)$ ] while there were no significant different between palmyrah [ $0.547(\pm 0.001)$ ] and kithul [ $0.545 (\pm 0.002)$ ]  $\text{mg}/100\text{g}^{-1}$ . DPPH scavenging ability with the IC50 values of palmyrah, coconut and kithul were  $0.0169 (\pm 0.003)$ ,  $0.029 (\pm 0.004)$  and  $0.021(\pm 0.004)$ , respectively. Total phenolic contents exhibited significantly positive correlation ( $0.79$ ,  $P=0.011$ ) with the IC50 values of different treacle. The results of this study showed that palmyrah treacle showed highest amount of minerals and antioxidant activity when compared with other palm treacle.

**Keywords:** Treacle, Palmyrah, Antioxidant activity

**Acknowledgement :** The authors like to thank Palmyrah Research Institute for providing the necessary facilities.

## Comparison of Different Enzyme Inactivation Methods for Ovomucin and Functional Properties of the Derived Peptides

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Ovomucin is considered as a protein with various important functions. This study was carried out to compare different enzyme inactivation methods for ovomucin and the functional properties of peptides produced from different inactivation methods for protease from *Bacillus licheniformis* ( $> 2.4$  U/mg). Ovomucin was dissolved (20 mg/ml) and hydrolyzed with  $\alpha$ -amylase (1:100) to check the effect of carbohydrates attached to the peptides. As shown with 15% SDS-PAGE, no difference was observed with and without  $\alpha$ -amylase. Then the pH of ovomucin solution was adjusted to 3.5 and protease from *Bacillus licheniformis* ( $> 2.4$  U/mg) were added (1:100) to hydrolyze the protein. Different inactivation methods, heating for 100 °C for 15 min (HT) and adjusting pH to 10.0 (PT), were used at 0, 3, 6, 9, 12 and 24 hrs of incubation, and the antimicrobial and metal chelating activities of the hydrolysates were determined. Antimicrobial activities were determined using the Agar-well diffusion technique. Locally isolated *Escherichia coli* and *Salmonella spp.* were used, and Augmentin<sup>XR</sup> (0.001 ppm) and distilled water were used as a positive and as a negative control, respectively. The results indicated that none of the hydrolysates suppressed the microbes at any given concentrations. All PT treatments showed high iron-binding capacity (70 - 80%). With HT treatments, 3 hr-incubation showed the highest iron-binding activity (76%). The Copper-chelating activity was opposite to the iron-binding activity: copper was released instead of binding to the peptides in all treatments. In HT treatment, 6 hrs of incubation released close to 100% of Cu<sup>2+</sup>, but in PT treatment, this value was varying with time (60 - 150%). According to the results the peptides derived from the treatments did not have any effect on microbial activity, but metal-chelating activity was different. Further studies are needed to confirm this results by analyzing the peptides and their structures.

**Keywords:** Antimicrobial, Enzymes hydrolysates, Metal chelating, Ovomucin

### Effect of Ozone Application on Postharvest Quality of Black Pepper

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Pepper (*Piper nigrum* L.) is the second most important perennial spice crop in Sri Lankan economy. A major problem faced by the pepper exporting industry in Sri Lanka is higher microbial contaminations. Ozone is a potent antimicrobial agent and considered as a GRAS (Generally Recognized as Safe) substance to be used in the food industry. This research study was conducted at Institute of Post-Harvest Technology, Sri Lanka to find out the effect of Ozone on the microbial quality of black pepper. Ozone concentrations and sample size to be treated were selected based on the preliminary trials. Pepper samples were collected from the local market. Black pepper samples were treated with Ozone (4 mg<sup>-1</sup>/h<sup>-1</sup>.g<sup>-1</sup>, 2.7 mg/h<sup>-1</sup>.g<sup>-1</sup>, 2 mg/h<sup>-1</sup>.g<sup>-1</sup>, 1.6 mg/h<sup>-1</sup>.g<sup>-1</sup>) for 15 minutes. Non-treated samples were served as the control. Total microbial count, yeast and mold count, coliform content, moisture and colour were determined prior to and after Ozone application. Treatments were arranged in a completely randomized design (CRD) and each treatment consisted with three replicates and the experiment was repeated three times. Turbidity of each sample were measured by UV spectrophotometer at 620 nm. Colour of each sample was measured by Chroma meter. Moisture content was determined by distillation method. Data was analyzed by one-way ANOVA using MINITAB 17. Microbial count, yeast and mold count and coliform content were reduced by Ozone compared to the control. The lowest microbial count (4.7 x 10<sup>3</sup>cfu/g<sup>-1</sup>) was obtained from 50 g of black pepper sample. Microbial count, yeast and mold count and coliform content of the treated samples were significantly different (P <0.05) from the non-treated control treatment as these values were higher than that of non-treated control. Results revealed that the microbial count was reduced by ozone and it can be considered as a suitable method to maintain the quality of black pepper. Therefore, there is a potential of using Ozone as a sterilizing agent for black pepper industry.

**Keywords:** Black pepper, Chroma meter, Microbial count, Ozone, Turbidity

## **Development of Soursop (*Anona muricata* L.) Incorporated Probiotic Drinking Yoghurt**

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Due to the anticarcinogenic value of soursop and its beneficial influence on human health, there is a great possibility of its use in the food industry. Hence yoghurt is a popular fermented dairy product due to its health benefits, the yoghurt with soursop extract may confer more health benefits than plain yoghurt. This study was carried out to develop value added soursop incorporated probiotic drinking yoghurt with adding appropriate level of soursop and to evaluate chemical, microbial and organoleptic properties. Soursop extract was prepared by blending de-seeded soursop pulp followed by pasteurization at 85 °C for 3 minutes. Plain yoghurt base was prepared by fermentation with 2% ABT-5 culture (*Lactobacillus acidophilus*, *Streptococcus thermophilus*, and *Bifidobacterium spp.*) and incorporated with prepared soursop extract at 0, 10, 15, 20 and 25 concentration levels. The best incorporation level of soursop was determined by sensory evaluation using 9 point hedonic scale using 30 panelists. Lactic acid bacteria counts, pH, titrable acidity and total solids were evaluated for 21 days shelf life period at 7 days interval. Fat and pH were lower in soursop incorporated yoghurt compared to the plain yoghurt. *E. coli* coliform and yeast and mold are not deviated from Sri Lanka standards specification for yoghurt. The lactic acid bacterial count in soursop incorporated drink was low compared to control yoghurt sample. There were no significant differences ( $P < 0.05$ ) in colour, taste, aroma and overall acceptability of all products. The most acceptable flavored yoghurt contains 10% soursop extract and had a general acceptability of 7.8.

*Keywords:* Anticarcinogenic, Drinking yoghurt, Sensory, Soursop



# **Genetics and Biotechnology**





**Growth Hormone Gene Sequencing, Expression Analysis of mRNA Transcripts in Embryos Development Stages and Tissues from *Acipenserbaerii*(Acipenseriformes)**

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The *Acipenser baerii* is primitive fish, inhabit in major Siberian river basins. The *Acipenser baerii* has remarkable growth starting from embryo to early larvae and juvenile stage. Implication for that, growth has not yet been well-documented. Therefore, this study was aimed molecular cloning, coding sequence and expression analysed of growth hormone gene from *Acipenser baerii*. Total RNA was extracted with RNeasy plus mini kit and reverse transcribed; cDNA was obtained by RT-PCR, cloned and sequenced. The development stages were collected from immediate after fertilization end of mass hatch out. Total RNA was extracted from development stages and tissues, such as, Brain (B), Eye (E), Fin (F), Gill (G), Heart (H), Intestine (I), Kidney (K), Liver (L), Muscle (M), Spleen (S), Gonad (Go). The first cDNA was synthesis with the Omniscript Reverse Transcriptase. The *Acipenser baerii* growth hormone gene cDNA consists 645 bp open reading frame, which encodes of 214 aa, represents the precursor composed of 24 aa signal peptide followed by 190 aa mature peptide. The 3' flanking region has consisted 279 bp upstream from stop codon and Polyadenylation signal responsible conserve motif is (aataaa) located downstream from the 3' exons. The cysteine residues are located in the deduced amino acids sequence of 75, 185, 201, and 208 positions. The ontogenetic profile of growth hormone gene mRNA transcripts was detected at first occurrence of advance hatching (stage 27, 29), 4 dph (days post hatching) and 9 dph stages. The significantly highest expression was reported; when larvae started exogenous feeding at 29 stages. On the other hand, based on expression level of gh gene transcripts in juvenile fish tissues, highest expression coincides with brain tissues and fewer level of expression has reported from spleen tissues. Thus, growth hormone gene expression is modulated in brain and spleen. Brain tissues are containing pituitary gland it may associate with growth hormone secretion. However, expression from spleen tissues may associate with response for immune actions. Specific expression may be associated with remarkable growth rate and size of fish due to the nutritional stressed.

**Keywords:** *Acipenser baerii*. Growth hormone, Gene expression, mRNA transcript

## **Genome -Wide Genetic Marker Studies for Genetic Improvement of Korean Native Chicken**

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Korean native chickens are one of the most important national genetic resources in Korea. They possess unique meat quality characteristics including flavor, texture, and meat composition that have big impacts on consumers compared to the meat from imported commercial chickens. However, Korean native chickens have lower growth rate, lower uniformity and high production cost up to market weight. Due to these factors the native chicken meat is far more expensive than the broiler chicken. The 15 years restoration program along with recent chicken breeding and genetic studies focused on refinement of phenotypic characters and generating high quality and commercially viable Korean native chicken strains. In this review, the recent studies conducted on development of various molecular markers for genetic improvement of economically important traits of Korean native chickens were documented. A total of five pure lines of Korean native chickens along with other commercial breeds were efficiently used for the molecular analysis. Quantitative trait locus mapping was conducted using full-sib model and half-sib model for body weight traits, meat quality traits, fatty acid traits, serum clinical-chemical traits, shank color and flavor related traits. Subsequently, candidate gene studies were conducted for economically imported traits of Korean native chickens to improve the accuracy and response to selection via breeding programs. Moreover, 1 Gbp reference genome assembly and a total of four million single nucleotide polymorphisms annotations were performed to efficiently identify the causal mutations in the candidate genes. There were 20, and 18 phenotype related quantitative trait loci, reported based on full-sib, and the half-sib models, respectively. Candidate gene studies showed, their polymorphisms were significantly associated with meat quality traits, growth traits, clinical-chemical traits, and shank color in Korean native chicken. After further verification of these positional and functional candidate genes, they could be used for future studies focused on commercial development of Korean native chicken using genetic markers.

*Keywords:* Korean native chicken, Economic trait, Genetic marker, Selection, Quantitative trait locus

## Development of DNA Marker for the Identification of Phytoplasma Disease in *Petunia* sp.

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Phytoplasma disease is caused by plant pathogenic Phytoplasmas which are cell wall less bacteria that causes devastating losses in yield and quality of crop production in Sri Lanka. *Petunia* belongs to family Solanaceae is having high demand as ornamental flower in Sri Lanka. Identification of phytoplasma infected crop by using molecular technology gain rapid accurate results to compete with increment of virulence of the pathogens. This study was conducted as a molecular approach for phytoplasma detection, identification and confirmation in *Petunia* sp. The Polymerase Chain Reaction based method was used with universal primers (P1, P7) for 16S rRNA gene to detect phytoplasma in *Petunia* sp. and the amplified DNA fragments in 557 bp were visualized on 2% agarose gel. Further confirmation was done using DNA sequencing (Macrogen, Inc. in a South Korea). For the accurate detection of phytoplasma signs in *Petunia* sp., oligonucleotide primers were designed, using sequenced phytoplasma DNA. Those designed primers were characterized, optimized and primer specificity was analyzed. The highest homology 80% obtained for complete genome of Strawberry lethal yellows phytoplasma (CPA) str. NZSb11 with  $2e^{-46}$  *e* value (NCBI- Basic Local Alignment Search Tool). Primers Px for *Petunia*, forward -5'- CGGCTTGGCTACCCTTTGTA -3' and reverse 5'- TACCTGGCCTTGACATGCTG -3'. The length of the primer was 20 bases and detectable band in gel profile was 288 bp with eight unstable hairpin loops. Primer Px best annealing temperature was 50 °C and showed 90% specificity. Px primers can be used for specific, sensitive detection of phytoplasma infect to *Petunia* (*Petunia* sp.).

**Keywords:** PCR, Primers, Gene Sequencing, Template DNA

**Acknowledgement :** Financial assistance by Plant Virus Indexing Center, Department of Agriculture, Homagama, Sri Lanka

**Effect of Growth Regulators on *In-Vitro* Shoot Initiation of *Oncidium* (*Oncidium multiflorum*) Using Inflorescence Segments**

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*Oncidium* orchids (*Oncidium multiflorum*), commonly known as the Dancing doll, is one of the most beautiful species of epiphytic orchid that have high economic value in the floriculture industry as a cut flower as well as a potted plant throughout the world. Though the popular method for generating new plants of *Oncidium* is seed germination, getting genetically identical plants is a problem. Plant tissue culture technology is being widely used for large scale plant multiplication of *Oncidium* to cater the demand in floriculture industry. Therefore, inflorescence segment culture was introduced to obtain *in vitro* shoots by direct organogenesis. This experiment was conducted to develop an efficient protocol for surface sterilization and shoot initiation using inflorescent segments as explant. After the removal of bracts around the bud, 5% sodium hypochlorite was used with different times (5 min, 10 min, 15 min, 20 min) of soaking to select the best surface sterilization method using percentage of uncontaminated explants. Inflorescence segments were cultured on Murashige and Skoog (MS) medium fortified with different concentrations of N6-benzyladenine (BA) and -naphthaleneacetic acid (NAA) in combination to identify the best combination for shoot initiation. Cultures were maintained at  $25 \pm 2$  °C temperature in a culture room. Experiments were set as Completely Randomized Design with ten replicates and data were analyzed using ANOVA in Minitab® 17.1.0. The results shown that the best assembly for surface sterilization of inflorescence segment explant was 5% Sodium hypochlorite for 15 minutes. Best hormonal combination for shoot initiation was  $0.5 \text{ mg l}^{-1}$  NAA with  $5 \text{ mg l}^{-1}$  BA and it has shown the increased shoot height compared to other treatments. Shoot initiation of *Oncidium multiflorum* using inflorescence explants can be accomplished successfully using above methods of surface sterilization and culture establishment.

**Keywords:** *Oncidium multiflorum*, Inflorescence segments, Shoot initiation, BA, NAA

## **Molecular Identification and Analysis of Taxonomic Affinities of Fish Species in Selected Minor Tanks of Uva Province**

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Freshwater fishes are advance aquatic faunal group with diverse range of taxonomical variation. Morphometric and meristic approaches are common and traditional methods of fish identification in ecological studies. However, above methods are questioned, since several species share close external morphological characters and some species show intra-specific variations. Identification of species by molecular approaches is the novel concept in taxonomical studies. The present study was aimed for molecular identification of fish species in two selected minor tanks in Uva province; Ballawidda Wewa and Mapakada Wewa. Fish species were collected using various fishing gears and fin tip of each sample was used for DNA isolation by Promega wizard genomic DNA kit. Approximately 500 bp partial mitochondrial genome of 16s rRNA region was amplified and sequenced. The obtained sequences were edited by Codon code aligner and compared with the GenBank database available in the National Center for Biotechnology Information to identify at the species level. Phylogenetic tree was produced using Neighbor-Joining (NJ) statistical method by MEGA.7 to detect taxonomic affinities. Total of eight species which belong to three orders (Siluriformes, Perciformes, Cypriniformes) within five families (Bagridae, Heteropneustidae, Cichlidae, Channidae, Cyprinidae; subfamily Cyprininae and Rasborinae) were accurately recognized with more than 95% identification level. Three main clads were resulted in the phylogenetic tree. *Dawkinsia singhala*, *Cirrhinus mrigala*, *Puntius thermalis* and *Amblypharygodon melettinus* species grouped under clade I while *Mystus zeylanicus* and *Heteropneustes fossilis* grouped in clade II. *Channa striata* along with *Etroplus suratensis* formed the clade III. *Cirrhinus mrigala* is identified as the only introduced food fish species in this study which is categorized under the clade I group. According to the phylogenetic tree, the collected fish samples from minor tanks of Sri Lanka are mostly related with Indian fish species. Most of species share common morphological and genetic characters in comparable environmental conditions. It is recommended to conduct detailed phylogenetic, biochemical and ecological interactions, using more samples to realize genetic relatedness between introduced and native fish species in reservoirs of Sri Lanka.

**Keywords:** Biodiversity, Freshwater Fishes, 16S rRNA, Phylogeny

**Acknowledgement:** This study was funded by Biodiversity Secretariat of the Ministry of Mahaweli Development and Environment with the support of GEF/UNDP.

### Genetic Diversity Analysis of Traditional Rice Variety "Pokkali" Using Simple Sequence Repeat Markers (SSR)

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*Pokkali* is a salinity and flood resistant traditional rice variety. The correct identification of the plant is important to utilize the above characteristics in future crop improvement programs. Morphological characterization together with molecular characterization provide exact information about the degree of genetic diversity. The objective of this study is to analyze genetic diversity of *Pokkali* rice variety. Nineteen *Pokkali* accessions with two controls, *Kaluheenati* and BG360 were used. DNA extraction was carried out using modified CTAB method. After confirmation of raw DNA, dilution series were prepared and identified most suitable dilution factor for Polymerase Chain Reaction (PCR). Touchdown PCR was done using 30 rice SSR primers and PCR products were analyzed using 8% Poly Acrylamide Gel Electrophoresis. Scoring of PCR products were done manually and bulked samples with multiple bands were expanded to individual accessions to check genetic difference within accessions in the same bulk. Cluster analysis was done and phylogeny tree was obtained using Nei's genetic distance which distance among accessions ranged from 0.0333 to 0.9097. Four clusters were obtained at relative distance of 39 clustering *Kaluheenati* and BG360 in to same cluster (second cluster) with AC#3701 proving that it is an off type of *Pokkali*. Eight genetically similar accessions or duplicates were observed. Seven accessions in the first cluster were recognized as the most acceptable representative set as it contains two major salinity tolerant accessions (AC#5557 and AC#4013) that have found in salinity screening experiments. Heterozygosity value for many primers was zero because rice is highly self-pollinating crop. High genetic diversity can be seen within the *Pokkali* accessions.

**Keywords:** *Pokkali*, Genetic Diversity, Simple Sequence Repeats, Molecular characterization

### Expression and Purification of Recombinant *EcoRI* Restriction Endonuclease

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*EcoRI* is one of the most widely used restriction enzymes in molecular biology. It can be extracted and purified from the naturally producing bacterium, *Escherichia coli* RY 13 strain. For large scale production this process is not economical. An effective approach is to overproduce this enzyme by cloning and expressing it in a recombinant system. In order to express *EcoRI* in vivo, *EcoRI* methylase also needs to be co-expressed. *EcoRI* methylase protects host cell DNA from auto-restriction and cell death by methylating the recognition sequence. This restriction modification system consists of two genes which encode *EcoRI* enzyme (*ecoRI*) and *EcoRI* methylase enzyme (*ecoRIM* gene). One of the most effective strategies to express two genes using a single vector is to use a two promoter vector which yield separate mRNA transcripts for the two genes. For this purpose pET-21a, a single promoter vector was modified as a duet vector which has two promoters and each gene has its own ribosomal binding site. The designed construct was commercially synthesized and expressed in BL21 (DE3) pLysS host strain. Briefly, cells expressing *EcoRI* were pelleted by centrifugation, resuspended in Tris buffer (20 mM, pH 8.5) containing mercapatoethanol and sonicated. The resulting cell lysate was centrifuged and the supernatant applied to a Diethylaminoethyl Sepharose (DEAE sepharose) ion exchange column. *EcoRI* enzyme was eluted using buffer containing a step gradient of KCl (0.1 to 0.5 M). Fractions were collected and activity tested by digesting lambda DNA with an aliquot of the eluent. Fractions showing enzyme activity were pooled and stored at -20°C in storage buffer containing 50% glycerol. The purified *EcoRI* is currently being tested for use as a substitute for commercial *EcoRI*.

**Keywords:** *EcoRI*, *EcoRI* methylase

### **Genetic Diversity Analysis of Traditional Rice Variety "Kuruluthuda" Using Simple Sequence Repeat Markers (SSR)**

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"Kuruluthuda" is a highly nutritious traditional red rice variety. Further crop improvement programs breeders have to identify true to type traditional rice varieties. Molecular characterization provides exact information about degree of genetic diversity and identity. The main objective of this study was to analyze genetic diversity of *Kuruluthuda* rice by molecular characterization based on SSR polymorphism. Nineteen *Kuruluthuda* accessions with two controls, *Kaluheenati* and Bg 360 were used. DNA was extracted from tender leaves of 14 days old seedlings using modified CTAB method. Confirmation of raw DNA was done using 0.8% Agarose gel electrophoresis. Thirty SSR markers were used in molecular analysis. Specific SSR regions of rice were amplified by Touchdown PCR. Amplified PCR products were analyzed by 8% non-denaturing Polyacrylamide gel electrophoresis. DNA bands were scored and in cluster analysis, phylogeny tree was obtained using Nei's genetic distance. The molecular analysis of 21 accessions generated eleven clusters at a relative genetic distance of 0.179. Two controls, *Kaluheenati* and Bg 360 were clustered in to two different clusters compared to *Kuruluthuda*. Out of eleven clusters, two accessions in one cluster were closely related at Nei's relative distance zero, inferring those are duplicates. Heterozygosity value for many primers was zero because rice is highly self-pollinating crop. Out of nineteen accessions, three accessions were recognized as mostly acceptable representative set of *Kuruluthuda* accessions. By grouping them in to nine different clusters, it shows that considerable higher genetic diversity exists within "Kuruluthuda" accessions collected from all over the country.

**Keywords:** SSR, Accessions, *Kuruluthuda*, Genetic diversity, Genetic distance



## Yield Performance of Exotic and Local Hybrid Rice Varieties

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Lack of high yielding rice hybrid varieties is a main constraint of hybrid rice development programmes. Evaluation of yield performance of exotic hybrid rice varieties was conducted to evaluate exotic and local hybrid varieties under local conditions and to identify the highest performing hybrid varieties for local environment. Field experiment was conducted at the Rice Research and Development Institute, Batalagoda which were situated in Intermediate Low country. Six exotic hybrid varieties which were imported from China, and two local rice hybrid varieties were tested with three standard check inbred varieties (Bg357, Bg304, Bg403) of 3 month, 3 1/2 month and 4 month. Standard heterosis was estimated for 3 month varieties using two exotic rice hybrid varieties and local hybrid rice variety comparing with Bg304, for 1/2 month varieties using four exotic rice hybrid varieties comparing with Bg357 and for 4 months varieties using local hybrid rice variety comparing with Bg403. Grain yields of six exotic hybrids were 2.25 t ha<sup>-1</sup>, 2.24 t ha<sup>-1</sup>, 2.4 t ha<sup>-1</sup>, 2.25 t ha<sup>-1</sup>, 2.57 t ha<sup>-1</sup> and 2.91 t ha<sup>-1</sup> which were significantly different among hybrids. Grain yields of two local hybrids were 4.48 t ha<sup>-1</sup> and 3.93 t ha<sup>-1</sup>. Two exotic and local hybrids of three months showed standard heterosis of -39.08, -34.07, and 22.66. Four exotic hybrids of 3 1/2 months showed standard heterosis of -11.19, -11.22, -0.86 and 14.44 and 4 months local hybrid showed standard heterosis of -1.90. One of 3 1/2 months exotic hybrids showed positive standard heterosis but it was less than 15% standard heterosis to select it for local conditions. One 3 months local rice hybrid variety was recorded a positive standard heterosis of 22.6% when compared to exotic rice hybrid varieties. Exotic hybrid rice varieties are not showing standard heterosis for yield in local environment and not suitable for the Intermediate Low Country conditions.

*Keywords:* Rice hybrid, Standard check, Exotic, Yield, Heterosis

**Genetic Diversity Analysis of Brinjal (*Solanum melongena* L.) Accessions Grown in Up Country Intermediate Zone, Using Morphological Traits**

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Brinjal (*Solanum melongena* L.) is recognized as one of the most important members of the Solanaceae family and believed to have Asian origin. In Sri Lanka, brinjal landraces, wild relatives and farmer varieties are widely available. It is a leading vegetable crop in Sri Lanka in terms of production and extends of cultivation. Badulla district in the Up Country Intermediate Zone is the second largest producer and rich in different genotypes. The aim of the present study was to characterize brinjal genotypes collected from Up Country Intermediate Zone using morphological traits and to assess the genetic diversity within germplasm. Thirty eight brinjal accessions collected were used and morphological characterization of ten plants per accession was accomplished in an open field using PGRC descriptor as a guideline. Thirteen qualitative and nine quantitative characters were employed. Cluster analysis was performed using standardized morphological data. Genetic distance of each accession was calculated using Euclidean distance while linkage was computed using complete method. A dendrogram which scale from 0.00 to 100.00 based on similarity coefficient was constructed and clearly separated thirty eight accessions into three main clusters. Results indicated that brinjal accessions did not show any clustering pattern based on the area where they were collected. Accessions in cluster three recorded the highest average fruit weight; however, highest yield was recorded in accessions in cluster two. Accessions in cluster one were recorded lowest yield with intermediate branching habit. Results indicated that high similarity coefficient among accessions, however all the accessions differ from each other. Therefore, all of those accessions can be used as different lines in breeding programs. Results proved that morphology based analysis was effective in differentiating brinjal accessions. Therefore, this information will be useful for collection, conservation and creating new brinjal cultivars.

*Keywords:* Brinjal, Cluster, Genetic Diversity, Morphological traits, Accessions

## Molecular Identification of Selected Octopus Species in Sri Lanka using DNA Barcoding Region

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There are many commercially important Octopus species which have cosmopolitan distribution. Seven species of Octopus have been reported in Sri Lankan waters that come under genus *Octopus* and *Cistopus*. Recently, presence of a new Octopus species, namely, *Cistopus taiwanicus* has been found in Sri Lanka. The objective of this study was to distinguish octopus species by using morphological and molecular approaches and DNA barcoding for species identification to overcome difficulties arising during morphological identification. Octopus samples were collected from Kalpitiya, Negombo and Jaffna regions and those species were identified morphologically as far as possible using external features such as, body colouration, total length, arm length and mantle length. The partial COI gene region of the mitochondrial DNA was amplified and sequenced. The obtained sequences were analyzed using BIOEDIT program and matched with barcoding data available in the Barcoding of Life database (BOLDSYSTEM) and the National Center for Biotechnology Information (NCBI). Genetic distances and the phylogenetic relationships among species were analyzed using MEGA7 software. All collected samples are genetically distant with more than 2% of p-distance value. OCTK\_2 sample collected from Kalpitiya was identified as *Cistopus taiwanicus* and phylogenetically related to Indian samples. Another sample from Kalpitiya region was suspected as *Cistopus indicus* or *Cistopus taiwanicus* and it is not phylogenetically similar with other samples. Two samples (OCTJ\_1 and OCTJ\_2) collected from Jaffna were identified as *Octopus aegina* found in Taiwan. A single sample (OCTN\_1) collected from Negombo which was morphologically identified as *Octopus vulgaris* was identified as *Octopus cyanea* found in Japan by DNA barcoding. Some Octopus species may co-occur in near-shore shallow reef habitats across the Southwestern Indian Ocean. Paralarval lifestyles of cephalopods give information on both their ecology and related geographic and vertical distribution of species. However, the presence of *Cistopus taiwanicus*, *Octopus cyanea* and *Octopus aegina* in Sri Lankan waters can be concluded. Further, this study suggests a larger sample size and more collection sites around Sri Lanka to detect strong relationship of Octopus species in the Indian Ocean.

**Keywords:** Octopus, Taxonomy, COI, Sequencing, Indian Ocean

**Anti-cancer and Cytotoxic Effects of Aqueous Extracts of Selected Seaweeds on Cancer (HeLa) Cell Line and Primary Fibroblast Cells**

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Seaweeds have extensively been tested for anti-cancer activities. Several studies have indicated that seaweeds constitute with bioactive compounds which could inhibit the growth and induce apoptosis of cancer cells. This study was performed to determine the cytotoxic and anti-cancer activity of aqueous extracts of selected Sri Lankan seaweed species using an MTT assay; based on the ability of living cells to reduce tetrazolium salt (3-[4,5-Dimethylthiazol-2-yl]-2,5-diphenyltetrazolium bromide) into formazan. *Ulva fasciata*, *Caulerpa racemosa*, *Gracilaria corticata*, *Sargassum illisifolium*, *Stoechospermum polypodioides* and *Jania adhaereus* were collected from Northern, Southern and North western coastal sites of Sri Lanka. Seaweeds were washed, dried, homogenized and aqueous extracts were prepared. Primary mice fibroblast (normal) cells and HeLa (cancer) cell line were used to determine *in-vitro* cytotoxic and anti-cancer properties, respectively. Cells were cultured in RPMI-1640 medium and treated with 200 gml<sup>-1</sup> of seaweed extracts. MTT assay was done and the absorbance (570/620 nm) was measured at 24 h and 48 h after treatment. Percentages of viable cells and growth inhibition were calculated. At 24 h, seaweed-treated HeLa cells showed increased cell proliferative activity. However, interestingly, at 48 h, four out of six seaweed species showed cytotoxic activity on cancer (HeLa) cells and no cytotoxicity on normal (primary) cells. These findings would shed some light on novel cancer therapy and value-addition to local seaweed resources. Further studies should be followed to identify the bioactive components of seaweeds and their exact mechanism on cancer cells.

**Keywords:** Anti-cancer, Cytotoxicity, Seaweed, MTT assay

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**Determination of Lethal Dose 50 (LD<sub>50</sub>) Value of <sup>60</sup>Co Gamma Irradiation for Tomato (*Lycopersicon esculentum* Mill) Variety Thilina**

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Mutation breeding is one of promising method to create genetic variations and to produce new varieties. Gamma irradiation is a physical mutagen which can be used to induce mutations. Lethal Dose 50 value is essential in mutation breeding for a specific crop to determine the optimum irradiation dose required to create a mutation. The purpose of this research was to identify the dose of gamma irradiation of LD<sub>50</sub> for seeds of Tomato (*Lycopersicon esculentum* Mill.). Thilina tomato seeds were subjected to different doses of gamma rays (0, 50, 125, 200, 275 and 350 Gy) with Cobalt 60 irradiation source and seeds were sowed. Characteristics of irradiated plants, germination percentage on 7<sup>th</sup> and 14<sup>th</sup> days, height of the plants on 12<sup>th</sup>, 15<sup>th</sup>, and 18<sup>th</sup> days after seed sowing, and growth rates were measured. According to the results, significant differences were observed only in germination percentage on 5<sup>th</sup> day and plant height on 12<sup>th</sup> day after seed sowing. Germination percentages on 7<sup>th</sup> and 14<sup>th</sup> days and heights of the plants on 15<sup>th</sup> and 18<sup>th</sup> days after seed sowing did not show any significant differences. Delay in germination of seeds were observed in early stages at 275 Gy. Seeds showed near 90% viability. All germinated plants showed significant variation in plant height in first few days of seedling emergence, and revealed that effect of gamma irradiation presented only in early stage and in later stage all plants showed similar performances. It can be concluded that the lethal dose 50 value of Thilina tomato cultivar does not exist within 0 to 350 Gy gamma irradiation range and it is not an adequate irradiation range to induce any morphological changes.

*Keywords:* Cobolt-60, Gamma Irradiation, Lethal Dose 50, Mutation, Tomato

### **Screening and Partial Characterization of Type II Restriction Enzymes from Soil Bacteria**

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Restriction enzymes are components of the restriction modification system of bacteria. These enzymes restrict growth of invading phages by cleaving double stranded phage DNA at specific nucleotide positions. Methyltransferases the other component of restriction modification system modifies bacterial DNA at sequences recognized by the restriction endonucleases and will protect bacterial DNA from cleavage. Restriction modification systems can be classified into four types, Type I, II, III and IV based on enzyme structure, recognition and cleavage sites and required cofactors. Type II enzymes are the mostly used restriction endonucleases in molecular biology due to their ability to cleave DNA at specific sites. The objectives of this study were to isolate restriction enzyme producing bacteria followed by characterization and purification of the restriction enzyme. Soil samples were collected into sterile falcon tubes and mixed well in PBS buffer prior to preparation of a dilution series. The dilution series was spread on Luria Bertani Agar plates and incubated at 37<sup>0</sup>C to obtain isolated colonies. These colonies were grown in Luria Bertani broth cultures (5 ml) and cells were harvested by centrifugation. Cell pellets were resuspended in lysis buffer and disrupted by sonication. Cell lysates were incubated with lambda DNA and subjected to gel electrophoresis in a 0.8% agarose gel containing ethidium bromide. Presence of distinct bands on the gel indicates the presence of restriction endonucleases. An isolated soil bacterium belonging to the genus *Brevibacillus* cleaved lambda DNA producing several fragments in the range of 12kb - 0.6kb. Different buffers were used for digestion and optimum activity was detected in buffer containing 6 mM Tris-HCl pH 7.5, 6 mM MgCl<sub>2</sub> and 100 mM NaCl. Further characterization of the enzyme and partial purification is currently being carried out.

**Keywords:** Restriction modification system, Restriction enzymes, Soil bacteria

**Use of Partial *mecA*, *femA* and 16SrDNA Sequences for the Identification of Clinical Isolates of Methicillin Resistant *Staphylococcus aureus***

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Availability of antibiotics is increasing with the development of health sector throughout the world. Overuse of antibiotics has created evolution of resistant pathogenic strains leading to a growing threat worldwide. Methicillin resistant *Staphylococcus aureus* (MRSA) is one such organism. MRSA strains cause nosocomial infections. Several genes are involved in elucidation of methicillin resistance. Among the genes involved in the expression of methicillin resistance, *mecA* and *femA* are important genes. This study was carried out to test the applicability of using partial gene sequences of *mecA*, *femA* and 16SrDNA to identify MRSA strains. Ten clinical isolates of MRSA from blood, wound, urine and pus samples were collected from Anuradhapura Teaching Hospital. The samples were inoculated in brain heart infusion broth. DNeasy Blood & Tissue Extraction mini kit was used for DNA extraction. *mecA*, *femA* and 16SrDNA were amplified using specific primer PCR. Amplified products were analyzed using 2% agarose gel and a molecular weight marker. All MRSA isolates contained *mecA* gene. *femA* gene and 16SrDNA sequences were amplified in 9 isolates. This study reveals that partial *mecA*, *femA* and 16SrDNA gene sequences are good genetic determinants of MRSA.

*Keywords:* *femA*, *mecA*, MRSA

**Acetylshikonin Isolated from *Lithospermum erythrorhizon* Induces Antagonistic Effects in LPS-Stimulated BV2 Microglia Cells**

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Microglia are known as main cells to regulate neuroinflammatory diseases such as Alzheimer's disease and multiple sclerosis. It is unclear whether Acetylshikonin (ACS) regulates expression of pro-inflammatory mediators based on molecular mechanisms in lipopolysaccharide (LPS)-stimulated microglial cells. Therefore aim of this study is to identify the antagonistic effects of ACS on microglia cells. Reverse transcription-polymerase chain reaction (RT-PCR) together with western blot analysis was used to evaluate the expression of pro-inflammatory mediators such as nitric oxide (NO) and prostaglandin E<sub>2</sub> (PGE<sub>2</sub>) as well as their regulatory genes such as inducible NO synthase (iNOS) and cyclooxygenase-2 (COX-2), in LPS-stimulated BV2 microglial cells. In this study ACS inhibits lipopolysaccharide (LPS)-stimulated NO production by suppressing the production of nitrite oxide (NO) and prostaglandin E<sub>2</sub> (PGE<sub>2</sub>) in BV2 microglia. Moreover, ACS significantly inhibited LPS-induced DNA-binding activity of nuclear factor- $\kappa$ B (NF- $\kappa$ B). Consistent with these data, it was found that ACS promotes the dephosphorylation of Akt that subsequently suppresses the DNA-binding activity of NF- $\kappa$ B in LPS-stimulated BV2 microglial cells. It was found that ACS enhances heme oxygenase-1 (HO-1) expression via nuclear factor-erythroid 2-related factor 2 (Nrf2) activation. In addition, zinc protoporphyrin (ZnPP), a specific HO-1 inhibitor, showed a partial suppressive effect of ACS on LPS-induced NO and PGE<sub>2</sub> production. But the presence of cobalt protoporphyrin (CoPP), a specific HO-1 inducer, predominantly suppressed LPS-induced NO and PGE<sub>2</sub> production. These results indicate that ACS down regulates pro-inflammatory mediators such as NO and PGE<sub>2</sub> via suppression of Akt-dependent NF- $\kappa$ B activity as well as induction of Nrf2-dependent HO-1 activity.

**Keywords:** Acetylshikonin, Nuclear factor- $\kappa$ B, Heme oxygenase-1, Nuclear factor-erythroid 2-related factor 2



**Indirubin-3-monoxime Suppresses Invasion of Cancer Cells via the AP-1 Activity by Nrf2 Mediated HO-1 Pathway**

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Indirubin-3'-monoxime (I3M), is a synthetic derivative of indirubin, was originally accepted as potent anticancer agent. Recent reports have suggested I3M exhibits anti-cancer properties by modulating cell cycle arrest, apoptosis, cell invasion and metastasis, however very lack of data about the mode of action. Despite, in the current study, it has been shown that I3M suppresses cellular invasiveness of LNCaP prostate carcinoma cells and to further investigate the underlying mechanisms of the I3M-inhibited invasiveness of cancer cells via down regulating Matrix Metalloproteinase-9 (MMP-9) activity. According to the western blot and RT-PCR analysis, concentration dependent manner treatment of I3M reduced PMA-stimulated protein and mRNA expression level of MMP-9 in LNCaP and DU145 cells. Further, Matrigel invasion assay showed that I3M substantially reduced the PMA-induced cell invasion. Nevertheless, I3M significantly enhanced the protein and m-RNA expression level of HO-1 in LNCaP cells. Accordance to the induction of HO-1 expression, I3M resulted in remarkably induction of Nrf2 expression in LNCaP cells at 24h. Moreover, I3M treatment notably enhanced PI3K and Akt phosphorylation, suggesting that the I3M-induced Nrf2 expression associated with the PI3K/Akt signaling pathway. Treatment of I3M reduced PMA-induced AP-1 activity by providing evidence that AP-1 may critically require to induce the MMP-9 transcription in prostate cancer cells. Considering above facts, results indicated that I3M attenuates PMA-induced expression of MMP-9 at mRNA and protein level by suppressing AP-1 activity via Nrf2 signaling pathway in LNCaP prostate carcinoma cells.

**Keywords:** Indirubin-3'-monoxime (I3M), Matrix metalloproteinase-9, Nrf2, AP-1, HO-1



# **Hospitality and Tourism Management**



## **Conceptual Model to Evaluate Net Foreign Exchange Earnings by Tourism for Sri Lanka**

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The economic growth due to tourism induces production in the host country through the demand created for goods and services. The statistics provided by the authorities regarding tourism industry has main focus on the arrivals and income per capita. But two ways flow of tourism is a common factor over looked in many situations when assessing the net income from tourism. Also the foreign content of the inputs for tourism is an essential component that should be measured in developing countries where the amount of imports in the market is significantly high. Therefore the calculation of net foreign exchange earnings should be redefined by including the outward cost, foreign content and the social cost of tourism along with the inward revenue. The sample data of Sri Lankan arrivals obtained for five Asian countries once compared with the arrivals from those countries to Sri Lanka clearly indicated that the outward cost is a significant factor, whereas a study carried out to evaluate the foreign content for the hotel industry using two star-rated hotels showed that an average of 70% of the inputs used to fulfill the needs of tourists such as beverages, cutlery and textile are imports. Therefore it is essential that policies should be created to develop the linking industries such as agriculture, textile and construction that can provide the requirements for tourism and thus reducing the foreign content. Apart from the outward cost and foreign content, social cost incurred due to tourism is also an important factor to consider when calculating the net income. It was concluded that the net foreign exchange income should reflect the inward revenue after deducting the outward cost, foreign content and the social cost of tourism. This method should be further developed by including precise cost components directly related to the industry with means of extraction from general data.

*Keywords:* Tourism, Net income, Outward cost, Foreign content

## **Promotion of Community Based Homestay Tourism in Ella Area: Opportunities and Challenges**

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Tourism is a booming industry in Sri Lanka where Ella is one of the attractive destinations recently became popularized. Experiencing the unique geographical features and authentic local life are some of the important features of Ella. Therefore, budget travelers as well as homestay tourists select Ella as one of their favorite destinations. Homestay tourism in Ella was originated as a solution for excess demand for accommodation, yet Ella has become one of the preferred homestay destinations presently. However, literature do not provide much information on the opportunities and challenges for homestay tourism in Ella and points that this challenges to the growth of Industry in the area. Hence, the paper is aimed at examining the opportunities and challenges of homestay tourism in Ella. Data for the research were collected from 100 homestay tourists and 50 homestay unit operators in the area, using the convenience sampling technique and two separate semi structured questionnaires were distributed among the tourists and homestay unit operators. The main analytical technique of the study was exploratory factor analysis. The study found that the homestay tourists preferred to experience nature and adventure based activities, community based cultural activities, leisure activities, rest and relaxation, budgetary vacation as the major opportunities. It also found that the level of awareness about the homestay tourism among tourists, lesser financial and family support, lack of educational programmes, difficulties in better customer services, poor infrastructure facilities, too much competition as the challenges to the industry in Ella area. Therefore, the study recommends that it is necessary to educate the homestay unit operators and the community on prevailing opportunities for the industry and their advantages to them. Furthermore, complete regulation of the homestay units in the area is a major requirement, while providing necessary infrastructure.

*Keywords:* Homestay Tourism, Ella, Community development

**Analysis of Service Quality & Tourist Satisfaction Levels with Reference to Tourist Information Centres (TICs) (With Special Reference to Kandy City)**

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Tourist Information Centre (TIC) is "a clearly labeled, publicly accessible, physical space with personnel providing pre-dominantly free of charge information to facilitate travelers' experiences" (Pearce, 2004). Tourists who arrive to each destinations visit TICs for receiving trustworthy information for their journey. Hence, TICs can be a strong strategic point to promote tourism of a region. Therefore, it is essential to pay attention on the service quality of the TICs and this paper sets out to report on research that investigated foreign tourist satisfaction on service quality in TICs. Foreign tourists who visited TICs in Kandy were taken as the population to the study and the convenience sampling technique was used to select the sample consisting 100 respondents from the population. Primary data were collected through a questionnaire and quantitative technique was employed to analyze the data. The results revealed that there is a significant and positive relationship between service quality in TICs and further, the tangibility dimension has mostly contributed for foreign tourist satisfaction than the other dimensions. The study further concludes that in order to increase the tourist satisfaction in TICs, the attention should pay on improvement of the service quality dimensions providing modern equipment to TICs. Findings of this study will be important for tourism planners and decision makers in the tourism industry.

*Keywords:* Tourist satisfaction, Service quality, Tourist information centres

**A Study on Identifying the Factors that Affects the Length of Stay (LOS) of International Tourists within a Destination (With Special Reference to Ella and Bandarawela)**

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Sri Lanka has proved to be one of the fastest growing tourist destinations. Although Sri Lanka is receiving an increasing number of tourist' arrivals annually, some issues associated with the Sri Lankan Tourism are recorded such as lack of marketing and promotional strategies to attract high spend tourists, no brand equity development in the promotions, lack of global communication partners and shorter LOS etc. This study focused on the factors that affect the tourists' LOS which is an important determinant of the overall impact of tourism in a given economy. The objectives of this study are to identify the significant factors that affect the LOS of international tourists who visit Ella and Bandarawela areas, identify the relationship between travel characteristics and LOS, identify relationship between destination image and LOS, and identify relationship between travel motives and LOS. Researcher collected data from the tourist who visit Ella and Bandarawela areas. Convenience sampling technique was used to select the sample and sample size was 100. Survey methodology approach has used to collect primary data from the respondents through structured questionnaire. Gathered data was analyzed through correlation coefficient, factor analysis and Hypothesis testing with the help of SPSS software. Researcher tested the relationship between Tourists' travel characteristics, Destination image, and Travel motives with length of stay. The findings show that total amount of days spend in Sri Lanka limit the tourists' LOS in Ella and Bandarawela. Further, it has been identified pull travel motives, push travel motives, service quality, destination attributes and economic characteristics are most important factors that affect the LOS. Moreover, the image perception of tourists regard with these two destination tend to have positive relationship with their LOS. On the other hand, Pull travel motives such as; Climate, Cost of the trip, Events, Activities, Attractions and Landscape tend to influence the tourists' LOS.

*Keywords:* Length of stay, Travel characteristics, Destination image,  
Travel motives



**A Study on Service Quality & Passenger Satisfaction in Immigration, Emigration & Duty Free Services Provided by Bandaranaike International Airport (BIA)**

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Aviation is energetic industry & it's really important for improvement of tourism. Civil aviation industry in Sri Lanka has nearly 72 years old history. Since, BIA is the main international airport serving in Sri Lanka, the tourists who visit Sri Lanka have to get many services from BIA. Therefore, assessing the passenger satisfaction on services offered by BIA is really important. This research was conducted to identify the existing level of passenger satisfaction on service quality of Immigration, Emigration & Duty free service offered by BIA, to identify the shopping preferences in duty free and to determine the significant factors that affect on satisfaction of duty free service. The researcher gathered primary data from 60 passengers by using convenient sampling technique. Factor analysis and descriptive analysis were used to analyze the collected data. Findings of the research revealed that passengers were mostly satisfied with the service offered by Duty Free Department, secondly passengers satisfied with the service offered by Immigration Department & finally satisfied with the service offered by Emigration Department. Furthermore, holiday mood of passenger, convenience, product variety & display of products at duty free shops impact on the duty free shopping at BIA. Finally, the most significant factor that influences the satisfaction of Duty free service was "Skills & abilities of Staff".

*Keywords:* Service quality, Passenger satisfaction, Immigration services, Emigration services, Duty Free services

**Assessing the Impact of Sustainable Business Practices on Tourist Perception in Small and Medium Scale Hotels**

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Sustainable development is widely accepted among tourism organizations as the sustainable business practices are an emerging topic in small and medium scale hotels. Despite of its important role, both Organizations and tourists are suffering different kinds of barriers when adopting sustainable business practices into small and medium scale hotels. The main objective of this study is to identify the sustainable business practices in small and medium scale hotels within Rathnapura, Kandy and Negombo areas and secondary objective is to identify the tourist perception on the sustainable business practices in small and medium scale hotels. Sample consisted of one hundred and twenty tourists and fifteen small and medium scale hotels have chosen. The primary data were gathered through the structured survey and questionnaire method has been adopted. Descriptive statistics and Correlation coefficient analysis used to analysis the data. Findings exposed the hotels in Rathnapura, Kandy, Negombo area aware about the sustainability issues in hospitality. Further, majority stated the use of comprehensive sustainability strategies and implementation of programs. Further, results revealed the strong positive relationship between tourist perception and the sustainable business practices in the small and medium scale hotels. As recommendations, the promotion of sustainable business practices and adopting green-marketing techniques in hospitality sector had been highlighted.

*Keywords:* Sustainable development, sustainable Business practices, Tourism, Tourist Perception, Small and Medium Scale Hotels

**Impact of Training on Turnover Intention (With Special Reference to Operational Level Employees of Star Category Hotels in Colombo District)**

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Turnover intention is one of the crucial and most discussed issues of Hotel and Tourism industry in Sri Lanka. According to the current context of Hotel industry in Sri Lanka, the turnover intention is more important because of the high industrial employment generation and the high income earning of Hotel industry in Tourism trade. This study empirically evaluated the training impact on turnover intention through person job fit of the operational level employees in star category hotels in Colombo District. The objectives of the study are, to identify the existing practices of training in hotel industry in Colombo district, to identify the relationship among training and to determine the mediating effect of person job fit on the relationship between training and turnover intention in hotel industry. The sample consisted of the hundred operational employees who are working in star category hotels in Colombo. The data were gathered by administering structured questionnaires. The analysis exposes that there is a strong negative relationship between training and turnover intention and further, the person job fit is partially mediating the relationship between training and turnover intention. Researcher found that the hotel industry should be executing appropriate strategies to develop the training base on the important factors that had been found by the study.

*Keywords:* Training, Person job fit, Turnover intention

**A Study on Tourist Perception towards Luxury Tourism (With Special Reference to Down South Area)**

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The Luxury Tourism concept can be identified as an emerging field of study among the academics. It is defined as the consumption of an expensive and high quality experience in travel and tourism. This has become the fastest growing segment in the global tourism industry with the increase of high-end travelers. Perception is an opinion about something experienced which plays an important role in customer satisfaction. The overall perception of luxury varies over person to person based on various factors. Hence, it is essential to understand how travelers perceive the concept of luxury in tourism, as these findings could be utilized in designing the promotions to attract this highly profitable niche market. This research examines the significant growth opportunities of Down South area to develop and promote as a luxury destination by investigating the possibilities and the best ways through developing an appealing product to the high spenders while identifying the opportunities to optimize their spend within the destination. By using a convenience sampling technique, a sample of eighty tourists was selected to conduct the survey. A Questionnaire was adopted to collect data from the sample. Descriptive statistics, EPI format and multiple regression analysis were used to analyze the data. The findings reflect strong potentials, to promote Luxury Tourism as a new tourism market since the expectations of the luxury tourists are compatible with the potentials existing in the area. Sri Lanka has a bundle of resources that can be utilized for tourism business where Luxury Tourism suppliers need to understand their roles in delivering an end-to-end luxury experience by exploring the latest technologies and adding innovations to their product. As a whole, this study could be useful to marketers interested in branding the image of Sri Lanka as an attractive destination for luxury travelers who can boost up the tourism revenues of the country in an outstanding manner.

*Keywords:* Luxury tourism, Tourist perception, Down south,  
Luxury tourist, Destination attributes, Luxury attributes

**Assessing the Effect of Service Quality on Revisit Intention of International Tourists; The Role of Tourist Satisfaction -With special reference to Resort Hotels in Galle district**

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Sri Lankan tourism industry is rapidly growing after the war period. According to the Sri Lanka Tourism Development Authority statistics, Sri Lanka reached highest tourist arrivals and it was about more than one million tourists. Thus, the purpose of this study was to investigate the effect of service quality on revisit intention of international tourists through the role of tourist satisfaction with special reference to resort hotels in Galle district. The research is comprised of the objectives of identifying the relationship between service quality and customer satisfaction, identifying the relationship between service quality and guest revisit intention, and to assess the relationship between service quality and revisit intention through customer satisfaction. The researcher selected five resort hotels in Galle district and data was collected by using close ended questionnaire from 100 guests who visited to those five resort hotels. Convenience sampling method was used as a sampling technique. Descriptive statistics, correlation, regression and mediator test were used to analyze the data with the support of SPSS 21.0 software. The study found that the service quality is a key driver of customer satisfaction in the resort hotels in Galle district. It was recommended that the management of hotels should be clearly considering service strategies in improving upon customer satisfaction. In that case management should consider the training programs for employees to develop their knowledge, skills and competencies further it will indirectly and indirectly influence on the performance of the hotels. In addition, the researcher suggest that hotel industry has to engage global trends and new technologies to expand the potential market and reach new markets.

*Keywords:* Service Quality, Revisit intention, Customer Satisfaction

**An investigation on the Potentiality to Develop Local Handicraft Business as a Sustainable Tourism Product**

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Tourism highlights as one of the most prominent industry within the service sector in modern world economy as well specially in developing economies. Advanced technology and ability of owners to adapting the current trend in market inherited significant impact on level of innovation as well develop the handicraft business as a sustainable tourism product. Handicraft industry alone has been promoted to faster economic development, reduce unemployment and it has become a means of livelihood to many advantaged communities. Handicraft industry is link with tourism as a sustainable business where the cultural heritage of a destination could be exhibit while enhancing the livelihood of the local community. The objective of the study is to identify the market profile of the handicraft business and investigates the potentiality to develop innovative value added product to the local handicraft market. Primary data has been collected through questionnaire method and survey method adopted including 60 handicraft business owners. Galle district has been chosen as the survey area where the local handicrafts highly combine with the tourism industry. Stratified Sampling technique adopted and interview method used for the data collections. Data analysis through descriptive statistics and in-depth analysis has been followed. Finding revealed the middlemen involvement of handicraft business need to be stronger as a link between the tourist and the industry. Handicraft owners do not earn enough to ensure sustainable growth and need to develop sustainable business practices linkages between handicraft product and tourism. Further the strategies could adopt the development of local handicraft business as sustainable tourism product. As recommendations, value adding of handicrafts and design uniqueness is significant determinant of innovative activity in handicraft sector, hence the industry more focus on value addition by securing the traditional cultural values in sustainable tourism product.

*Keywords:* Handicrafts, Innovation, Sustainable tourism product, Tourism, Value added products

## **Influence of Social Networks on Destination Selection of Millennial Tourists Visiting Sri Lanka**

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The sudden supremacy of social networks in every industry, including Tourism and Travel industry has drastically evolved adopting the social networks in communication, branding and promotion of destinations and Tourism products. The tech-savvy millennial generation is the target market of using social networks in Tourism industry. Therefore, this study explored the influence of social networks in tourism on destination selection of millennial tourists on the objectives to determine the influence of Social networks on Millennial Europeans when selecting Sri Lanka as a destination, to identify what is the most used method and current usage of social networks by the millennial tourists, to determine the important consideration millennial tourists expect when selecting destinations through social networks, to identify the relationship between Social networks and destination selection of Millennial Tourist. Hence, the aim of this research is to answer above mentioned research questions and fulfill the objectives in order to conclude the results and apply the results to the industry for the further benefits. One hundred millennial tourists responded to a structured questionnaire which was administered and used as the data collecting instrument. The analysis exposes that there is a strong positive relationship between social networks in Tourism and destination selection of millennial tourists. With further analysis it was revealed that five dimensions used to analyze the independent variable are the factors that should be improved to increase visitation of millennial tourists to Sri Lanka through social networks. To elucidate these results on the two variables of the study and in order to fulfil the objectives of the study descriptive statistics, correlation analysis and perception analysis were used to analyze the data. Finally, it is concluded that utilizing the most used social network sites and considering the dimensions used to measure travel social networks the promotions of Sri Lanka should be commenced more accurately in order to attract more millennial tourists as a growing market worldwide in order to increase and improve the visitation to the Island.

*Keywords:* Social networks, Millennial tourists, Destination selection

**Development, Calibration and Validation of a Scale to Measure Tourist Destination Mobilities: Local Residents' Perspective from Sri Lanka**

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Macro level movement of populations, material and physical objects, technological relocations, information, communication, ideas and image transfers, temporal transformations of dwellers through daily movements all count as common forms of mobility triggers at tourist destinations. Recently, the discourse has attracted tourism and other social researchers' attention mostly at theoretical and conceptual level showing significant absence of empirical studies. Discourse of mobilities, regardless of its vital significance in day-to-day life, has generally been under examined in scientific community. A significant obstruction for this is the nonexistence of a scale to measure Tourist Destination Mobilities (TDM). Thus, the central focus of this paper is to develop, calibrate and validate a scale to measure TDM from residents' perspective. The item generation was conducted in several stages to make sure the subjects are identified and measured in their factual forms. Accordingly, a comprehensive literature review on mobilities and tourism development was undertaken. Parallel to the literature survey a series of in-depth interviews were conducted with tourism industry stakeholders to dig deeper the discourse of TDM. Based on the findings of literature survey as well as of in-depth interviews the initial items were proposed and were reviewed by four tourism professors and three tourism industry professionals for further refinement. Initial scale was comprised of 42 items and it was field tested with a sample of 67 residents in Dambulla and Sigiriya UNESCO world heritage tourism zones in December 2015. Scale refinement and purification was accomplished through a sample of 302 residents in the same tourism zones in January and February 2016 that generated 32 items with 6 dimensions. Final validation was completed through a sample of 791 in March, June and July 2016 at the same tourism zone. Factor analysis succeeded 26 items with 5 dimensions explaining a total of 84 percent variance of TDM. Dimensions of the final scale are; Multiplicity of destination governance (6 items), Varying image and identity (6 items), Migration and changing communal values (5 items), Transport & telecommunication infrastructure (5 items) and Restructuring of economic space (4 items). Findings refracted concurrent tourism and mobilities literature emphasizing governance and capital as key mobility stimuli. TDM scale requisites further validation in different contexts to establish generalizability.

*Keywords:* Local residents, Scale development, Sri Lanka, Tourist destination mobilities



**Assessing the Factors Affecting Women Career Advancement in Hotel Industry  
Special Reference to Star Hotels in South Coast Region in Sri Lanka**

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Hospitality industry emphasizes high disparity in female empowerment and career advancements in most of the countries where the problem is acute in developing countries as women face many encounters, often concerted in low status, low paid, gender discrimination and unsecure jobs in the hotel industry. With the increased number of women workforce who enrolled with higher education in the past few decades, still women employees has not been embedded in the sophisticated managerial positions in most of the Sri Lankan hotels. As concerns tourism presents a wide range of prospects for an individual in the international arena, hotels still do not recruit, promote or assist women compared to male. In recent years, female under representation in top management positions has made women's status in the industry a great concern. The main objective of the study is to identify relationship between career advancement factors to women career advancement and conducted a quantitative survey based on 70 women supervisory and upper level managers in south coast region in Sri Lanka. The study was considered three major career advancement factors; job related, organizational, and sociocultural factors which affect on women career advancement in hotel industry. Judgmental sampling techniques adopted, Person Correlation and Regression Analysis were used to analysis. Findings revealed weak negative relationship between the career advancement factors and women career advancement. Job related factors identified as the major factor to affect women career advancement. As conclusions the women participation and women in top positions in hotel industry in south coast in Sri Lanka is considerably low due to impact of job related factors. The study recommends that at the hotel level, corporate policy and senior executive commitment is key feature in formulating strategies to facilitate women's career advancement to management positions lead on women empowerment.

*Keywords:* Female career advancement, Hotel industry, Hospitality,  
Job related factors, Organizational factors, Socio cultural factors

**Determinants of Non-Executive Level Women Employee Turnover Intention in Hospitality Industry - Special Reference to Western and Southern Provinces**

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Hospitality industry is a highly labor-intensive industry, but the high labour turnover is a serious problem within the industry, all around the world. According to the world statistics, it distinguishes that women's employment in hotels is important. But the female employees clear off the job more than male employees. Researcher has identified empirical and knowledge gaps in this context. The objective of this research is to identify the actual determinants that can affect the non-executive level women employee turnover intention in hospitality industry. Research data mainly depends on the primary data collected by the Researchers from 150 Sri Lankan non-executive women employees, who are working at 3-5 star classified hotels in Western and Southern Provinces in Sri Lanka through self-administrated questionnaire. In order to achieve the objective of this research, the researcher conducted exploratory factor analysis method (EFA), and found that the determinants stimulate the higher non-executive women employee turnover intention in hospitality industry. This study evident that employee satisfaction, organizational commitment, organizational support, carrier advancement, work load, work environment and socio-cultural perception are the main determinants of the turnover intention of the non-executive women employees. Further, based on the determinants, researcher recommends increasing satisfaction, flexible supervision and policies, increasing performances via training sessions and performance appraisal, providing a safety environment and better facilities, giving opportunities to make their future path a success and flexible work load, responsibilities and working hours, arranging carrier guidance programmes and CSR activities to change the image and perception of hospitality industry in the society.

*Keywords:* Determinants, Women employees, Turnover intention,  
Hospitality Industry

## **Implications of Backpacker Tourism as a Viable Solution in Sri Lankan Tourism**

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Demand for the activity based tourism is considerably devoted to the materialized tourist traffic with new typologies and movements over recent years. Thus, backpacker routes are emerged as a global phenomenon with designated geographies predominantly restricted to the traditional activities and interests. Due to lack courtesy to the sector, Sri Lanka still do not have clear cut agenda on this mounting niche piece of tourism. This study was steered to investigate the characteristics, travel motives and impacts of backpacker market to recognize the potentiality of implementing a more sustainable and viable platform as a tourism niche. Subsequently, sample of 80 backpackers who visited Ella, Sigiriya and Unawatuna were selected conveniently based on the accommodation distribution of country. Survey data gathered through a structured questionnaire and a framework for backpacking tourism (motivations and perceptions) was created in order to understand the concept and possibilities to develop backpacking travel segment in Sri Lanka. The findings of this research propose value of the segment as a niche with supplementary benefits to the community over other more general forms of tourism which Sri Lanka should be seeking to develop. The study indicates that Sri Lanka has growing popularity with young, educated backpackers around the world. Majority of the backpackers had devoted Sri Lanka as a new destination where culture, nature and history are strongly directed as main travel motives which mainstream expectations of backpackers are addressed. Authorities and local government should take backpackers as a significant segment and should initiate healthy agendas to develop more community benefits with sustainable implications over it. The industry should realize the real meaning of backpacking tourism in Sri Lankan context and should develop ongoing profile to measure travelers' real needs and motivations to certify a more viable benefits to the country.

*Keywords:* Backpacker, Tourism, Travel motives, Sustainable

**The Study on Pilgrim Tourists' Perception of Jaffna as a Tourist Destination  
(With Special Reference to Nallur and Nagadeepam)**

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Tourists' perception on a destination is playing a vital role to make it as a remarkable tourist destination in the world. The pilgrimage is a journey undertaken for betterment of the spiritual knowledge and peace. The flow of people to places of religious importance in Sri Lanka has increased after the war. This is due to availability of various means of travel, development in accommodation facilities and growth of information and communication technology. Jaffna in Sri Lanka is mostly considered as pilgrimage and heritage tourist destination. This survey conducted to capture their perception, preferences and satisfaction with various services and facilities available in Jaffna and to measure the overall satisfaction with respect to accommodation, travel services, food and beverage, relaxation, price of services. The present study consisted sample size of 50 foreign pilgrim tourists who visited Jaffna. The results of the study with regards to the attributes perception of the tourists' are in a medium level which means not in a satisfactory level. Few recommendations were suggested to overcome its long term negative perceptions like developing accommodation facilities and restaurants together with the travel environment. Cleanliness and Price of goods and services are the main things needed to be monitored to build up a positive image for Jaffna bringing benefits of the industry in Jaffna and Sri Lanka as a whole.

*Keywords:* Pilgrim tourism, Tourist destination, Tourist satisfaction, Perception

**Competencies and Attitudes of Government University Hospitality Graduates:  
Employers' Views on Importance and Performance**

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With tourism to play a key role in Sri Lanka's economic growth and development, the Hospitality industry also has been given allied importance. This industry is highly depending on human resource for profitable functioning and thereby putting the employers' expectations complicated and soaring towards the workforce who are joining with the organizations. In Sri Lanka, industry oriented higher education was introduced to the university system focusing on significant development of industries such as Tourism. With the low rates of job retention and the employers' pessimistic opinions regarding the government university hospitality graduates, this study has developed a conceptual frame work to find whether there is a gap between the expected and actual competencies and attitudes of those graduates from employers view point. Employers were asked to rate the importance of a selection of graduate competencies using a five-point Likert scale, and were asked to rate government graduates' performance for the same graduate competencies. Descriptive statistics and paired t-test were conducted to analyze and elaborate the objectives of the research. The findings revealed significant differences in expected and actual status. Employers affirmed attitudes protrude for effective performance in hospitality industry while government graduates were found to be considerably lacking from those with a significant gap. Both graduates and the educators should scrutinize the gaps and invigorate the workforce to develop the Hospitality industry.

*Keywords:* University, Graduates, Competencies, Attitudes, Gap

## **Analyzing the International Tourists' Destination Image Perception on Colombo City as a City Tourism Destination**

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In tourism industry, the competitiveness among tourism destinations has become highly demanding. Niche tourism refers to approach that well-defined tourism product tailored to meet the interests of a particular tourist segment and city tourism integrates many niche tourism segments together. Hence, most cities of the world have already become the paramount tourism destinations. A large amount of existing and emerging cities are competing to enhance the destination image perception in order to attract more international tourists. This research was conducted to identify the potentials to promote Colombo city as a city tourism destination by analyzing the international tourists' destination image gap on Colombo city attributes. According to the Morgan table, a sample of 382 international tourists who visited Colombo city during the month of June 2016 were selected to conduct this survey by using convenience sampling technique. A descriptive survey among the international tourists was conducted with a structural questionnaire. EPI format (modified SERVQUAL) was used to obtain data from the respondents which was used to analyze the international tourists' destination image gap and the overall satisfaction rating regarding the Colombo city attributes. The numerous potentials have been identified which will be in capable of promoting Colombo city as a city tourism destination. It is suggested to focus the importance of the new product development and service designing, service quality improvements, global promotional campaigns with the collaboration of social media marketing tool and government intervention to reduce the destination image gap and to enhance the tourist satisfaction.

**Keywords:** Tourist destination, City tourism, destination image perception, Image gap, Tourist satisfaction

**Identify the Recreational Opportunities to Promote *Iranamadu* Tank and Nearby Area as A Tourism Destination**

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Iranamadu tank is one of the largest reservoirs in the Northern Province of Sri Lanka with the land representing the watershed and the command area believed to be around 970 km<sup>2</sup>. Close proximity to the major high way connecting the South with the northern city Jaffna as well as near proximity to Killinochi town boosts the potential for being a tourism destination with recreational opportunities. Exploring these recreational opportunities is timely as the demand for visiting this area at the backdrop of ending of three decade civil war since May 2009. This study aimed to identify the recreational opportunities to promote Iranamadu tank and nearby area as a tourism destination. Specific objectives were to find out potential tourism typologies, community perception on tourism development and benefits for community through tourism development. For this mixed method research, Residents and stake holders of Iranamadu tank and nearby area and travellers to this area were considered as study population. Twenty five residents were selected by simple random sampling. Convenient sampling was used to select 25 travellers and 10 stake holders. Primary data was gathered from residents and travellers using two types of self-administered questionnaires. Data from allied Officers & community members of Iranamadu tank and nearby area was gathered by interview method. Data was entered and analysed using SPSS software. Quantitative data was analysed using descriptive statistics such as graphs and tables. Qualitative data was analysed using verbatim quotes. The results of this study revealed that the community has high perception on infrastructure, facility development and community involvement and considering potential tourism typologies to be promoted, highest priority was for water based tourism and secondly for eco-tourism. As a conclusion, it is highly recommend that the nature of the area, agriculture and their socio-cultural values shouldn't be disturbed or damaged due to tourism activities.

*Keywords:* Recreational opportunity, Tourism development, Iranamadu tank

**Type of Brand Image and CSR (Corporate Social Responsibility) Activities of Hotels (With Special Reference to the Local Community Established around Hotels in Galle and Kandy Districts)**

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As one of the largest and expanded industries in the world, Tourism industry offers more benefits to various groups of communities in both rural and urban areas. Sri Lanka tourism is rapidly growing after the civil war period recording higher number of tourist arrivals annually. Diversified tourism activities have been developed by focusing the tourists and maintaining a strong interaction with local community is almost important since these activities generate negative impacts too. Amidst to this background, this study aims to analyze the type of brand image that hotels gain through CSR activities, identify the most effective CSR activities which can create positive brand image on local community and further, to compare the type of brand image between hotels that conducting CSR activities and non-conducting CSR activities in non-urban areas. The population for the study being the local community who established around hotels and experienced CSR activities conducted by the hoteliers, a sample of 100 community members were selected from Kandy and Galle districts by applying the judgmental sampling technique. Reviewing the related literature, a questionnaire was prepared to collect primary data from the respondents and Secondary data were used. Descriptive statistics, multiple regression analysis, correlation analysis have been used to analyze data while importing them to the Statistical Package for the Social Sciences (SPSS). The results revealed that the sensuality type brand image effects highly by CSR activities among three types of brand image and CSR activities have a significant relationship with the brand image of the local community. Further, this study illustrates that there is a huge difference of brand image value between hotels that conduct CSR activities and the hotels that do not conduct CSR activities on local community who established around their hotels.

*Keywords:* CSR activities, Local community, Brand image



**Heritage Attributes and Tourists' Satisfaction; Special Reference to Uva Province in Sri Lanka**

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In recent decades, Tourism has become a booming industry in the world. In this competitive environment, tourists' satisfaction is identified as a crucial factor for the existence and development of the tourism industry. Accordingly, heritage attributes is identified as one of the aspects to determine the sustainability of tourism market. According to literature, Uva province has failed to generate sufficient revenue from tourism industry due to its less attractiveness. Even though, there are articles and journals published about the Uva province and it has not yet been covered the impact of heritage attributes to the tourists' satisfaction. Hence, intention of this paper is to fill the gap in the literature by examining the existing situation of the heritage attributes in Uva Province, ascertaining the relationship between heritage attributes and satisfaction of tourists and identifying the impact of heritage attributes to the tourist satisfaction. In this study, heritage attribute is conceptualized as multidimensional construct which depends on four dimensions such as historical ruins, architecture, cultural village, and entertainment. Primary data were gathered through distributing a self-administrative questionnaire and 100 tourists were selected by using convenient sampling technique. Descriptive statistics, Correlation coefficient analysis and Regression analysis were used for the purpose of data analysis. The research findings revealed that there is a strong positive correlation between historical ruins, cultural village, and architecture and tourist satisfaction while entertainment has a weak positive correlation. Further, Cultural village and architecture were identified as highly affected factors to the tourists' satisfaction. The study suggests that policy makers need to pay their attention to develop strategies to market heritage attributes by introducing several facilities to attract tourists as well as to segment heritage tourism into niche markets.

*Keywords:* Heritage, Satisfaction, Tourists

**A Study on Livelihood Enhancement through Community Based Tourism(With Special Reference to Haputale)**

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Tourism has the greatest pro-poor impact on rural communities with the creation of economic effect on the host community. Accordingly community based tourism emerged as a possible solution to the mass tourism in developing countries which became a strategy for community organizations in order to enhance the living condition. The research exploited the opportunities for livelihood enhancement through community based tourism in Haputale in Badulla district. The research comprises of a mixed approach, in which, the secondary research was conducted by reviewing literature from academic literature resources. The primary data was gathered by conducting face to face interviews. The sample consisted of 50 respondents from the community for quantitative survey and 5 respondents for the interview including a government official. The research aimed to identify the current practices of tourism in the community while investigating the barriers and identifying the community perception of tourism. The results indicated that, the livelihood of Haputale community had been enhanced due to community based tourism. Mainly small enterprises such as food outlets are more evident in the community. The analysis showed that community perception on tourism is average and the future development opinion is to develop tourism. Moreover, the researcher suggested to take the government support in order to enhance the community livelihood in Haputale area.

*Keywords:* Community based tourism, Economic effect,  
Livelihood enhancement

**Identification of Inbound Tourist's Image Perception on Local Foods and Cuisines in Sri Lanka by Cognitive and Affective Factors (With special reference to Galle district Sri Lanka)**

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Food and related tourism experience is a significant part of every travel experience. Foods and beverages accounts for nearly thirty percent from overall expenditure of the destination and involves to significant part of total expenditure of tourist's budget. (WTO statistics, 2014) Local foods and cuisines are important part of the destination experience in many destinations in the world. Amidst to this background, it would be worth to identify the tourists' image on Sri Lankan local foods. Hence, this research mainly focused to investigate the image perception of tourist's on Local Foods in Galle district in Sri Lanka. The data was collected from 100 sample of inbound tourists who visited the selected destinations. Data was collected by using convenience sampling method using a structured questionnaire. Based on the related literature, a model was developed to identify the most favorable, moderate and unfavorable image dimensions and the impact of each dimension to overall destination. Descriptive analysis and regression analysis were used to analyze the data in order to achieve the objectives of the study. According to the research findings, there is a moderate level of image on Sri Lankan foods in the destination among inbound tourists visiting the destination and there is a significant impact from local foods and cuisines image perception variables for overall destination image. Moreover, destination has a huge potential to develop the local foods and culinary tourism experience as a destination attraction tool and the potential dimensions and indicators of the local food image can be used by entrepreneurs and tourism related entities to develop destination food and cuisines experience as a separate niche market for destination sustainability.

*Keywords:* Local Foods, Tourist's image, Food tourism, Tourist's experience

**Determinants of Revenue per Available Room (RevPAR) Analysis in Tourist Hotels (Special Reference to Southern Province Star Category Hotels)**

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Currently tourism industry is one of the rapidly growing industries in the world. It is becoming one of the major income generators of many countries. In addition, most of the hotels are trying to increase their revenue. But most of them used wrong determinants to measure the revenue, and empirical level gap was identified in this context. The purposes of this study are to identify RevPAR determinants of individual firms located in a destination and find the relationship between RevPAR and those determinants. RevPAR, or revenue per available room, is a performance metric in the hotel industry. In Sri Lanka less researches or studies have been done regarding RevPAR. The study area selected for this study consists of all Sri Lankan star classified hotels as population. According to convenience sampling technique, the sample composed of 50 star classified hotels of Southern Province, Sri Lanka, and data have been collected from financial statements and questionnaires. This research was conducted as a quantitative research by using SPSS software as an analyzing tool. *Correlations, anova* table values, charts, descriptive statistics help to get the final outcomes. Final findings identified that number of employees, star category of the hotel, founding year and refurbishment year of the hotel, location of the hotel as the determinants. Further, based on the determinants, researcher found that positive relationship between RevPAR and Number of employees, Star category of the hotel Facilities and services, and negative relationship between RevPAR and location and founding year of the hotel. At the theoretical level, researcher suggests doing "GopPAR" (Gross Operating Profit per Available Room) analysis to maximize the revenue so far. The researcher recommends avoiding seasonality, providing unique services and products, doing unique promotions, providing special packages and upgrading star category of the hotel are the most important factors of maximizing the revenue.

*Keywords:* Hotels, Performance metric, Revenue, Determinants

**Impact of Tourist Satisfaction towards International Tourist Revisit Intention to Boat Safari (With Special Reference to the Madu River)**

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Tourism is a fastest growing sector. Further, The tourist arrival almost reaching 2.2 million within first three quarters of this year and the industry being expanded to encompass entire island. Unexceptionally, south-west region of the country is becoming popular and experiences influx tourist arrival particularly from Kaluthara to Hikkaduwa. River cruise or the boat ride in Madu River has become as a very popular tourist product among the international and domestic tourists. Thus, Madu river boat has been included almost all tour itineraries toward south of the island. Although there are few studies on Madu River, there is no study on tourist satisfaction and revisit intention of international tourists' on Madu River boat safari. This research investigates on tourist satisfaction can be an inevitable element for potential tourism development in Madu River. As a holistic case study the researcher selected popular registered board service provided in Balapitiya. 100 structured questionnaires were distributed among the tourists who were selected from five boat operators. The descriptive statistics analysis was done through, correlation and regression analysis through the support of SPSS 21.0 version. Descriptive statistics has implied exiting level of tourist satisfaction and tourist revisit intention. Further, multiple linear regression analysis has exposed how to impact interaction quality, physical environment quality, outcome quality, access quality to tourist satisfaction in boat safari and regression analysis has confirmed by 88.9 percent coefficient determination. The implication of the study emphasizes that the tourists' satisfaction should be taken into serious consideration to ensure the memorable experience of boat safari in Madu River. This would enhance the revisit intention of international tourists. Enhancing the tourists' satisfaction demands the better service quality and guaranteed product through proper human capital development and product designing and development. Further, sustaining the environmental quality and meeting the global trends and technological sophistication are underpinned criteria to ensure the potential market.

*Keywords:* Madu River, Boat Safari, Tourist Satisfaction, Revisit Intention

**Motivational Factors Influencing the Demand for Themed Weddings in Sri Lanka  
(With special reference to Colombo District)**

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Themed wedding is a concept that creates in a couple's mind. According to particular concept, they do everything starting from the invitations, cake structure, as the customer flavors of the color or anything and go throughout the wedding. The concept may create according to a place, their profession or their personal interest. This study explores the motivational factors influencing the demand for themed wedding packages in Sri Lanka with special reference to Colombo district. It comprised of two components with a qualitative study to explore the knowledge of weddings planners and a descriptive cross sectional study to assess demographic and other factors influencing the choice of themed weddings. Sri Lankan wedding directory was taken as the sampling frame for the wedding planners which provide a list of 15 wedding planners in Colombo District, and identified 10 couples who took their weddings with each of these planners. One hundred and thirty seven clients completed the questionnaires sent through the emails and 10 event planners responded to the semi structured interview regarding themed weddings. The gathered data were analyzed by using descriptive statistics and content analysis. Majority of the respondents mentioned that their personal attitude mostly influence to select a themed wedding. Other than that Affordability to a themed wedding ( monthly Income), Wedding Cost, Seeing and attending themed weddings of friends and relatives, Prestige of the family, Organizing and experiencing themed wedding of a family Member, Knowledge gained by participating wedding fairs, seeing wedding magazines and events shared in social media and Childhood dream were influents couples to select a themed wedding. Wedding fairs are the most effective marketing tool to promoting themed weddings. In Sri Lankan context, the most popular wedding theme is traditional Kandyan theme while color themes and nature based themes are also popularized. This research will provide evidence and open up new research avenues by filling the gap of non-availability of evidence around the topic "themed weddings". Identifying the factors influencing to the demand for themed wedding packages will help the industry in promoting themed weddings.

*Keywords:* Themed weddings, Wedding planners, Clients

**Assessing the Level of Effective Listening Skills towards the Workplace Performance of Hospitality Industry (With special reference to Hospitality and Tourism Undergraduates of Uva Wellassa University)**

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Listening is an important element of interpersonal communication. An individuals' skills in listening impact on his or her personal relationships as well as interaction on the workplace. Many researchers have shown that level of listening, just like any other skill, can be developed by training. A study by University of East London has shown that that development of better listening skills improve work place performance and academic performance. Therefore, this study was conducted to investigate the level of listening skills of Hospitality, Tourism and Events Management undergraduates of Uva Wellassa University. Hospitality industry functions in an environment characterized by rapid change and it is totally a service oriented industry. Especially, the hospitality workforce and the guests they serve are becoming increasingly diverse. Hence, the ability to listen take increasing importance among hospitality employees as listening is essential in the course of delivering personal, customized service. For hospitality organizations, success is tightly linked to the quality of service produced by employees. As the same way, listening is the foundation of two organizational processes essential to service delivery, one involving the accurate exchange of information and the other facilitating the development of strong relationships. Hence, this study was done with special reference to Hospitality and Tourism undergraduates. Because, they are the future employees who are going to work with hospitality industry. The researcher used survey design for this study. The population of the study was all the undergraduates who are reading Hospitality, Tourism and Events Management degree program in Uva Wellassa University, with sample size of 75 respondents. The researcher used both primary and secondary sources of the data in course of the study. Primary data were collected through self-structured questionnaires and semi structured interviews. Data were analyzed descriptively using elementary statistics. According to the findings, the most common barrier to active listening for respondents was concentration problems. When listening to foreigners, they have the problems of English vocabulary and pronunciation. As the same way, the research findings revealed that communication breakdown has effect in the performance of the workplace which results in low productivity. The significance of the study lies in its contribution to curriculum building, listening skills development, as well as teaching skills development.

*Keywords:* Listening, Hospitality, Communication, Workplace Performance

**An Efficacy of Destination Branding in an EWOM (Electronic Word of Mouth) environment: A Case of Sri Lanka**

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In today's ever competitive market globalization has enables travelers to effortlessly travel from a geographically distant location to another. Therefore, with destination competition vigorously in the never ending battle of competition, DMO's (Destination Management Organizations) are required to pay closer attention to creating a unique destination personality and identity to represent positive images of the destination. This research study focuses on addressing how Sri Lanka can be branded as a popular tourist destination and captures more tourists from the world market. To be more precise, to identify the effects of destination branding for the escalation of the tourism industry in Sri Lanka and to explore the role played by eWOM in helping to magnetize tourists to SL that will allow for a thriving destination brand. It is vital for destinations to be differentiated rather than competing in similar characteristics of the world market. Therefore, branding Sri Lanka will enable to flourish the destination brand and truly become a "Wonder of Asia". However, a destination is entitled to hold negative image by tourists due to crisis events and the researcher understood the inadequate attention paid by internal management of destinations to the concept of branding Sri Lanka as a destination based on different theories. This research therefore focused on the brand identity, brand image, destination personality and electronic word of mouth on the destination branding in Sri Lanka. The research philosophy used is the positivism which emphasized on the deductive empirical approach. The sample selected well represented the tourist population attracted to the country where geographical stratification in random sampling was practiced. All the variable selected have significantly impacted on the destination branding within the 95% confidence interval. Hence there is a strong policy development basis towards the destination branding through the hypothesis tested in order to improve the tourist attraction to Sri Lanka.

*Keywords:* Destination branding, eWOM



**Ravana Tourist Trail with Prehistorical Values (An Exploratory Video Documentary on Ravana Legend and Prehistorical Sites in Uva Province)**

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The Ramayana is an ancient Sanskrit epic attributed to the poet Valmiki and one of the most important literary works of ancient India. It has fascinated many generations and had a profound impact on art and culture in the Indian subcontinent and Southeast Asia. There are many sites in Sri Lanka which are connected to the epic. Ravana legend trackers and heritage tourists visits these sites, but there is no proper tourist trail with well-defined folktales and prehistorical evidences. Even though Ravana tour trailers and tour packages are emerging in the market, there is a lack of academic literature on the topic. Further, archeological evidences are infrequent on pre-historical period of the country. Thus, this study incorporates with Ramayana legendary in Uva province and identified pre-historical places at relevant passage. Uva province was selected according to judgmental sampling, since the region facilitates for the most folktales and prehistorical places affiliated to the Ravana legend. An exploratory video documentary produced to identify the pre-historical values of sites affiliated with Ravana epic. In-depth interviews with archeological authorities, historians and inhabitants were used to bring focus group data in to the documentary. Thirty minute documentary covers unexplored and unmapped pre-historical sites affiliated with Ravana epic located in Uva province. Untouched cave complexes were explored and recorded using modern video recording techniques. Findings of this documentary have developed an academic outline on Ravana legends in the Uva province while establishing a Ravana tour trailer with a specific GPS path. This study recommends that Ravana tour trailer need to be develop as an adventurous heritage tour trail and to promote exploratory travel documentaries on social media as marketing stimuli for Ravana legend trackers to develop heritage tourism in Uva Province.

*Keywords:* Ravana, Tourist trail, Exploratory video documentary

**Identification of Potential to Develop Wedding Tourism in Sri Lanka With Special Reference to Southern Province**

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Wedding tourism has increased popularity over the past decade and is recognized as a significant market segment with a possibility of enhancing effectiveness of the industry by amalgamating two segments as one destination. This is already existing niche market which has not been yet capitalized and can be developed as a diversified tourism product and the effects of seasonality can be minimized. Hence, the profile of the customer, the preference of the customer and the capability of destination on wedding tourism has been taken into consideration in order to identify the potential. Primary data collected by the researcher from 100 foreign tourists and 10 hoteliers applying convenience sampling method and interview method accordingly. Southern province was the research area for data collection. Both quantitative and qualitative data analysis methods were deployed. The findings reflect that, there is an adequate potential for wedding tourism as a new tourism product. Expectations of wedding tourists are compatible with the potential existing in present in southern province. In conclusion, industry should be realized the real significance of wedding tourism in Sri Lankan context and it should be developed ongoing profile measuring traveler's real needs and expectations to be certified a direct influence on developing wedding tourism in Sri Lanka.

*Keywords:* Wedding tourism, Visitor profile, Tourists' expectation, Destination Capability

**Nature and Factors Influencing the Tourist Harassments in Sri Lankan Coastal Belt (With Special Reference to Hikkaduwa and Unawatuna)**

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Nature of tourists' harassment and factors leading to this menace are some of the issues with not only negative but also significant effect on the growth of tourism. This study attempt to identify various tourists' harassments occurs in down south. The main objective of this study was to identify the nature and factors leading to this problem and to investigate whether the harassment situation has affected to the international tourist arrivals to Sri Lanka. Convenience sampling technique was used to select the sample of a total 100 international tourists from both Hikkaduwa and Unawatuna. Close ended and open ended questionnaires were used to collect data on nature of harassment: types of harassment, most problematic harassers, hot-spots for harassments, and factors leading to harassment: gender, age, travel companion, purpose of visit, and travel experience of tourists. The data was analyzed using the mixed methodology. According to the results of the study, the most prevalent type of tourist harassment was pestering to buy goods and services. Local vendors were identified as the most problematic tourist harassers and shopping centers were the frequent hotspots for harassments. Tourists who belong to 20-29 years age group experienced slightly more harassment than the other age groups of tourists. On Travel companion, the highest occurrence of harassment was reported among the group representing the single tourists. Tourists travel for surfing & adventure purpose were slightly more harassed than other purpose of visit tourists. Further, the study demonstrated that tourists on first visit to Hikkaduwa and Unawatuna were more experienced with harassment than those on repeat visit. According to the tourist perspective, revisit intention, recommendation, comments and suggestions, it is exposed that, "Harassment situation affected to the international tourist arrivals to Sri Lanka." Therefore, harassments affect for the future wellbeing of the tourism industry in Sri Lanka. The study fills a gap in the literature on a growing concern. Research concludes with future tourism development to deepen understanding of the issue, take the possible reactions and make the tourists satisfaction and create memorable travel experience within Sri Lanka. It will be very useful if research can be conducted in island wide for the Sri Lankan tourism industry.

*Keywords:* Harassments, Nature, factors, Coastal belt, International tourist arrivals



# **Humanities and Social Development**



## **Parent-Child Interaction and Academic Achievement of Sri Lankan Undergraduates**

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Parents are the first and most influential edifiers to the children will ever have. The present study will be utilizable to cognizance the paramount of parent-child interaction and academic achievement of Sri Lankan Undergraduates. The objectives of the present research were to find out the relationship between parent-child interaction and academic achievement of Sri Lankan Undergraduates and to find out the study of parent-child interaction and academic achievement between the Sri Lankan Undergraduates with the respect level of study. Survey methodology was used for the present research and 300 parents have been selected from public and private universities as the sample of this research using simple random sampling method. Two hypotheses were tested in the current research by assuming there is no significant difference in the mean scores of parent-child interaction and academic achievement of Sri Lankan Undergraduates with respect to level of study and there is no significant relationship between parent child interaction and academic achievement of Sri Lankan Undergraduates. Major findings of the present research were Year 1 and Year 2 students are significantly differing in the mean scores of parent-child interaction of Sri Lankan Undergraduates, Year 1 and Year 2 students do not significantly differ in the mean scores of Academic Achievement of Sri Lankan Undergraduates and there is no correlation between the parent-child interaction and Academic Achievement of Sri Lankan Undergraduates. Accordingly, Based on Year 1 and Year 2 students, significantly differ in the mean scores of parent child interaction of Sri Lankan Undergraduates. The mean scores of Year 1 students are higher than the Year 2 students. It may be due to the fact that undergraduates have newly entered into Year 1. It is a new situation for the Year 1 students. Hence the parental involvement is more in this situation. But Year 2 students have enough maturity because they experience a lot in the year 1. In the light of the findings of the study there is a need to organize the parent teachers association programs for parents, teachers and students in university level. The parent teachers association programs for parents and teachers should aim at the enrichment of the educational achievement of Sri Lankan Undergraduates.

*Keywords:* Academic achievements, Parentchild interaction, undergraduates

**Listening Barriers in Academic Contexts (A Case study of Uva Wellassa University Students)**

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Even though lecturers are fully committed in a teaching integrating variety of activities, some students are unable to gain its full benefits basically due to listening barriers. Although many intellectual factors influence on learning, listening is the key skill which leads acquiring the expected educational goals in the process of learning. Further, students are varied in their ability to listen actively while gaining the maximum out of what they listen especially in academic contexts. However, if communication is not efficacious, it cannot be said that the fault is merely of the receiver. Academic listening can be affected by many factors. Therefore, this paper mainly focuses on the factors influence on active listening in the process of learning at undergraduate level. Accordingly, the study was conducted to investigate listening barriers encountered by undergraduates in academic contexts. Both qualitative and quantitative data were collected from 465 first year undergraduates of all three Faculties; Animal Sciences & Export Agriculture, Entrepreneurship & Management and Science & Technology in Uva Wellassa University. A self-structured questionnaire and a semi structured interviews were implemented as primary data collection methods while using elementary statistics for analytical purpose. According to the findings, the majority of the undergraduates (67%) is poor in listening to lectures. Furthermore, many first year undergraduates of the Uva Wellassa University face language problems and psychological problems. The most common barrier encountered by the undergraduates in academic listening has been the difficulty of coping with English terminology and the speed of the speakers. Physical and environmental factors have been identified as the least influenced factors. The significance of the study lies in its contribution to curriculum development, listening skill enhancement as well as adopting creative teaching techniques. The study formulates some implications for future research.

*Keywords:* Listening, Academic, Undergraduates, Barriers, Communication, Skills



## **Learning obstacles of the Adolescents who lost their Parents in the War in Jaffna District**

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War is now well known to cause a variety of social deprivations. In Northern Sri Lanka, different age group of the population in war-torn areas is often direct or indirect victims of violence, and witnesses to various issues associated with war disaster. Thus, this study chose to undertake a closer look at the impact of the war, particularly the learning obstacles of the school going adolescents in Jaffna who lost their parent due to the war. This study, conducted a qualitative research based on the purposeful random sampling method. This paper has reported on the experiences of 52 adolescences (age group of 10-19). The participants were selected from a list of those registered as adolescents who had lost their parents in the war disaster by the divisional secretariat in Chavakachchri in the Jaffna district. Fifty two participants have been included in the in-depth interview. The method for the analysis of data is theme analysis based on *Grounded Theory* for the analysis of field interviews. The focus of this paper is on adolescents as they are the ones more likely to have a profound experience of learning obstacle on the basis of their gender, age, their day to day life events and family environment. The result of the study confirms that the most influential social - economic and psychological factors affecting the learning activities in the studies are - gender, age, way of income level, recourses of schools, the nature of family members, and Adolescents with Disability in post war Jaffna, Sri Lanka. Also, this study has found a new form of family structure in the post war society which is identified as Child headed family. Thus, since each family is made different individuals in a different setting, each family environment is unique. Since war affected children/adolescent issues have become a central part of the development and social work discourse in the post-war Tamil society. The findings of this study can be helpful in developing better understanding of school going adolescents and their need in post-war of northern Sri Lanka. It will also help in identifying the kind of approaches and policies that need to be formulated to address their issues and grievances.

*Keywords:* War, Adolescents, Adolescents with disability, Learning obstacles

## **A Reference about Art in Period of Anuradhapura that Sustained by Buddhism**

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From The bloom in Establishment of Sri Lankan society to the present, the Sri Lankan painting system has been residual as ancient, archaeological between us. This ancient paintings is the Sri Lankan painting system. This painting which has painted in temples walls or in caves got different art traditions in different time periods and the social, economic, cultural and religious background of the painters concurrent period. The purpose of this paper is to examine the reference about art in the period of Anuradhapura that sustained by Buddhism. So, the necessity of a methodology to examine this topic. The method that has been applied in data collection and analysis is Qualitative Research Method. Secondary data were used as a main source for analyzing information. When we are learning about this painting history, it has been divided into periods as the born periods. Therein the classification done according to the ancient, political factors and the place which the paints existing. Ancient communication per iodization done by the critic part. And the other classification is based on the paintings practical structure. In the bloom period of Anuradhapura, the painting which has been painted in the temples not apparent for now. Therefore giving information about painting according to the archaeological factors was a little bit difficult. The paper concludes the Buddhist literature we can obtain some information about the painting. When referring about the ancient periods painting it is necessary to consider about not only the residual murals, but also the different literary and recorded. When referring about the ancient periods painting it is necessary to consider about not only the residual murals but also the different literary and recorded sources like Mahavamsa, Visuddhimargaya, Samanthapasadika, record of Tara pahian.

*Keywords:* Art, Period of Anuradhapura, literature, Buddhist temple, Tradition

**Public Speaking Anxiety among University Undergraduates (A Case study of Uva Wellassa University Students)**

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Public speaking anxiety is a very common problem among undergraduates. Due to speaking anxiety, students often try to avoid performance situations in the classroom. As a result, they fail to take the advantage of many opportunities to develop their communication skills. With this background, this study was conducted to investigate whether providing a proper training on public speaking with strategies helps students to reduce their public speaking anxiety. To measure the actual level of public speaking anxiety of the students, at the beginning of the semester, students were asked to fill up a questionnaire. For this, the questionnaire of Personal Report of Public Speaking Anxiety (PRPSA) developed by McCroskey (1970; 1992) was used. Further, as the second part of the research, the students were trained by teaching five strategies of reducing public speaking anxiety. At the end of the semester they were again asked to fill up the same questionnaire. 200 third year students of the Uva Wellassa University were selected as the research sample. The results of the study indicated that the public speaking anxiety of the students was reduced after they had been taught the strategies in the training.

*Keywords:* public speaking, Anxiety, undergraduates, strategies

**Influence of Gender and Job Satisfaction over Mental Health of School Teachers:  
with Special reference to the Kurunegala District, Sri Lanka**

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The teachers were customarily held very high esteem by the different sections of people and society was sensitive to take care of the desiderata of the teacher. With the transmuting socioeconomic scenario and incrementing unemployment, the values of edifier and their professional concern with the job have forcibly undergone a transmute which adversely affects the mental health of the teacher. The caliber of mental health an edifier has affected his/her working as well as administrative environment. If teachers don't relish sound mental health, they cannot concentrate in edifying and retain the erudition given to the students. Considering those facts the study is aimed at finding the Influence of Gender and job gratification over the mental health of government and private school teachers. The sample of the present study comprised of 125 teachers of Government Schools and 125 teachers of private schools situated in to the Kurunegala District of North Western province, Sri Lanka, Convenient sampling was used to select the sample. Mental health inventory and job satisfaction inventory were utilized. It was found that government school teachers possess good mental health in comparison to private school edifiers. Gender has no Influence on the mental health of school teachers. Further findings show that that job satisfaction has an Influence on the mental health of the teachers. Findings from this study have implicative insinuation for the roles of policy makers, school ascendant entities and higher scholastic ascendant entities. As private School Teachers in Kurunegala District differ significantly in mental health and are less slaked in their job in comparison to government School Teachers in Kurunegala District School administrators and higher inculcated ascendant entities should arrange in-service training for edifiers to refresh their knowledge of content and edifying method.

*Keywords:* Gender, Job satisfaction, Mental health

## **A Critical Analysis of the Concept of Anarchy in Political Realism**

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Realism, a major theoretical approach in International Relations, advocates that international politics is a struggle for power among states. The core claim of both classical realists and neo-realists is that states interact in an environment of anarchy due to the absence of a central authority to govern the state behavior. The objective of this research is to critically analyze the role of anarchy in the present international system as a concept put forward by political realists. A theory is a way of seeing or a perspective which is subject to be challenged constantly due to the presence of other contrasting perspectives and theories. In that regard, the ultimate outcome of this study is to emphasize the need for a multi-theoretical approach to explain the nature of current international politics. The entire research will be driven by qualitative research methods, mainly based on secondary sources; such as scholarly articles, books and journal articles written on the subject matter. Firstly, the study aims to analyze the effects of anarchy which drive the state behavior and constrain the state behavior. Secondly, criticisms of the realist claims on anarchy will be discussed in light of the claims made by political liberals and constructivists as the main critics of realism. They emphasize the importance of non state actors and their potential to bring cooperation to the forefront of international politics by bringing moral principles to the system as opposed to realism, which does not have a moral claim. Thirdly, the author analyses the validity of those criticisms. The main result of the research is that we could not totally deny the realist claims on anarchy. Conflicts, wars and competition over resources between independent states still prevail in the forefront of international politics. Therefore, both realist standpoints and the criticisms to those standpoints have their validity and limitations when analyzing the politics and economics of the key areas of world politics today. The author concludes the research emphasizing the need of a more holistic approach in analyzing world politics. The most pragmatic recommendation is that the current international community should aspire to achieve not a safe, peaceful world; given the validity of the realist arguments that conflict is inevitable. Yet, they should aspire to achieve a less violent, less dangerous world based on mutual cooperation; given the validity of the claims made by liberals and constructivists.

*Keywords:* Realism, Liberalism, Constructivism, Conflicts, Anarchy

## **Humour as an Effective Pedagogical Tool in Sri Lanka**

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Humour is a universal trait/characteristic common to all human cultures. When used constructively, it is enriched with the capacity to tranquilise and to build a harmonious rapport in social interactions, and its power in classrooms is no exception. Globally, constructive humour is used widely in academic settings with continued research, although its use is mostly overlooked in Sri Lanka. Thus the objective of this study was to test the effectiveness of humour as a pedagogical tool in Sri Lanka. We used an experimental design for this study. The experiment was conducted as a teaching session for students learning English as a second language in Sri Lanka. The 45 minute session consisted of a lesson on English idiomatic expressions and pre-post tests to evaluate knowledge. Hundred and six (106) female participants (age 11-12) from a girls-only school in Colombo participated in the study. Fifty seven (57) students were in the experimental group and forty nine (49) were in the control group. Both groups had the same teaching-learning experience, except for the use of humour as a pedagogical tool with the experimental group. The study revealed that the participants in the experimental group performed better at the end of the lesson evaluation, with a statistically significant mean difference in scores compared to the control group. This indicates that humour contributed to enhance the effectiveness of teaching, and that it could be used successfully in Sri Lankan classrooms as a pedagogical tool. This result invites academics and researchers to observe the extended usage of humour in many contexts in Sri Lanka (e.g. social life, governance, politics, economic interactions, etc.), and the comparatively limited use of humour as a pedagogical tool in formal teaching-learning environments. Thus, future studies which explore factors that contribute and restrain the use of humour in Sri Lankan academia would shed new light on how constructive humour could be effectively utilised to benefit students and future generations.

*Keywords:* Humour, Constructive humour, Pedagogical tool, Teaching-learning activities

## **Buddhist Approach on Sex Related Offenses**

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Sex related offenses become complicated in the modern world as it has various forms which changing from day by day due to the technological development. As a result, in some cases, legal frameworks are not efficient enough to prevent it. Religious teachings are also discussing the matters relevant to sex related offenses in the moral codes and teachings of virtuous behavior. Buddhist teachings discussing this matter in more detail in the disciplinary code of *Sagha*. The purpose of this research is to discuss the Buddhist approach on sex related offenses and its applicability in common social context. Documentary study is the method of data collecting and content analysis is used for data analyzing in this research. Buddhist teachings are given two definitions to lay and clergy communities as it comes matters relevant to sex related offenses. According to these teachings if a *Bhikku*, or *Bhikkuni* having any kind of sexual relationship is an offense. Any kind of sexual intercourse will lead to lose the membership. For *Upsakas*, and *Upsiks* not having any kind of extramarital sexual relationship is one of the five precepts, one should practice to become virtuous. Other than having sexual relationships doing various types of sex related activities also discussed under a disciplinary code of *Bhikkus*, and *Bhikkunis*. All types of sex related activities appear in a society are discussed under them. The most important factor in Buddhist interpretation in sex related offenses is the way it defines whether the act is an offense or not. According to Buddhist interpretation the most important thing to decide whether it is an offense or not is the mental state of the individual. Not the physical act. If the individual mentally involves in the physical act, it is an offense. If not, even the act has done already it is not an offense. Buddhist point of view in sex related activities is having a broader approach to prevent sex related offenses by promoting to become virtuous. On the other hand it is having a broader point of view regarding solving sex related offenses.

*Keywords:* Five precept, Physical Act, Mental state, Clergy community, Lay community

## **Standardizing Spoken Tamil For Sri Lankan Context To Teach Tamil As A Second Language**

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For the past decade, Sinhala and Tamil have been taught intensely as a second national language mutually to the native speakers in Sri Lanka. The government has instituted Tamil (or Sinhala) as an essential subject from primary level education and is required for government servants for their confirmation. Tamil textbooks / handbooks, published in Sri Lanka, are provided to students to develop comprehensive writing and reading skills while giving less attention to listening and speaking. Despite this there are several textbooks/handbooks that offer different dialects of Tamil. Tamil is a multi-dialect language. Consequently, there is a need to have an acceptable Sri Lankan Spoken Tamil. The objective of this research is to codify a standard Sri Lankan spoken Tamil to use only for the purpose of teaching Tamil to Sinhala speakers as a second language. This study considers whether the use of Jaffna Tamil or other dialects in teaching spoken Tamil may cause difficulties for Sinhala speaking students as well as teachers all over the country. There is no adequate research that has been done until now on this issue other than a verbal discussion on the notion of the Sri Lankan Spoken Tamil in teaching Tamil as a second national language. The corpus for this study is taken from identified geographically and ethnologically - Tamil dialects among societies and electronic media by casual observations and some corpus are selected randomly from textbooks published in Sri Lanka. Standardization is a process and goal oriented action can be carried out by individuals and institutions. This empirical and descriptive survey tries to standardize a unified Sri Lankan spoken Tamil by the process of selecting, codifying, and unifying to become normalizing. Outcomes show that many of the differences that appear in the dialects are interrelated. Specifically, some variance in the accents is mainly phonetic and have tonal systems. The variation in the verbal structures is immense. Though, they can be codified as a standard one. This standard spoken Tamil will support students to develop their communicative competence and help teachers to take part in teaching Tamil as second language effectively in the Sri Lankan context. And standardization of Sri Lankan Spoken Tamil will thrust upon to national integration.

*Keywords:* Sri lankan spoken Tamil, Standardization, Tamil as a second language, Tamil dialects, Sinhala speakers



## **Engaging Military in Post Conflict Development of Sri Lanka**

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As a result of new defense strategies adopted by the former government since the Marvillaru Battle in 2006, enrollment for the three armed forces had been significantly increased. The total strength of three forces was approximately 400,000 by 2009. This strength was consisting with professionals, commissioned officers and young soldiers. After the war victory, the government has decided to get it them involved in the post conflict reconciliation process. However, military involvement in non-military activities was highly criticized by several fronts. They urged that nation is becoming militarized. A national discussion was developing in this regard before the presidential election in 2015 as security forces actively participated in infrastructure and youth development, rehabilitation, resettlement during 2009-2014. However, the involvement of military forces was gradually fading away from the development and reconciliation process from 2015. The main objective of this study is to assess the involvement of security forces on nation building while analyzing public impression on that. Primary data were collected through one to one interviews with 1000 civilians, including government and private sector workers, university students, ex-LTTE cadres and ex-military personals. Through this analysis, it was found out that, the majority of people in the south has a positive impression on military involvement in nation building process while the majority of the North have not reflected positive impression. Ex- LTTE carders and students were agreed with it. However, ex-service persons expressed mixed responses. Considering above mixed responses, it was suggested to re-design the strategic policy or structure to streamline military involvement on nation building and youth development while maintaining a sustainable peace.

*Keywords:* Nation Building, Youth development, Post war, Sustainable peace, Militarization

## **The Professional Challenges Faced by the Working Journalists of Jaffna**

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During the war period in Sri Lanka, in Jaffna peninsula the media suffered a lot of pressure and the utmost challenge the journalists faced was the life threat. And no other professional challenges were considered central. Now that threat is low, but, the journalists are facing other vital challenges and troubles related to their field, particularly to develop their career graph and professionalism to make them achieve the expected standards. This research on The Professional Challenges Faced by the Working Journalists of Jaffna was carried out among the working journalists full-time attached to the daily newspapers published in Jaffna; *Yarl Thinakkural*, *Uthayan*, *Valampuri*, and regional editions of *Virakesari*. This research focuses on the current Problems and challenges faced by the journalists, such as, job satisfaction, salary, training and capacity building, working hours, promotion, gender differences, right to work independently, work security, social status, psychological aspects and, the expectations of the family members. The qualitative and quantitative methodologies were employed in the research. The data for this research were collected through the survey by interviews from the chief editors and news editors and the data collected from the sub editors and staff reporters through questionnaires. The data collected were analyzed and it has been found out that the major challenges the full-time journalists of Jaffna face are regarding their wages and psychological issues and these issues cause other professional related challenges they meet. Many of the journalists are satisfied about their work and its pattern and they felt that their personal aspiration leads to choose the job even though the hardships surround them in terms of personal security in the past. Contradict to the expressions of the journalists, the family members not agreed to their stand to continue the lifelong job and the family preferred to move them for the better payment avenues.

*Keywords:* Working Journalists, Professional challenges, Career development, Job satisfaction

## Global API for Ingenuous Event of the News

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The objective of the research is about server-side web API (*Application Programming Interface*) consisting of ingenuous events of the news and publicly exposed endpoints to a defined *requestresponse message* system in JSON. The Right to Information is a central component of the society. Everyone has right to know the correct information about any event happening anywhere in the universe, if that information is not prohibited from legal background. Most of news corporations do not publish the correct information on their channels. Because, most of these organizations function under the pressure of political, religious, commercial or any other biased background. The biased news reintegrated into society through the popular mass media (TV, Radio, News services APIs) slippage of information right belong to human right are far become a strong substantive issue at present. The final result is about an API which releases ingenuous event on the news. This is executed by co-ordinate information grasp through the NLP (*Natural Language Processing*). The researcher gathers news for a related event from popular news available service APIs and extract the general publics' views on quantum through the social media comments and also the online newspapers. Such information is grasped through the method of *Extraction Ontologies*. The comparison of the news accrued, will be able to generate unbiased news, which will attract the viewers faith in API. In here, to compare each information, used the methods of comparing incidents applicable to each category, integrating categories, delimiting and writing theory technology of the *Constant Comparative Method*. And to summarize the above as a summary, algorithms mentioned in ranking sentences by importance using the core algorithm, Reorganizing the summary to focus on a topic; by selection of a keyword, Removing transition phrases, Removing unnecessary clauses, Removing excessive examples.

*Keywords:* News API, NLP, Content comparative, ontologies, Summarization



# **Materials Science and Engineering**



## Optimization of Descriptor Values for Benzamide to Estimate Its Partition Levels in Environmental Compartments

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Evaluation of the distribution levels of organic chemicals in natural environmental compartments is considered as an important procedure in effect or exposure assessment. Many amide compounds including benzamide lack effect or exposure data due to the lack of economic and technical resources needed to assess the chemicals in the environmental sites. As a solution to this problem, quantitative structure property relationships (QSPR) can be developed to predict the distribution levels of organic chemicals in environmental systems. Benzamide is known to cause acute health effects depending on the levels of exposure, and it is also released to the environment by industry in large quantities every year. Therefore, the estimation method described herein is important to evaluate its concentration levels in the environment, and for the exposure assessment. Application of the method is specifically useful to countries like Sri Lanka with developing economies, as it significantly reduces the cost of chemical evaluations. The QSPR used in this research study is the Abrahams Solvation Parameter Model. In order to assign the descriptor values for benzamide, the retention factors were measured in several Gas Chromatography and Liquid Chromatography stationary phases including HP 5 (5 % diphenyl dimethyl siloxane), SPB Octyl (poly methyl octyl siloxane), DB 225 (50% cyanopropylphenyl dimethyl siloxane), Rtx 50 (Cross bonded phenyl methyl poly siloxane), RTX OPP (poly (dimethyl trifluoropropyl siloxane)), Sunfire C18, and Synergy Polar RP. The temperatures for the experiments were varied from 80 °C to 240 °C. Partition coefficients were determined in selected organic liquid-liquid partition systems. The descriptor values for benzamide were assigned using the Solver Algorithm in Excel such that the obtained values possess a minimum standard deviation. The descriptor values optimized for benzamide are, E= 1.2578 (Excess molar refraction), S = 1.3859 (Dipolarity/polarizability), A = 0.6430 (Hydrogen bond acidity), L = 5.2383 (Gas-Hexadecane partition coefficient), B = 0.6548 (Hydrogen bond basicity), and V = 0.9728 (McGowan characteristic volume) respectively, and possess minimum error. Optimized descriptor values can be used to accurately estimate the toxicity endpoints and bio-partition values.

**Keywords:** Descriptors, Solvation parameter model, Gas chromatography, Liquid chromatography, Partition levels

### **Synthesis and Characterization of Hydroxyapatite Derived from Eppawala Apatite for Biomedical Applications**

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Hydroxyapatite is widely used as a bio implant material because of its chemical and structural similarity with the mineral phase of bone and teeth. However, synthesizing this material from natural minerals is not that much popular. Here, we synthesized hydroxyapatite from apatite (high grade phosphate) available in Eppawala, Sri Lanka as a value added product. The synthesizing procedure was carried out using two different methods i.e. sol-gel method and solid-state pressure less sintering. Synthesizing by sol-gel method was done in two different ways. The first method was mixing apatite with ethanol and the second method was mixing apatite with diluted nitric acid. The solid-state pressure less sintering was done by mixing apatite with calcium hydroxide. The obtained hydroxyapatite powders were characterized by Fourier Transform Infrared Spectroscopy (FTIR) and X-ray Diffraction spectroscopy (XRD) in order to identify their structure i.e. types of bonds and functional groups available and its crystallinity. Our FTIR results show that the presence of hydroxyl groups and it is confirmed the formation of hydroxyapatite from apatite. Our XRD data show the reflections corresponding to structure of hydroxyapatite. Both FTIR and XRD results were compared with the literature and it is revealed that the possibility of formation of hydroxyapatite from Eppawala high grade phosphate available in Sri Lanka.

*Keywords:* Hydroxyapatite, Eppawala high grade phosphate, Sol-gel method, Solid state sintering



## Development of pH Responsive Ceramic Material for Detecting Spoiled Food

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The only information available to know about food spoilage is the expiration date. Prediction of the exact date of food spoilage with accuracy is difficult. Therefore, this research is mainly focused on developing a nontoxic pH responsive ceramic material to be used as a smart label, which changes its color due to acidic or basic medium. Kaoline is used as the ceramic material due to its chemical inertness and non-toxicity. Purple cabbage extract, which consists of purple anthocyanin pigments can undergo molecular rearrangements due to polyphenolic groups and extended conjugation of double bonds depending on the pH of the medium. Therefore, anthocyanin is selected as the pH indicator due to color change and low toxicity. A series of pellets based on kaolin containing 2%, 4%, 6%, 8%, and 10% of rice husk (particle size 150 $\mu$ m) were prepared. The purpose of adding different percentages of rice husk is to control the porosity of the ceramic material produced. Oven dried pellets were fired at 700 °C using a muffle furnace. Next, the pellets were dipped into purple cabbage indicator and checked with the spoiled food. These pellets were checked for color stability with mineral acids and bases as well as commercial food items. The air stability of dye was checked by measuring UV-Visible spectrum of the purple cabbage extract after every 4 hrs, up to 24 hrs. After 24 hours, color intensity was reduced by 31.88% and the pH of the medium was reduced by 12.18%. However, there was no significant color and pH reduction after 24 to 48 hours. The dye material exposed to the food area was about 3 mm diameter region, allowing minimum impact to taste and color of the food. Pellets were tested for 1mol dm<sup>-3</sup> HCl and 1mol dm<sup>-3</sup> NaOH solutions and purple color of pellets were changed to pink with dil. HCl and green with dil. NaOH allowing clear distinction between acid and base medium. Furthermore, pellets were tested for variety of spoiled foods and observed a clear change in color with higher accuracy where drastic pH changes are present. Therefore, it is clear that this ceramic material is pH responsive and has a potential to be used in detecting spoiled food.

*Keywords:* Purple cabbage, Ceramic, pH solutions, Spoiled food

## **Physico Mechanical Properties of Low Density Polyethylene (LDPE) and Un-fractioned and Unbleached Crepe Rubber (UFUB) Blends**

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The processing behaviour, vulcanization characteristics and mechanical properties of low density polyethylene/ un-fractioned and unbleached crepe rubber blends were evaluated in comparison with low density polyethylene /technically specified rubber blends. The use of this crepe rubber to form a new material would introduce a new economically viable industrial application with further value addition. First, un-fractioned and unbleached crepe rubber were produced and characterized for plasticity, plasticity retention index, volatile matter content and Mooney viscosity. Then a series of low density polyethylene/ technically specified rubber and low density polyethylene/ un-fractioned and unbleached crepe rubber blends were prepared by varying sulphur loading from 0 to 1 part per hundred at 0.25 intervals. The blends were prepared using dynamic vulcanization process using a laboratory scale internal mixer at a temperature of 140 C and a rotor speed of 60 rpm. Then mechanical properties (tensile strength, elongation at break, hardness and retention to ageing) were measured. Torque curves showed that un-fractioned and unbleached crepe rubber blends could be prepared from melt mixing similar to technically specified rubber blends. Un-fractioned and unbleached crepe rubber blends showed lower onset vulcanization times than that of technically specified rubber blends at each sulphur concentration. All the blends showed almost similar hardness values at each sulphur concentration. The un-aged tensile strength and elongation at break percentage of un-fractioned and unbleached crepe rubber blends were higher than technically specified rubber blends at each sulphur concentration. The highest un-aged tensile strength and elongation at break percentage of un-fractioned and unbleached crepe rubber vulcanized blends were 6.92 MPa and 255.39% respectively. Some values of retention percentage of tensile strength to ageing of blends prepared at some sulphur concentrations were higher than 100% in both blends.

*Keywords:* Polymer blends, Technically specified rubber, Unfractioned and Unbleached Crepe Rubber, Low density polyethylene, Dynamic vulcanization

## **Analysis and Design of a Better Performance Spacer Device for Asthmatic Patients**

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Asthma is a chronic disease. It does not usually go away for a long time, but it can be treated. Medical treatment method for asthma involves direct delivery of drugs to the respiratory system of the patient. Meter dose inhaler with a spacer device is the widely used method of treatment for asthma. Spacer device is an interface device between inhaler and the patient. It provides tidal breathing for the patient and causes the inhalation of the drug easy and effective. Product design, development and performance analysis of spacer devices were the main objectives of this research project. The aerodynamic shape of the device has great influence on its performance. Flow patterns inside the spacer device were analyzed using computer fluid dynamic software and obtained results were used to produce and validate a new design with higher performance. Existing devices were modeled using computer aided design software and computer fluid dynamic simulations were obtained by altering the parameters of their geometry to reduce the stagnant area and utilize the flow patterns. Above computer fluid dynamic simulation process was carried out, by observing the flow patterns of the existing ones. Sixteen different models were selected to cover the entire volume range which vary from 50 ml to 900 ml and also to cover different shapes such as cylindrical, conical and peer. Simulations were carried out by altering the geometrical parameters of volume and shapes of the devices until optimum flow patterns emerge. Designing and simulations were performed using *Solidworks* and *Ansys Fluent* software respectively. The results of this simulation have been implemented as a behavior of streamlines within the chamber. Effective flow patterns, which have low stagnant areas, were obtained from a shape close to peer shape and it is better suited for proper drug mixing.

*Keywords:* Spacer performance, Spacer CFD analysis, Drug inhalation

## **Crumb Rubber and Silica Nano Particle Derived Rubber Floor Tiles: A Partial Solution for Waste Management**

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Currently, crumb rubber derived flooring is a small, but growing sector in the world floor coverings market. However it is not widely spread in Sri Lanka. Such flooring includes mats, rolls, sheets, and indoor and outdoor tiles. Among the materials used for flooring, natural rubber blended with synthetic rubber is one of the low cost and commonly used ingredients. However, the pristine rubber blends show retarded mechanical properties. Thus, reinforcement with additives and vulcanization is commonly practiced technique. In this research the blend of natural and synthetic rubber is reinforced with crumb rubber and silica nano particles. Both of these additives were prepared from the waste materials. Thus, this research is focused to introduce a partial solution for waste management. The idea is analogous to making large particle reinforced composites such as concretes in which two different sizes of particles (coarse gravel and sand) are densely packed with an adhesive (cement). In this study, fine rubber crumbs of four different sizes in the range of 3.15 mm to 500 m were prepared by mechanical grinding. Silica was extracted from rice husk and further purified before preparing the silica nano particles by precipitation method. They were further characterized using Fourier transform infrared spectroscopy (FTIR) and X-ray diffraction (XRD) analysis. FTIR peaks confirm the presence of O-H, Si-O and Si-O-Si bonds in nano silica. The broad peak between 22° and 23° (2) in XRD data revealed that silica nano particles were in amorphous form. The composite materials were prepared with different ratios of rubber: silica nano particles: crumb rubber. The samples with same compositions but different rubber crumb sizes were also prepared. All the composites were further reinforced by vulcanization with sulfur. The tensile and compression tests were done to evaluate their mechanical properties.

*Keywords:* Rubber floor tiles, Silica nano particles, Crumb rubber, Rubber vulcanization

## **Optimization of Processing Parameter Ranges for Reduction of Defects in Surgical Glove Production**

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Surgical gloves are one of the major dipped products processed from natural rubber latex (NR). The current research study was carried out to investigate the effect of temperature of former, concentration of calcium nitrate in coagulant medium and total solid content of natural rubber latex compound on defects in gloves. Those three parameters were monitored under current processing conditions. Temperature of formers before dipping into the compounded latex was in the range between 58<sup>o</sup> to 66<sup>o</sup>. Concentration of the calcium nitrate in coagulant medium was at three levels of 16.0%, 17.5% and 19.0%. Total solid content of latex compound was at three levels 26.5%, 28.5% and 30.5%. Major defects per batch were counted and converted it into a ratio, the defect ratio, to the total number of gloves produced in a batch. The defect ratio was taken as the response variable. It decreased with the increase of former temperatures within the range monitored and possible optimum temperature range can be narrowed down from 63<sup>o</sup> to 66<sup>o</sup>. The diluting concentration of calcium nitrate in coagulant medium at 19.0% to 17.5% is required to perform minimum defect ratios. Therefore, optimum concentration range could be narrowed down approximately by 10%. Total solid content had a negative relationship with defects. Total solid content of 28.5% to 30.5% range was performed as the optimum range. Temperature of formers should be maintained within a range without overlapping melting temperatures of chemicals and less energy consumption. Therefore, the narrowing down of the process parameters in to optimum ranges as identified in this study would enhance the productivity and the efficiency in the surgical glove production.

**Keywords:** Coagulant concentration, Defects ratio, Natural rubber, Surgical gloves, Total solid content

## **Study on Possibility of Improving Manufacturing Performance through Lean Six Sigma Method in the Apparel Sector: A Case Study**

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Lean Six Sigma is one of the most familiar concepts which organizations experience in order to manage manufacturing operation. Moreover if the manufacturing organization successfully implements the Lean Six Sigma for its manufacturing process mostly the organization would be able to run the manufacturing process more effectively and in an efficient manner. Since the major goal of Lean Six Sigma is defect reduction, reduced defects will consequently improve yield and will reduce cost. This method has a process, which focuses and aims to highlight process improvement opportunities through systematic measurement. The current study is based on the Lean Six Sigma project, which is conducted in leading apparel-manufacturing organizations in Sri Lanka. Throughout this study researcher has conducted customize Lean Six Sigma practices in sewing process with the objective of introducing Lean Six Sigma into other organizational processes. Researcher has conducted this study as a benchmark for other processes. Researcher revealed that current sigma level of organizations sewing process in previous year was 3.98 and Defects Per Million Opportunities (DPMO) was 6470, which is not in an acceptable level. Therefore researcher geared current study in order to increase the sigma level and to decrease the DPMO in order to achieve the quality standards of the sewing garments. Consequently it leads to the reduction of defects and increase the efficiency of the sewing process. Define, Measure, Analysis, Improve, Control (DMAIC) method was adopted for this project. In the Define phase the scope and nature of the problem was identified. Then in the measurement phase current situation of the quality and efficiency of the process was detected. After that in the analysis phase major root-causes were identified. Then in the improvement phase the optimal solution was implemented for the identified root-causes and finally in the control phase the impact of implemented solutions was measured. After implementing these solutions, sigma level has increased to 4.17 and DPMO level has decreased to 3730. Findings suggest that Lean six sigma method is a very effective method to improve the process with a reduction in quality defects and an increase in process efficiency and productivity.

*Keywords:* Lean Six Sigma, DPMO, DMAIC, Efficiency

## Synthesis and Characterization of $\text{Li}(\text{Ni}_{1/3} \text{Mn}_{1/3} \text{Co}_{1/3-x} \text{Na}_x)\text{O}_2$ Cathode Material for Lithium Ion Rechargeable Batteries via Glycine Nitrate Combustion

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Expensiveness of electrode materials, such as  $\text{LiCoO}_2$ , is recognized as one of the main barriers that prevents the development of the rechargeable Lithium Ion Batteries (LIB) from reaching the common masses. Therefore, layered transition metal oxides such as  $\text{Li}(\text{Ni}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3})\text{O}_2$  are presently being investigated as an alternative cathode material. Moreover, substitution of Na in transition metal oxides of Ni, Mn and Co (NMC) has been identified as an effective strategy to improve their electrochemical performance. The present work attempted to synthesize  $\text{Li}(\text{Ni}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3-x}\text{Na}_x)\text{O}_2$   $x = 0.02$  and  $0.06$  through substituting expensive Co by cheaper Na, using Glycine Nitrate Combustion (GNC) method. The GNC is an effective method to synthesize sub-micron size particles formed by agglomerating primary nano scale particles. This particle morphology is chemically stable and provides greater rate capability and electrochemical performance.  $\text{Li}(\text{Ni}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3-x}\text{Na}_x)\text{O}_2$ ,  $x = 0.02$  and  $0.06$ , oxide powders were synthesized by GNC method, keeping the Glycine:Nitrate ratio as 0.6, by calcining at  $900^\circ\text{C}$  for two hours. This process is a simple and single step process with a low calcination period. Scanning electron microscopy showed that the synthesized powder consists of quasi-spherical, secondary particles formed by aggregating nano-scale primary particles. Chemical analysis of synthesized powders reveals that the composition of these synthesized samples was close to stoichiometric ratio given by its empirical formula. Fourier transform infrared spectra of  $\text{Li}(\text{Ni}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3-x}\text{Na}_x)\text{O}_2$ ;  $x = 0.02$  and  $0.06$  are characterized by IR absorption bands in three distinct regions. These bands represent the characterized chemical bonds in layered metal oxides with  $-\text{NaFeO}_2$  structure. The four probe D.C. electrical conductivity measurements performed on the dense sintered pellets showed enhanced electrical conductivity in these novel materials compared to that of base material,  $\text{Li}(\text{Ni}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3})\text{O}_2$ . Hence this study revealed the possibility of preparing cheaper  $\text{Li}(\text{Ni}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3-x}\text{Na}_x)\text{O}_2$  by GNC method, for the intended LIB cathode applications.

**Keywords:** Lithium Ion Rechargeable Batteries, Glycine Nitrate Combustion,  $\text{Li}(\text{Ni}_{1/3}\text{Mn}_{1/3}\text{Co}_{1/3-x}\text{Na}_x)\text{O}_2$ , Cathode Materials

## Fabrication of Dye Sensitized Solar Cells on Polymer Substrates

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As energy is the lifeblood of modern era, energy crisis has become a threatening issue to the current world. Many alternative sources have been found to overcome this concern. Solar energy is one of those choices. With continuous research studies conducted in this field, we have come across the third generation of solar cells; the dye sensitized solar cells. Typical Dye-sensitized solar cells (DSSCs) contain glass plates, which are heavier in weight, so to reduce this problem, plastic substrates can be used to replace glasses. In this study, 5(6) Carboxyfluorescein dye, Anthrance A and Erythrosin B are used as a dye (sensitizer) to fabricate a solar cell. These dyes were coated on titanium coated conducting plastic substrate, which was prepared by doctor blade method and then was pressurized using a hydraulic pressure instrument. These dyes have different surface chelating groups and make bonds easily with metal oxides. This result was confirmed by FTIR measurements. Platinum coated plastic substrates were attached to the dye coated films and the space was filled by the  $I^- | I_3^-$  electrolyte by capillary action. Current-voltage characteristics were measured under light illumination. There is no photocurrent in cells with ITO | PEN (Indium doped Tin Oxide | Poly Ethylene Naphthalate) substrates for all three dyes. When FTO (Fluorine doped Tin Oxide) substrates were used for fabrication of solar cells, photocurrent of  $172 \text{ Acm}^{-2}$ ,  $252 \text{ Acm}^{-2}$  and  $127 \text{ Acm}^{-2}$  were obtained for cells with 5(6) Carboxyfluorescein dye, Anthrance A dye and Erythrosin B dye, respectively. This shows that the efficiency of these three dyes for DSSCs is very low.

*Keywords:* Dye-sensitized solar cells, 5(6) Carboxyfluorescein , Anthrance A, Erythrosin B



## **Fabrication and Characterization of Novel Red Clay Based Composite Material for Roof Tile Industry**

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Red clay based roof tiles have a long history and still there is a high demand due to their high abundances, vitrification at low temperatures, low production cost and their resistance to fire, heat and electricity. Its a better alternative for the cheap asbestos which create many health problems and which are banded in many countries. However, it is a timely need to fabricate novel red clay based roof tiles as a good alternative to asbestos. This can be done after incorporating additives such as ceramic and polymer waste. In this work, a novel composite material was fabricated using red clay and polymer waste i.e. polyethylene terephthalate (PET). Polymer waste reduces the production cost for firing, add value to waste, reduce the weight and support for a green environment. Here, PET wastes were crushed into small pieces and melted around 200 °C and incorporated with raw red clay which was sieved using 150 m mesh. Different weight ratios of PET and red clay were mixed and proto-type samples were made using a mold to study the compositional dependence and basic physical properties. Our results show that very low water absorption, low density (light weight), and low shrinkage compared to the traditional red clay samples. In order to study the structure, FTIR spectroscopy was used. Here, we see that the clear polymer-clay interactions between polar groups of polymer and cations present in the clay. It concludes that the polymer has become flexible when the temperature is increased and formed new bonds between clay molecules. Therefore, PET act as a matrix to keep the clay particles together. As a result light weight, high strength, and very low water absorptive novel red clay based composite material can be fabricated and used as a better substitution for the current red clay based roof tiles. In addition, the low water absorption will further help to reduce the discoloration of the tiles due to algae and fungus growth on the surface of the tile.

*Keywords:* Red clay, Polymer, PET, Roof tiles, Composite materials

## Development of a Filter Material for Removal of Glyphosate

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Glyphosate [N-(phosphonomethyl) glycine] is an organophosphorus compound, based on phosphonate and a broad-spectrum of non selective, systemic herbicide. Recently, glyphosate received worldwide attention due to its toxicity and the health consequences, thus, banned in Sri Lanka. Though, glyphosate is banned from use, it still persists in soil sediments and continuously washed in to the surface water causing damage to the environment. The main objective of this study is to investigate the potential of a ceramic filter developed using kaolin clay and several admaterials to remove glyphosate from aqueous solution. It could be cost effective than the methods exist at present. Kaolin has received considerable recognition as an adsorbent due to its cation exchange capability. Adsorption capacity of kaolin for glyphosate is expected to increase by calcination, which causes the structural modification. As Ca has high affinity to bind with glyphosate, CaCO<sub>3</sub> and activated carbon were used as additives to enhance the adsorption capacity of kaolin. A spectrophotometric method was developed for the measurement of residual aqueous glyphosate concentration using vanadomolybdophosphoric yellow color method in nitric acid medium. Our results support the possibility of the determination of glyphosate by this method within the range acceptable for the analysis of phosphate (1-10 mg L<sup>-1</sup> range). Pellet effect on the pH, dissolution of pellets and glyphosate adsorption (in 0.1%, 1%, 10% v/v glyphosate) on pellets were evaluated. Results showed that glyphosate was adsorped on pure kaolin pellets and adsorption capacity of kaolin was increased significantly by adding CaCO<sub>3</sub> and activated carbon. Overall, kaolin with CaCO<sub>3</sub> and activated carbon is highly effective in removing glyphosate in aqueous solution and it could be a distinct advantage to treat the glyphosate-contaminated water compared to expensive reverse osmosis systems that are currently in use.

*Keywords:* Glyphosate, Filter material, Kaolin, Ceramic

## **Synthesis and Characterization of Local Bone Ashes and Their Applications in Ceramic Industry**

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Bone china is a specific porcelain material that has high strength and translucency. It is manufactured exclusively in China and imported to Sri Lanka at a very high price to use in ceramic industry. Bone china consists of three major raw-materials; bone ash, kaolin, and a feldspar based mineral. Usually, after deboning process in meat industry, bones are discarded as a waste material in Sri Lanka. Therefore, the aim of this study was to synthesize and characterize the local bone ashes and to find out their applications in Sri Lankan ceramic industry. In this work, bone ashes from chicken, bovine, and caprine bones were prepared by removing adhering meat manually, and removing moisture at high temperature (900<sup>0</sup>C). The Calcinated powders were characterized by several methods. The particle size and chemical composition of the prepared powders were determined using digital particle size analyzer and X-ray fluorescence spectroscopy, respectively. In addition, the crystalline phases of different bone ashes were determined using X-ray diffraction. The structure i.e. types of bonds and functionality was identified using FTIR spectroscopy. The surface morphology was obtained using Scanning Electron Microscope (SEM). The results obtained in this study were compared with commercially available bone ash and they showed an excellent agreement. The highest yield was reported in chicken bone ash. The prepared value added products from animal bone waste can be utilized as a replacement for imported commercial bone ash in ceramic industry.

*Keywords:* Bone ash, Calcination, Porcelain, FTIR spectroscopy, X-ray diffraction

## **Development of an In-House System for the Evaluation of Water Vapor Permeability of Dry Coatings and the Study of its Performance on Exterior Paints**

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There is an immense importance in measuring the moisture management properties such as water vapor transmission rate (*WVT*) and water vapor permeability (*WVPm*) of a dry coating which is expected to be used as a water permeable or semipermeable dry coating. However, water vapor permeability testers are expensive and yet not available in Sri Lanka. This research was aimed to develop an in-house system by modifying the wet cup method described in ASTM-D 1653 to measure *WVPm* and to evaluate its performance using different types of commercially available exterior wall coatings. The permeability cup was kept inside a chamber with controlled temperature of 31 °C and 98% of relative humidity difference was maintained between two surfaces of the paint film, which was assisted by humidity and temperature detecting sensors and continuous air circulation. All paint films with wet thicknesses 1 mm and 2 mm which were made using adjustable film applicator, were attached to the permeability cup which was periodically removed and weighed. The weight loss as a function of time was recorded and plotted on a graph and using the steady-state region of the plotted graph *WVT* and *WVPm* was calculated. Among the tested films of 1 mm wet thickness, the lowest *WVPm* was observed in a water resistant paint. The second lowest *WVPm* was observed in two coatings which are warranty paints for exteriors that are specially designed for high durability. The highest *WVPm* was observed in a normal exterior coating. With increasing thickness, *WVT* was decreased in all tested films of coating samples. *WVPm* was decreased with the increasing thickness for all the test films except for the coating which showed the lowest *WVPm*. The results confirmed that the developed system is functioning accurately.

**Keywords:** Water vapor transmission, Water vapor permeability, Wet cup method, Exterior paints, Water resistant paints

## Study of Efficiency of Dispersants and Enhancing the Quality of Emulsion Paints

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Paint industry faces challenges due to the increase of raw material cost and regulatory compliance. Delivering paints with good paint properties in a cost effective way is another challenge. Therefore, paint formulations should produce paints with required gloss, colour intensity, contrast ratio, abrasion resistance and levelling properties. Energy reduction with minimum grinding times is also desired. Better pigment dispersion is the best solution to overcome the above mentioned challenges which makes dispersants an important auxiliary at this stage. A better pigment dispersion can be achieved by developing a completely new dispersant or discovering a better blend of dispersants using existing dispersants. Research studies have been conducted in developing amphoteric dispersants and high molecular weight dispersants with low viscosity and high stability. This particular research was conducted to find a better blend of dispersants using existing dispersants in the market R 40N; Sodium salt of carboxylic acid, Sodium hexametaphosphate and TAMOL; Sodium salt of condensed arylsulfonic acid. The efficiency of each dispersant was checked by plotting dispersant demand curve. R 40N and TAMOL were selected to form the blends with ratios 2:1, 1:2 and 1:1. White interior emulsion paint with Titanium dioxide pigment was prepared separately using the blends 2:1 and R 40N alone. Standard tests such as gloss D 65/ 10°, contrast ratio, abrasion resistance, water resistance, viscosity and levelling properties were conducted for the produced paints to investigate paint properties. The paint formed with blend R 40N:TAMOL in 2:1 ratio showed higher gloss, lower viscosity and opacity than the paint formed with R 40N alone, while providing equal values for other properties like, abrasion resistance, water resistance and levelling properties. According to the research the blend R 40N:TAMOL in 2:1 ratio gave a better paint formulation at lower cost than the existing dispersants in the market.

*Keywords:* Dispersants, Sodium hexametaphosphate, Gloss, Opacity

## **The Effect of the Incorporation of White Rice Husk Ash in Place of Precipitated Silica on Rheological and Mechanical Properties of a Natural Rubber Based Non-Marking Caster Wheel Compound**

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Casters are fixed under the chairs, beds, carts, trolleys, cupboards and heavy equipment to facilitate the safe movement or delivery. Those consist of wheels that roll easily, operate with slight or no noise. Some of these wheels are made of various polymer composites. Natural rubber based non-marking caster wheels are mainly reinforced by adding precipitated silica. Silica is the main component in rice husk which is considered as a waste material in rice industry. Burning rice husk and dumping it into open space cause environmental pollution. White rice husk ash (WRHA) contains more than 90% of silica by weight. Therefore it is important to provide a value addition to rice husk ash by eliminating its environmental pollution. In this research the effect of replacing precipitated silica by WRHA on rheological properties and mechanical properties of a selected caster wheel rubber compound was investigated. WRHA was prepared by burning rice husk at 500 °C in a muffle furnace and then it was crushed into a fine powder. The powder was sieved to obtain particles less than 300 m in size to be incorporated into the preparation of a natural rubber based non-marking caster wheel compound. A series of compounds were prepared by varying the amounts of WRHA and precipitated silica. When increasing the amount of WRHA, scorch time t<sub>90</sub> of the compound shows a slight decrease followed by a slight increase at 20% by weight of WRHA, compared to the compound without WRHA. Mooney viscosity of samples containing WRHA is slightly lower than that of the sample with no WRHA. Modulus at 100% elongation and the hardness show a slight decrease followed by a slight increase with increasing the amount of WRHA. Resilience shows a slight increase with increasing the amount of WRHA. Tensile strength of the samples containing WRHA is slightly lower than that of the sample with no WRHA. It can be concluded that WRHA is a promising reinforcing filler replacing precipitated silica in natural rubber based non-marking caster wheels.

**Keywords:** Natural rubber, Caster wheel compounds, Rice husk ash, Rheological properties, Mechanical

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### **The Effect of Maturity Level of Compounded Natural Rubber Latex on Tensile Strength of Household Gloves**

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Household gloves are mainly manufactured using natural rubber compounded latex. Properties of the natural rubber compounded household gloves are highly dependent on its tensile strength. Tensile strength of these products is affected by the degree of maturation of the compounded latex. With the maturation of the compounded latex, Swelling Index (SI) of the compound is changed. Obtaining higher tensile strength with optimum SI is important to have an effective and efficient production of these gloves. This research was carried out with the aim of finding the optimum level of compound maturity and Swelling Index of compounded latex for the highest tensile strength of natural rubber household gloves. Standard natural rubber household glove compound formulation used by the industry for the production, was selected for this research. Then the compound was produced according to the selected formulation and was allowed for maturation. Meanwhile, three samples from the compound were taken at three-hour intervals up to 147 hours and the swelling test was conducted. Average Swelling Index (SI) of above three compounds was measured. Three replicate household gloves from each replicate were produced by hand dipping at three-hour intervals up to 147 hours. Then, the tensile strength of the produced household gloves was measured using tensile tester. Swelling Index for the highest tensile strength of the gloves was determined by analyzing the data. Results showed that Tensile strength increased up to a maximum of 266 kgf/cm<sup>2</sup> upon 95 of swelling index and then the tensile strength decreased. Therefore, Swelling Index of 95 is the optimum value for the highest tensile strength of household gloves, against the range between 100 and 90, which is currently being used. The optimum maturation level of the compounded natural rubber latex was found as 78 hours to achieve the maximum tensile strength.

*Keywords:* Household gloves, Latex compound maturation, Swelling index, Tensile strength

## **Different Methods of Extraction of Lignin from Coconut Sawdust: The First Step of Development of Lignin-Based Polyurethane Thermoplastics**

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Lignin is one of the major polymers found in the cell wall of plant biomass. It is a heterogeneous cross-linked polymer, which has a high molecular weight and contains three major phenolic compounds; coniferyl alcohol, sinapyl alcohol and p-coumaryl alcohol. These phenolic groups lead to guaiacyl, syringyl, and p-hydroxyphenyl propane type units. Furthermore, lignin may contain free hydroxyl groups in its structure. Therefore, it is hypothesized that lignin obtained from waste biomass could be utilized as a replacement for petrochemical based polyols in the manufacturing of polyurethane. With increasing concern about the shortages of fossil resources and the impetus for reducing costs of polyurethanes, preparation of polyols from waste biomass will be an interesting subject in the polyurethane industry. Especially for Sri Lanka, it is very advantageous and perspective to replace petrochemicals if possible since petrochemicals are not economical due to high exportation cost. *Cocos nucifera*, generally named as coconut, is a hardwood species making it a low cost raw material for obtaining polyols. Sawdust is considered to be the remaining, left after the processing of coconut timber. Generally, this fall off materials remain as wastage product with no industrial value and usually dumped into the environment without control. In the study, as a first step of the long-term research, lignin was extracted from sawdust of coconut palm (*Cocos nucifera*), which is a common waste material and identified as a rich source of lignin by two methods; acid lignin extraction and alkaline lignin extraction. It was found that the yield obtained from acid hydrolysis (24%) was higher than that from alkaline method (2%). The lignin obtained from both methods was characterized by FTIR and UV-Visible spectroscopy. Further, 3.04% of phenolic OH content of the acid insoluble lignin samples was identified.

*Keywords:* Lignin, Klason, Soxhlet, Polyurethane



## **Optimization of Centrifuge Latex Parameters in Manufacturing of Disposable Medical**

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Natural centrifuged latex is used for glove manufacturing. Medical disposable gloves such as examination and surgical are made by coagulant dipping process. There is a high rate of defects during manufacturing of gloves in commercial glove industry. Cut mark, large hole, bubble hole, pin hole, web hole and scum are considered as major defects. Under optimum processing conditions, changes in the specification range of centrifuge latex will affect the formation of defects. Centrifuge latex parameters are Volatile Fatty Acid (VFA), Mechanical Stability Time (MST), Total Solid Content (TSC %), Dry Rubber Content (DRC %), Total Alkalinity and Non Rubber Solids. Difference between TSC % and DRC % is taken as Non Rubber Solids. Total numbers of maturity days of centrifuged latex were concerned with above parameters. The aim of this study was to optimize specification range of centrifuge latex parameters for manufacturing latex disposable medical gloves and make recommendations accordingly. During this study, daily reject analysis due to defects of examination gloves in production line No 3, No 4 and surgical gloves in line No 5 were measured using randomly selected glove samples within 2 months period. Testing of centrifuged latex parameters was carried by using randomly selected 20 centrifuge latex samples from each production line. The results of the study revealed that there is a significant relationship between VFA, MST with total number of defects, but there is not enough evidence to conclude the relationship between Total Alkalinity and Non Rubber Content with total number of defects at 95% of confidence interval. According to the results of non-liner regression analysis, optimized value of VFA number is 0.032 and optimized value of MST is 1171 seconds. Maturity days of centrifuge latex which are preferable to reduce the defects will be in the range of 25 - 45 days. According to the results, it can be recommended to use above optimized specification ranges to reduce the defects and increase profits of the company while ensuring customers requirements.

*Keywords:* Centrifuge Latex, Medical disposable gloves, Specification range, Defects, Centrifuge latex parameters



# **Mineral Science and Technology**



## **Upgrading the Whiteness Index of Kaolin from Meetiya-goda In-situ Deposit, Sri Lanka**

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The kaolin deposit at Meetiya-goda, Southwestern Sri Lanka has been exploited for several decades and its reserves are rapidly diminishing. To sustain the industry with a continuous supply of local material, improvement of quality of previously unexploited lower grade deposits will be essential. Iron and titanium are the major contaminating elements in commercial kaolin that degrade its quality, mainly whiteness index, which is considered as a vital property that makes raw kaolin suitable for ceramic industry. Iron is present mainly in goethite, hematite, magnetite, pyrite and ilmenite while titanium is found in rutile, anatase and ilmenite. In this context increasing the whiteness index of kaolin pigment is essential. Sodium silicate and potassium persulfate was used as a dispersant agent and oxidative bleach respectively, to treat clay in order to remove titanium impurities from aqueous slurry of solid content of 30 to 40 percent. Sodium dithionite was added to kaolin as chemical bleach to remove iron bearing impurities. Sodium silicate was added with deionized water to kaolin sample according to selected percentages and stirred it. The dispersant agent gives flowing capability to titanium ions while oxidative bleach acts as oxidant to react with titanium ions. The filtrate was dried in oven at 150 °C for 2 hours. Whiteness Index of purified kaolin was measured by reflectance spectrophotometer. Experiments proved that whiteness index could be upgraded from 75% to 84%.

*Keywords:* Kaolin, Impurities, Whiteness index

## **Feasibility of Extracting Garnet from Beach Sands of Southwestern Coastal Area of Sri Lanka**

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Southwestern coastal area of Sri Lanka is well-known for garnet-rich beach sand. However, detailed investigations on its economic feasibility are scarce. This work investigates the distribution of garnet and other heavy minerals in beach sand and describes separation of garnet from beach sand. Particle size analysis and microscopic analysis of raw beach sand samples indicate that they consist of poorly sorted mineral grains enriched with round to elongate shaped garnet (49.66%) together with angular and sub angular shaped quartz (38.92%) and elongated illmanite (5.03%). Most of the garnet grains are in the size range between 0.5 mm and 1 mm. Panning was carried out for the garnet enriched fraction (0.5 mm - 1 mm) for further concentration of garnet. Microscopic analysis indicated that the high density fraction after panning was enriched with garnet (75%) while low density fraction with quartz (70%). In addition to garnet, high density fraction consists of quartz (5%), illmenite (5%), monazite (5%) and zircon (5%). This study reveals the potential of beach sand in Southwestern coastal area for extracting garnet. Particle size and shape of the extracted garnet are optimum for the use of them as water filtering medium and as an abrasive. Detailed investigations on chemical composition, chemical stability and mechanical stability of garnet are needed to establish its suitability for the intended uses.

*Keywords:* Garnet, Heavy minerals, Microscopic analysis, Panning

### **Oxidation Behavior of Different Morphological Varieties of Vein Graphite**

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In this study, the mild chemical oxidation technique was investigated to enhance the performance of Sri Lankan vein graphite for the anode application in rechargeable Li-ion batteries (LIB). Sri Lankan vein graphite is categorized into four morphological varieties, shiny-slippery-fibrous graphite, needle-platy graphite, coarse striated-flaky graphite and coarse flakes of radial graphite. Typically, mild chemical oxidation of vein graphite is done with strong chemical oxidants which are expensive and non-ecofriendly. In this study, H<sub>2</sub>O<sub>2</sub> was used as an oxidant to oxidize the vein graphite, due to the environment-friendly nature and low cost. For oxidation, purified vein graphite was treated with 30% H<sub>2</sub>O<sub>2</sub> solution at 60°C for 24 hours. Fourier transform infrared spectroscopy obtained on graphite after mild oxidation showed the existence of absorption peaks corresponding to C=O stretching at 1720-1680 cm<sup>-1</sup>, O-H stretching at 1360 cm<sup>-1</sup> and C-O stretching at 1260-1000 cm<sup>-1</sup>, indicating surface oxidation. The type of oxidizing species and intensity of absorption peak, related to oxidizing species, are different depending on morphological varieties of the vein graphite. Further, intensity of absorption peaks representing carbonyl groups and C-O acid group of mildly oxidized vein graphite with H<sub>2</sub>O<sub>2</sub> are relatively weaker compared to that of oxidized vein graphite with strong chemical oxidant (NH<sub>4</sub>)<sub>2</sub>S<sub>2</sub>O<sub>8</sub>. This may be related to weak oxidation ability of H<sub>2</sub>O<sub>2</sub> (E<sub>0</sub> = 1.7 V) compared (NH<sub>4</sub>)<sub>2</sub>S<sub>2</sub>O<sub>8</sub> (E<sub>0</sub> = 2.1 V). The direct current electrical conductivity results indicated that the mild oxidation has not caused any adverse effect on the electronic property of graphite. Scanning electron microscope images indicated some improvement of surface morphology of vein graphite due to the mild oxidation. Mild oxidized graphite synthesized by cost-effective and eco-friendly process in this study can be a potential candidate for the LIB due to the improvement on the graphite surface structure.

**Keywords:** Mild chemical oxidation, Sri Lankan vein graphite, Morphological varieties, H<sub>2</sub>O<sub>2</sub>

## **Enhancement of Heat Resistivity of Different Polymers by Adding Different Sizes of Mica Filler Particles**

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Sri Lanka is a tropical country where people experience high heat during day time. Therefore, people are accustomed to carry an umbrella to get protected from high temperature. However, materials used in umbrellas are not good enough to reduce heat that penetrates through umbrella cloth. Various physical properties of materials such as mechanical strength, modulus, and heat deflection temperature can be improved by adding inorganic mineral fillers into plastic resin. Mechanical properties of particulate filled polymer composites depend strongly on size, shape, distribution of filler particles in the matrix of polymer, and good adhesion at the interface surface. Therefore, applying a heat resistive coating material inside the umbrella will be effective. This can reduce dehydration and sunburns. In this study, the heat resistivity of polyethene as the polymeric material, and mica as the filler material were investigated to be used as a potential heat resistive coating. Heat resistivity studies on polyethene were conducted by preparing thin sheets of polyethene using a custom designed mold prepared in house. After monitoring different temperatures and time periods, the optimum temperature and time period was identified as 300 °C for 40 minutes in order to dissolve 3.5 g of polyethene so as to obtain the desired sheet. Different percentages of mica particles with desired sizes were added to the polymer to make the composite. Then the heat transfer rate was calculated using Fouriers Law. According to the results, the sample with only polythene indicated a decline in heat transfer rate, which is 0.04 °C sec<sup>-1</sup> while the polyethene sample containing 1% of 125 – 63 micrometer mica fillers showed a decline in heat transfer rate which is 0.068 °C sec<sup>-1</sup>. This study shows that polyethylene can be used as a coating material with mica filler particles. However, further studies are needed to properly incorporate mica in to a suitable material to be coated in umbrellas.

*Keywords:* Polyethene, Mica, Heat resistant



## **Study on the Effect of Different Types of Crude Oils on the Rate of Corrosion and the Properties of Some Selected Ferrous Metals**

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In the industry of crude oil refining, ferrous metals find a wide range of applications including transportation and storage. Corrosion of ferrous metals is a major problem faced in this industry. The corrosion is known as the formation of metal oxides, sulfides or hydroxides on the surface of the metal due to chemical reactions between the metal and the surroundings. In the current research it was expected to investigate the effect of Murban and Das blend crude oils on the rate of corrosion of seven different ferrous metals which are used in the crude oil refining industry. It was also expected to investigate the change in hardness of each metal due to the corrosion. The sulfur content of each crude oil was tested by XRF analyzer. The acidity in each crude oil was also determined. A series of similar size pieces of seven different types of ferrous metals are immersed in each crude oil separately for 15, 30 and 45 days. Their rate of corrosion was determined by using their relative weight loss after these time periods. The corroded metal surfaces were observed under the optical microscope. While the corrosion the important property of metal the hardness of each metal piece was tested before the immersion in crude oil and after the corrosion with the aid of Vicker's hardness tester. It was found that Das blend crude oil contains higher sulfur content and acidity than Murban crude oil. Carbon steel metal pieces show the highest corrosion rates whereas the stainless steel metal pieces show the least corrosion rates in both crude oils. The mild steel piece and the monel piece show relatively intermediate corrosion rates compared to the other types of ferrous metal pieces in both crude oils. It was observed that there is a slight decrease in hardness of all the ferrous metal pieces due to corrosion. The corrosion rates of ferrous metals are varied with the properties of crude oils such as sulfur content, acidity and the amount of mercaptans, which has a formula of "RSH".

*Keywords:* Ferrous metals, Steel, Corrosion rate, Crude oil, Hardness

### **Structure and Physico-Chemical Properties of Red Clays used in Roof Tile Industry in Sri Lanka**

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Clay is a vital material in human life that has gained significance due to its civil engineering and environmental applications as a result of their wide ranging properties, high resistance to atmospheric conditions, geochemical purity, and accessibility to their deposits near the earth's surface and low price. Red clay based products such as floor tiles, roof tiles and cooking wares have received much attention due to their abundance and the capability of its low temperature vitrification compared to china clay and ball clay. Red clay based roof tiles have been used for a long period with several drawbacks. Aimed at understanding the properties of raw material the clay samples were collected from roof tile factories so as to represent all red clay deposits of Sri Lanka. The samples were analyzed for particle size distribution, density, conductivity, pH and moisture content. The microscopic structure of different clays were identified using FT-IR spectroscopy. Shrinkage, strength and water absorption were measured using fired prototype clay bodies. Firing shrinkage increase with higher temperatures and it varies for different clays. In here we used 900–1000 °C temperature and it was not suitable for some clay samples. Our results show that the clays from dry zone are composed of high amount of quartz, illite and kaolinite as trace. Clays from wet zone are rich in quartz and have a structurally well-ordered kaolinite. In addition they have significant amount of Fe-bearing minerals and are composed of prime oxides such as SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub> and Fe<sub>2</sub>O<sub>3</sub> depending on the location and the interaction between cations and silicate groups. Further, it shows the locations dependence for differences of molecular water from constitutional hydroxyl groups and also the availability of non-crystalline impurities. In this study we observe a locality dependence of physico-chemical properties of red clay that possibly corresponds to its mode of formation.

*Keywords:* Red clay, Structure, Physico-chemical properties, Roof tiles

## **Developing an Integrated Geothermal Energy Utilization System for Wahawa Geothermal System in Sri Lanka**

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Wahawa geothermal field is one of the major geothermal fields in Sri Lanka, which comprises of more than 15 hot-springs with 60<sup>0</sup>C average surface temperature. However, these natural resources have not been utilized yet. The broad aim of this study was to develop an appropriate utilization system to use these geothermal resources for various energy purposes. Ground magnetic and resistivity surveys were conducted to gather information of the near surface structures. The geophysical exploration suggested that the drilling of a well to a depth of 150 m is sufficient to reach temperatures over 100<sup>0</sup>C. The artesian flow will be used for bringing-up heated water to the surface. The water so obtained will be transported through the shielded tubes and it is expected that the temperature would be around 90<sup>0</sup>C, when it reaches the processing plant 01 which is a fish drying plant. Then the water will be sent through oven tubes and the temperature will be controlled by a remote thermal-sensor system. Next, the water with remaining heat will be utilized in the processing plant 02 which is a fruit drying plant. In this, the water will be mixed with required amounts of cold water so that the temperature would be around 70 – 80<sup>0</sup>C, which is the optimal temperature values for drying vegetables and fruits. In the final stage, the used water will be sent to bathing pools for recreational activities. Finally the water will be re-injected to the subsurface in order to maintain the mass balance of the subsurface reservoir. The near subsurface water flow path which was identified in the present study will be used to accomplish the re injection of water. Geothermal energy is a green energy source with a very low energy unit price, which does not depend on the prevailing weather or fluctuations of the oil or fuel price in the market. This will be, in turn, a successful technique to harness the underground heat for our benefits.

*Keywords:* Geothermal field, Hot springs, Geophysical surveys, utilization model

## **Review on Physico-Chemical Studies Done Related to the Mineral Formulations of Traditional Ayurvedic *Rasaushadhi* Preparations**

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“*Rasashastra*” is the branch of Ayurveda which deals with metals and minerals related pharmacology. The ayurvedic drugs affiliate with mineral, metallic preparations are called “*Rasaushadhies*”. Due to innate qualities like quick action, lesser dose, tastelessness, prolonged shelf life, better palatability, the drugs derive from *Rasaushadhies* i.e. “*bhasmas*” are becoming more popular. The traditional ayurvedic non-toxication process of these metals and minerals comprise of mainly 3 processes called *Shodhana* (bio purification), *Jarana* (roasting) and *Marana* (incineration /calcination), including *Putra* (heating) systems. During these processes toxic heavy metals and minerals subjected to changes in their particle size, structure and chemistry and further, toxicity decays. The minerals which are being used in these *rasaushadhi* preparations undergo many physical and chemical changes, during the preparation methods. Many researches have been conducted to study the changes happen in these mineral formulations. This paper reviews the general physico-chemical changes which occur during these *rasaushadhi* preparations. The studies were searched in the database of Directory of Open Access Journals, under the key words *rasaushadhies*, *bhasma* and physico-chemical studies. The studies which followed modern analytical procedures and techniques such as XRF, XRD, SEM, TGA, ICP-MS etc. were selected. In these studies, the transformations of minerals during the *rasaushadhi* preparations were clearly identified based on most common *rasaushadhies* like *vanga*, *vaikrantha*, *yashada*, *naag*, *parada* and *sagandha bhasmas*. The changes were identified in physico-chemical parameters like color, odor, weight change, particle size, chemical composition, crystal structure etc. The minerals undergo common physico-chemical changes while the preparations proceed, regardless of the type of mineral being used and the type of *bhasma*. Changes occur in between the procedures depend on the type of *bhasma* being prepared. Physical qualities of all the *bhasmas* are similar except in the color of *Naag bhasma*. Identification of changes occurs in minerals and other constituents during these preparations is helpful in artificial synthesis of medicines of same functional capacity. And to use minerals in biological purposes by reducing their natural toxicity.

*Keywords:* Rasashastra, Ayurveda, Bhasma, Minerals, Metals



# **Sustainable Animal Production**



**Determination of Growth Performance and Meat Quality Traits of Broilers Fed Different Levels of Dietary Salt**

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Addition of dietary salts in the feed can beneficially affect maintain the acid-base equilibrium and ionic balance of animals. The aim of this study was to investigate the growth performance and meat quality traits of broilers fed different levels of dietary salt. A total of 750 one-day-old chicks (Cobb-500) were allotted for five treatments and three replicates according to completely randomized design. Feeding program consisted of three phases (1-14, 15-28, 29-35 days of age). Controlled treatment (T1) included only basal feed while other four treatments had different concentrations of dietary salt (0.45 and 0.55%) in short term (1<sup>st</sup> day to 28<sup>th</sup> day) and long term (1<sup>st</sup> day to 35<sup>th</sup> day) basis (T2: 0.45% for long term; T3: 0.55% for long term; T4: 0.45% for short term; T5: 0.55% for short term). The initial body weight, final body weight and daily feed intake were recorded and feed conversion ratio (FCR) was calculated. Birds were slaughtered at 35<sup>th</sup> day and used to estimate dressing percentage, organ weight/body weight ratio percentage and proximate analysis, meat quality parameters and sensory evaluation of their breast meat. Data were analyzed by one way analysis of variance using General linear model procedures of Minitab 17 software. The highest body weight gain, feed intake and dressing percentages were shown by broilers fed with T3 ( $P < 0.05$ ). The lowest FCR was shown by broilers fed with T3 ( $P < 0.05$ ). Broilers fed with T5 and T2 had the highest water holding capacity in their breast meat ( $P < 0.05$ ). The highest a\* value (redness) in breast meat was shown by broilers fed with T1 ( $P < 0.05$ ). However, addition of dietary salt to broiler diet had no significant effect on organ weight - body weight ratio percentage, proximate analysis and sensory evaluation of breast meat ( $p > 0.05$ ). It can be concluded that addition of 0.55% dietary salt for long term showed significantly high growth performances in broilers.

*Keywords:* Broilers, Dietary salt, Growth performance, Breast meat, Feed conversion ratio



**Comparative Study on Growth Performance of Broiler Chicken Fed a Diet Supplemented with Two Different Toxin Binders Comprised With or Without Mannan-oligosaccharide**

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Mycotoxins caused economical losses in poultry industry by affecting performance and health of the animals. An experiment was conducted to compare the effect of two different toxin binders comprised with or without mannan-oligosaccharides on growth performance of broiler chickens from hatch to 21 days of age. A total of nine hundred day-old chicks (Cobb 500) were randomly allocated in to 3 dietary treatments consisted of three replicate pens (100 birds per pen). The dietary treatments were 1) rice-corn and soybean meal based control diet [Standard (ST)], 2) ST supplemented with toxin binder containing mannan-oligosaccharides [positive control (PC)], and 3) ST supplemented with toxin binder that did not contain mannan-oligosaccharide [negative control (NC)]. This study was conducted in a controlled environment using floor pens littered with paddy husk. Respective dietary treatments and water was provided *ad-libitum* basis during the study. Body weight and feed intake were recorded at the age of day 14 and day 21 to calculate average daily gain, average daily feed intake and feed conversion ratio. Addition of toxin binders to the broiler diet did not significantly affect ( $P > 0.05$ ) on growth performance and feed intake at the age of day 14, independent of Mannan-oligosaccharide. However, broilers fed PC had an improved feed efficiency on day14 ( $P < 0.05$ ), and subsequent showed significantly higher growth performance compared to those fed ST and NC ( $P < 0.05$ ). Nevertheless, feed intake and feed efficiency of the broiler chickens were not affected significantly with toxin binder supplementation to diet on day 21 ( $P > 0.05$ ). In conclusion, toxin binder containing mannan-oligosaccharide improved the growth performance of the broiler chickens without altering feed intake from hatch to 21-day of age.

**Keywords:** Broiler, Growth performance, Mannan oligosaccharide, Toxin binder, FCR

## Comparison of Growth Performances, Meat Quality Traits and Necrotic Enteritis Exposure in Broiler Chickens Fed Probiotics Compared to Antibiotic as Growth Promoters

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Antibiotics have been banned in European poultry industry due to public health hazards caused by antibiotic residues and microbial resistance. Necrotic enteritis caused by *Clostridium perfringence* results in an economic damage. Therefore, alternatives should be identified to withdraw antibiotics from animal feeds. This study was conducted to determine the effects of probiotics on growth performance, meat quality and necrotic enteritis exposure in broiler chickens. Experimental diets were based on maize and soy-bean meal. Five dietary treatments were prepared as feed without growth promoters (Negative control; T1); *Bacillus licheniformis* isolated from healthy poultry (T2); commercial probiotic containing *Bacillus* species (T3); a combination of *B. licheniformis*, commercial probiotic, *Lactobacillus* spp. and *Saccharomyces* spp. (T4) and with antibiotic, Zinc Bacitracin (positive control; T5). The inclusion rate of growth promoters was 0.1 g/kg of basal diet. In T4 all four probiotics were included at equal level (0.025/0.1 g of the combination). A total of 420 day-old broiler chicks (Cobb 500) were randomly assigned to experimental pens. Each treatment replicated 6 times with 14 birds in a pen. Results revealed that birds fed growth promoters had higher ( $P < 0.05$ ) weight gain than those fed no growth promoters. Birds fed antibiotic and commercial probiotic had similar growth (2 kg) and feed conversion ratio (1.5) compared to negative control, 1.8 kg and 1.6 respectively. Antibody levels against alpha toxin were higher ( $P < 0.05$ ) in birds fed no growth promoters compared to those fed growth promoters, indicating an aggravated *C. perfringence* infection. A better juiciness, mouth feel and overall acceptance were identified in breast meat of broilers fed T4 compared to those from other birds. In conclusion, *Bacillus* species incorporated probiotics can be used as alternatives to antibiotic growth promoters, to gain similar growth performances and better quality breast meat.

**Keywords:** Antibiotic, *Bacillus* species, Growth performance, Meat quality traits, Necrotic enteritis

**Growth Characteristics, Forage Yield and Nutritional Composition at Different Harvesting Stages of Fodder Sorghum and Fodder Maize Grown in Dry Zone, Sri Lanka**

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A field experiment was conducted to evaluate growth characteristics, forage yield and nutritional composition (dry matter-DM, crude protein-CP, ether extract-EE, crude fiber-CF) at different harvesting stages and to determine the best harvesting stage of fodder sorghum and fodder maize grown in dry zone, Sri Lanka. There were 5 treatments for each fodder type as; for sorghum; T1 (4 weeks /vegetative), T2 (6 weeks /early growth), T3 (8 weeks /half bloom) T4 (12 weeks /dough) and T5 (14 weeks /mature) and; for maize; T1(4 weeks /vegetative), T2 (6 weeks /silking), T3 (8 weeks /blisters) T4 (12 weeks /milk) and T5(14 weeks /mature). Plant height, stem diameter, leaf number were measured at different stages to determine the growth characteristics and forage yield (fresh basis). Chemical composition of whole sorghum and maize plants were analyzed at different stages of growth. Results revealed that the plant height, leaf number and forage yields were increased ( $P < 0.05$ ) after eight weeks of planting of both maize and sorghum. The highest plant height and forage yield were resulted by both maize and sorghum at 12 weeks after planting. The mean values of DM (21-23 kg day<sup>-1</sup>), CP (15-16%), EE (4-6%) and CF (25%) content at half bloom and dough stages of sorghum were compatible with the standard nutrient requirement of a dairy cow at mid lactation. The DM, CP, EE, and CF content at milk stage of maize were aligned with the standard nutrient requirement of a dairy cow at mid lactation. In conclusion, half bloom stage (8 weeks) of fodder sorghum and maize plants at milk stage (12 weeks) were the best stages to harvest for cattle feed with low cost of production.

*Keywords:* Fodder sorghum, Harvesting time, Growth stage, Stem-diameter, Forage yield

**Effect of Traditional Veterinary Practice: Neem (*Azadirachta indica*) Leaves and Turmeric (*Curcuma longa*) Powder on Gastrointestinal (GI) Parasitism in Goats**

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Anthelmintics have a key role in preventing goat parasitism though high cost and reported anthelmintic resistance in parasites limit the usage of *anthelmintics* in rural goat farming. Since parasitism can reduce goat performance, traditional veterinary medicine (TVM) has re-emerged to overcome these limitations. However, few literatures are available on effectiveness of TVM on goat parasitism. Hence, study was conducted to identify the effect of Neem (*Azadirachta indica*) leaves and Turmeric (*Curcuma longa*) powder against goat GI parasites. Traditional veterinary practitioners were interviewed to gather information TVM used in goats. Animal trial was conducted for 2 treatments; western medicine (WM) and traditional medicine (TM). Equal body weight (BW), 3-6 months old, local goats (n=20) in a single farm with high faecal egg counts (FEC) were selected. At day 0, goats in WM and TM were dewormed with albendazole (10 mg/kg BW) and TVM prepared from *Azadirachta indica* (3 g) + *Curcuma longa* (1 g), respectively and FEC were measured for 15 days by modified McMaster counting technique. Log transformed FEC were analyzed by repeated-measures analysis in MIXED procedure of SAS 9.2. The treatment effect on FEC is not significant ( $P > 0.05$ ) reflecting similar response in WM and TM. However, the effect of time and treatmenttime on FEC is significant ( $P < 0.05$ ). Since FEC have been reduced with time after deworming, both treatments are effective against GI parasites. Least square means of FEC in WM ( $41.34 \pm 11.58$ ) and TM ( $53.53 \pm 14.99$ ) at day 15 is low. Further, interaction effect revealed during day 0-3, WM has significantly lower FEC compared to TM due to rapid reduction of FEC in WM ( $P < 0.05$ ) and day 7 onwards, both groups have statistically similar FEC due to rapid reduction of FEC in TM. In conclusion, TVM is also effective against goat GI parasitism as anthelmintics. Findings can be strengthened by identifying the active compounds in *Azadirachta indica* + *Curcuma longa* and the effective dose.

**Keywords:** Traditional Veterinary, Anthelmintic, Faecal Egg Count

**Relationship of Electrical Conductivity (EC) with Sub Clinical Mastitis Detection Methods; California Mastitis Test (CMT) and Somatic Cell Count (SCC)**

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Subclinical mastitis (SCM) is a major problem in Sri Lankan dairy industry which affect on milk production and productive life of cows. Diagnosis SCM by clinical signs is difficult and thus diagnostic tests; CMT and SCC have a key role. The study objective is to identify relationship of EC with subclinical mastitis detection methods; SCC and CMT. 30 cows were selected from 3 farms in Peradeniya (2) and Kurunegala (1). A total of 150 milk samples were collected including 120 samples directly collected from individual udder quarters and 30 samples from bulk; bucket consisting milk from all 4 quarters of individual cow. CMT, SCC (using Somatic Cell Counter) and EC (using Bench Top Electrical Conductivity Meter) were recorded from each sample and analyzed based on groups divided using results of CMT; SCM negative-CMT(N) and SCM positive-CMT(P). CMT(P) were divided into 4, based on severity; CMT(+), CMT(++), CMT(+++) and CMT(+++). Results revealed, 53.33 CMT(N) and 46.67 CMT(P) teat and 33.33 CMT(N) and 66.67% CMT(P) bulk milk samples. In CMT(P) teat samples, 29.69% , 18.75% , 10.94% , 28.13% and CMT(P) bulk samples, 35, 15, 30 and 20% are CMT(+), CMT(++), CMT(+++) and CMT(+++), respectively. There is a significant positive correlation between EC & CMT ( $R^2=0.558$ ) and EC & SCC ( $R^2=0.455$ ) in teat milk ( $P < 0.05$ ) reflecting higher EC with more severe level of SCM. Correlation is not significant in bulk milk ( $P > 0.05$ ). The mean EC and SCC of teat milk showed a significant difference between groups ( $P < 0.05$ ) of CMT. The mean EC values of teat milk are  $5.49 \pm 0.049$ ,  $5.72 \pm 0.08$ ,  $5.83 \pm 0.154$ ,  $6.12 \pm 0.166$ ,  $6.29 \pm 0.167$  mS/cm, respectively in CMT groups. Further, mean SCC values of teat milk in CMT groups are  $92.63 \pm 12.8$ ,  $461.35 \pm 46.0$ ,  $874.55 \pm 229$ ,  $2673.14 \pm 574$  and  $4358.20 \pm 787$ , respectively. In conclusion; EC increases with onset and severity of SCM. Future research can be focused on defining critical level of EC for SCM which increase applicability of EC as field level SCM detection method.

**Keywords:** Subclinical Mastitis, Electrical Conductivity, California Mastitis Test, Somatic Cell Count

**Growth Performance of Broiler Chickens in Response to Different Levels of Dietary Non-Starch Polysaccharide in Starter Diets**

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A study was conducted to evaluate the differences in growth performance and feed efficiency of broiler chickens resulting from five different non-starch polysaccharide levels in starter diets. A basal diet was formulated to meet the Ross broiler nutrition specification (2014) and top dressed with wood powder (i.e., 0, 0.5, 1.0, 1.5 and 2.0%, respectively) as a non-starch polysaccharide source to make five dietary treatments. Two hundred and ten, day-old Ross broiler chicks were arranged in a completely randomized design and allotted to one of the above five dietary treatments. Chickens were offered the experimental diets and fresh water ad libitum for 14-day experimental period. Growth performance, feed intake and feed conversion ratio were determined in weekly intervals. In each week of the experiment, no differences ( $p > 0.05$ ) were found in all growth performance and feed intake measures. However, the birds fed a diet supplemented with 2% non-starch polysaccharide had lower ( $p < 0.05$ ) weight gain and feed intake for overall experiment period from day 1 to day 14. No differences were found in feed conversion ratio between the dietary treatments ( $p > 0.05$ ). In conclusion, our results suggested that the basal diets supplemented with up to 1.5% non-starch polysaccharide do not affect growth performance of broiler chickens including average daily gain and daily feed intake during starter period.

*Keywords:* Broilers, Non-starch polysaccharide, Growth performance

**Effect of *Aspergillus* Extracted Phytase Enzyme Incorporated Diets on Growth Performance, Meat Quality and Phosphorus Utilization in Broilers**

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Phytate is a major unavailable form of phosphorus for broilers. Addition of microbial phytase in poultry diets has increased recently to reduce the usage of Di Calcium Phosphate (DCP). A total of 810 day old (Sex ratio 1:1) Indian River chicks were used in 35 days experiment to determine the effect of *Aspergillus* extracted phytase (Natuphos® E) enzyme on growth performance, meat quality, phosphorus utilization and investigate the phytase is a suitable replacement for DCP usage in the diets of broilers. Birds were randomly allotted for 3 groups in a complete randomized design. The control group (T1) were fed with basal feed and three levels of DCP (Booster 0.82%, Starter 0.75%, Finisher 0.80%) while other two groups were fed with basal diet with 0.01% (T2) and 0.02% (T3) phytase levels (DCP replaced by limestone). Average final body weight and feed intake were recorded and feed conversion ratio (FCR) was calculated. Feces analysis was conducted in last 3 days of metabolic trial. Blood collected and birds were slaughtered to estimate length of Shank and Tibia, meat quality traits of thigh and tibia ash analysis on the 35<sup>th</sup> day. Data were analyzed by one way ANOVA (Minitab 17). The highest feed intake, P% and Ca% of tibia bone was shown by T2 (P <0.05). The highest body weight gain, shank length and crude protein% were shown by T2 and T3 (P <0.05). The lowest FCR was given by T3 (P <0.05). The highest tibia bone length, P availability, Ca% and P% of thigh meat were shown by T3 (P <0.05). The lowest Ca% in serum analysis was given by T2 and T3 (P <0.05). In sensory evaluation, T2 and T3 are most preferable in juiciness and tenderness of the leg meat (P <0.05). It can be concluded that fed with *Aspergillus* extracted phytase diet enhanced the availability of phosphorus that supported the growth performance, increased P content, retention of Ca and P. These results showed that the feasible supplementation of 0.02% (T3) phytase diet can be replaced DCP usage by adding limestone.

**Keywords:** Broilers, Growth performance, Phosphorus utilization, *Aspergillus* extracted phytase, Tibia bon

## **The Effect of Tulasi (*Ocimum sanctum L.*) Leaf Powder Extract as Phytobiotic on Broiler Growth Performance and Meat Quality**

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The use of antibiotics in broiler industry causes human health hazards due to the formation of cross resistant pathogenic bacteria. Many phytobiotics can be used as alternatives to these antibiotics. Therefore, this experiment was conducted to investigate the effect of Tulasi (*Ocimum sanctum L.*) leaf powder extract as phytobiotic on broiler growth performance and meat quality. Sixty, day-old chicks (Cobb 500 males) were randomly allocated as two treatments (T1 and T2) and the control. Water extracts of Tulasi leaf powder (T1: 10 g/L and T2: 20 gL<sup>-1</sup>) were given as 1 ml extract/L of drinking water as treatments and normal tap water as the control with *ad-libitum* feeding for 35 days. Intake of water and feed, growth performance parameters, meat quality parameters and sensory evaluation of meat were evaluated. According to the statistical analysis, leaf powder extract did not significantly affect ( $P > 0.05$ ) the water intake, body weight & weight gain, organs % abdominal fat weights of birds, cooking loss, texture, colour and water holding capacity of meat. However, it significantly reduced ( $P < 0.05$ ) the feed intake of birds (T1: 16.73% and T2: 18.86%). Due to that the lowest feed conversion ratio (FCR) was observed in T2 ( $1.36 \pm 0.03$ ) compared T1 ( $1.48 \pm 0.10$ ) and control ( $1.67 \pm 0.09$ ). T2 had the highest ( $p < 0.05$ ) ultimate pH and the lowest drip loss % and rancidity compared to T1 and control. In the sensory evaluation of meat, significantly higher score values were recorded by the T2 for the colour, texture, juiciness and overall acceptability except for the taste and aroma than T1 and the control. According to the findings, different levels of Tulasi leaf powder water extract had no significant effects on the growth performance of broilers but, had significant positive effects on the other parameters tested. Further, the T2 performed better than T1. Thus, Tulasi leaf powder water extracts can be used to reduce FCR and improve meat quality of broilers.

**Keywords:** Tulasi (*Ocimum sanctum L.*), Antibiotics, Growth performances, Broiler, Meat quality.



**Animal Welfare in Broiler Industry: From Farm to Processing Plant**

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Animal welfare relates to the general health and well-being of animals. The world animal welfare can be divided in to two categories; 1) countries having specific strategies to prevent animal welfare abuses and 2) countries not having specific strategies to prevent animal welfare abuses. Sri Lanka might be included in to second category. The objective of this case study was to identify general welfare practices of a commercial broiler company from farm to processing plant. Separate pre-tested questionnaires were used to collect information from farmers, catching crew, drivers and unloading crew of the broiler company. According to results, 94% of the farmers practice the starvation period 8 hours before catching and 63% of farmers give water continuously until transportation. However, 31% of farmers do not receive training workshops to know about the good poultry farming practices including welfare practices. All the members in catching crew and unloading crew use the birds legs for catching. Average space given per bird by 99% farmers was 1.2 m<sup>2</sup>. All drivers transport birds at 60-70 km/h<sup>-1</sup> with good welfare practices. They transport animals humanely. The primary records showed a daily poultry mortality rate of 2 - 3% . The commercial broiler company where this study was conducted at practice good animal welfare practices from farm to processing plant.

*Keywords:* Animal welfare, Broilers, Transportation, Starvation, Mortality rate

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### **The Effect of Rubber Seed Wax (*Hevea brasiliensis*) on Internal and Sensory Attributes of Chicken Eggs Stored under Room Temperature**

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Edible coating extends the shelf life of egg by reducing moisture and gas evaporation. Currently mineral oil (MO) coating is used as a common egg coating material. Rubber seed wax (RSW) is an oily substance which can be used in bio-diesel and synthesis of alkaline resins and as a coating material. The objective of this study was to compare the internal and sensory properties of RSW over MO as coating materials in eggs that are stored under room temperature (27<sup>0</sup>C, 80% RH). A Total of 240 medium-sized, fresh, white eggs were purchased from commercial layer farm at Wennappuwa. Eggs were coated with MO or RSW (Brix value of 24), and non-coated eggs (NC) were used as the (-) control. The eggs were stored under room temperature (27±3<sup>0</sup>C) for 7 weeks. Internal qualities (Haugh unit (HU), pH, and weight loss), sensory attributes and microbial contamination of the eggs were measured at each week. Changes in egg white structure were measured using the FTIR technique. The HU decreased significantly in NC eggs from 80.25±8.84 to 39.41±3.79 (P < 0.05) but MO or RSW coated eggs had their HU decreased from 80.25±8.84 to 59.14±4.21 and 60.61±4.46 (p >0.05), respectively after 7 weeks of storage. NC eggs lost 7.87±0.57% of their weight while MO- and RSW-coated eggs showed 0.32±0.0.10% and 2.01±0.56% weight loss, respectively. There was no significant difference in sensory attributes in all 3 treatments up to third week (P > 0.05). However, after the 4<sup>th</sup> week NC eggs could not be analyzed further due to low HU. But, MO and RSW coated eggs had no changes in sensory attributes up to fifth week of storage (P > 0.05). FTIR analysis showed same absorbance peaks throughout the storage in all treatments resulting no changes in albumin structure. Microbiology results revealed NC, MO and RSW coated eggs were free from Salmonella sp. In conclusion, RSW can be used as a good alternative coating material to MO to increase the shelf life of eggs up to 7 weeks of storage under room temperature conditions.

**Keywords:** White eggs, Mineral oil, Rubber seed wax, Shelf life

**Productive and Reproductive Performances Affecting Milk Yield in Sahiwal × Jersey Cross At Bingiriya NLDB Farm.**

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Dairy sector plays a leading role in Sri Lanka livestock industry and the profitability of a dairy enterprise depends on obtaining high level of milk production from animals. This study was conducted to find out the production and reproduction performance of Sahiwal × Jersey crossbred dairy cows in Intermediate Zone of Sri Lanka. Data from 116 dairy cow history sheets were recorded from Bingiriya farm of National Livestock Development Board, Sri Lanka from 2005 to 2015. The collected data were analyzed using Minitab 17 software by removing the outlier records. Multiple Linear Regression model was performed to identify the significant factors which affect to the average milk yield in dairy cows in the farm. The descriptive mean statistics of productive and reproductive performances of Sahiwal and Jersey crossbreds were determined for milk production ( $1974 \pm 88.3$  L/lactation), number of services per conception ( $2.11 \pm 0.12$ ), calves body weight at birth ( $19.67 \pm 0.18$  kg), lactation length ( $308.90 \pm 10.3$  days), dry period ( $187.40 \pm 12.5$  days), calving interval ( $495.90 \pm 12.9$  days), gestation length ( $282.81 \pm 0.63$  days) and age at first calving ( $43.48 \pm 0.73$  months). Results of multiple linear regression indicated that the number of services per conception, calf body weight, lactation length, dry period and calving interval were significant ( $P < 0.05$ ) on milk yield. Extended days of lactation length, calving interval and higher number of services per conception and calf body weight were positively correlated to milk yield whereas dry period of crossbred dairy cows was negatively correlated to the milk yield. Further, Sahiwal and Jersey crossbreds performed better in terms of average milk production, lactation length, age at first calving and gestation length compared to Sahiwal and was lower than the pure Jersey. Thus, Sahiwal × Jersey crossbreds perform better than pure Sahiwal in Intermediate zone in Sri Lanka. In conclusion, lactation length, calving interval, higher number of services per conception, calf body weight and dry period were significantly affected to the average milk production in the Sahiwal × Jersey crossbreds dairy cows in Bingiriya farm.

**Keywords:** Average milk yield, Sahiwal × Jersey crossbred, Calf body weight, Gestation length



# **Sustainable Crop Production**



**Identification of Factors Contributing to Ontogenic Resistance of Tea  
(*Camellia sinensis*) Leaves to Blister Blight**

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Blister blight is the major leaf disease caused by obligate fungus *Exobasidium vexans* Mese. Only young, succulent leaves and stems are susceptible to blister blight. Mature parts of the tea bush show resistance to the disease even in a susceptible cultivar. The reasons for this ontogenic resistance have not well understood. This study aimed at understanding underlying reasons of ontogenic resistance of blister blight in tea with the specific objectives of analyzing the variations of spore germination and leaf physical and biochemical characteristics with leaf age. Healthy tea leaves at five maturity stages (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 1<sup>st</sup> mature leaf from the apical bud) of tea cultivar TRI 2024 were used. Effect of the leaf age on the germination of basidiospores of *E. vexans* was studied by artificial inoculation of spores (10<sup>-6</sup> spores ml<sup>-1</sup>). Leaf cuticle wax was extracted in chloroform using 10 g of each leaf sample. Freeze dried (at -40 °C temperature) powdered leaf samples were used for the biochemical analysis. Total polyphenol content of leaves at different maturity stages was determined by colorimetric method using folin-ciocolteu reagent. Leaf caffeine and catechine content was determined by HPLC (High Performance Liquid Chromatography) method. The first and second leaf of a tea shoot were thin, soft and dull and had lower wax content while mature leaves were thick, glossy and had higher wax content. Also the first and second leaf showed higher total polyphenol content than other mature leaves. Higher caffeine and epicatechine contents were recorded in resistant mature leaves while reverse was observed for epigallocatechine and catechine. Results of this study suggest that both physical and biochemical components contribute for the ontogenic resistance of tea plant to the blister blight disease. This information would be helpful in developing resistant tea cultivar for blister blight.

**Keywords:** Blister blight disease, *Exobasidium vexans*, Leaf age, Ontogenic Resistance, Tea

**Allelopathic Potential of Essential Oil and Byproducts Resulting after Hydro Distillation of *Cymbopogon citrates* (DC) Stapf (Lemongrass)**

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Allelopathy is an eco friendly phenomenon in weed management. Present study was conducted to assess allelopathic potential of essential oil and byproducts after hydro distillation process of *Cymbopogon citrates* (DC) Stapf. Essential oil was extracted by hydro distillation and chemical composition of essential oil was analyzed by Gas Chromatography and Mass Spectrometry. Lettuce was used as an indicator plant. Different concentrations of essential oil (1000, 5000, 10000 and 15000 ppm) were prepared by diluting in acetone (80%). Seeds were germinated at room temperature (25 °C) in petri plates containing three layers of filter papers soaked in distilled water added with 1.5 mL of essential oil of particular concentration. There was dark brown colour solution remains in the flask after boiling leaves during hydro distillation process and distillate was collected after separation of essential oil. Different concentrations of the discarded solutions, 25, 50, 75 and 100% were prepared diluting with distilled water. Distilled water was used as the control. Completely Randomized Design (CRD) was used with three replicates. Germination was examined up to five days and inhibitory percentage was calculated. Inhibitory percentage of germination was 100% with respected to all concentrations (1000 ppm, 5000 ppm, 10000 ppm, 15000 ppm) of essential oil tested. Both discarded solutions after hydro distillation also demonstrated strong inhibitory effect on lettuce seed germination. Citral,  $\beta$ -Citral, Geraniol, Pinene, cis Verbenol are some major chemical compounds identified in the oil and mainly terpenoids considered as the key chemical group responsible for phytotoxicity as observed in this study. Results of the current study explore the allelopathic potential of essential oil and byproducts after hydro distillation of *Cymbopogon citrates* (DC) Stapf which is possible to apply in weed management in agriculture as an alternative to harmful chemical herbicides.

**Keywords:** Allelopathy, *Cymbopogon citrates* (DC) Stapf, Essential oil, Germination Hydro distillation



## **Evaluation of Tea Smallholders Currently Involved in Organic Tea Farming in Badulla District**

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Adoption of agricultural knowledge and correct practices in organic tea are vitally important to enhance the productivity and overall performance in organic tea industry. Study was conducted in Badulla district in 2016 to study the current situation in organic tea cultivation. Level of adoption of recommended organic agricultural practices, identification of the factors affect to the level of adoption and major problem faced by cultivators are specifically considered. The sample size was 60 organic tea small holders representing all divisional secretariats with small scale organic tea cultivation. Data were gathered using a structured questionnaire and direct interviews. Awareness and adoption levels were measured under six categories such as maintaining buffer zones, obtaining of organic certificates, solid organic fertilizer application, liquid organic fertilizer application, preparation of vermicompost and conversion period. Descriptive statistical analysis method was used to determine the status of problems faced by the organic tea small holders while multiple linear regression method was used to find out the effect of independent variables (gender, age of the farmer, time duration of organic tea cultivation, land extent, location of the farm, availability of input supply and infrastructure facilities in the village) on the level of adoption of recommended organic agricultural practices. Results revealed that time period of the cultivation and infrastructure facilities in the village had significant positive effect on the adoption of recommended correct organic field practices while age of the farmer and land extent had significantly negative effect. Major problems faced by small scale organic tea farmers are inadequate support from government, nullity of organic subsidies and higher initial investment in organic tea cultivation.

*Keywords:* Adoption, Organic tea, Problems in Organic Tea Farming, Tea Small Holders

**Evaluation of a Grafting Technique by Using Different Types and Lengths of Scion Sticks of Nutmeg (*Myristica fragrans* Houtt.)**

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Nutmeg (*Myristica fragrans* Houtt.) is a well-known spice. Total extent is 1013 ha and it is the third most important spice crop of Sri Lanka having a potential to increase exportation. Nutmeg is sexually propagated through seedling that yields 50% male plants from the population, which is economically unproductive. Available vegetative propagation methods for nutmeg are air layering, cuttings, budding and grafting. At present, grafting is the major vegetative propagation method among others but results low success rate. Therefore, the objectives of this study were to identify the best scion type with optimum length for a successful grafting and thereby to increase the success and survival percentages of grafted nutmeg plants. The experiment was conducted at the Central Research Station, Matale, Sri Lanka, during August to November, 2016. Cleft grafting was performed by using one year old root stocks. Ten different lengths (0-5, 0-10, 0-15, 0-20, 5-10, 5-15, 5-20, 10-15, 10-20, 15-20cm, 0 indicates the tip) of scion sticks which were in the range of softwood to hardwood were used as the treatments with thirty replicates in this experiment. The success and survival percentages of different treatments were evaluated by using Cluster analysis. The results revealed that success percentage and survival rate were 86.67 and 36.67%, respectively when scion stick length was 0-10 cm. When it was 0 - 5 cm length, success and survival percentages were 76.67 and 23.33%, respectively. By considering overall results, scion length of 0 - 10 cm was the best size which contains softwood and semi hardwood in order to achieve the highest grafting success (86.67%) of nutmeg.

*Keywords:* Nutmeg, Grafting, Scion stick, Survival, Scion length

***In Vitro* Response of Cotyledon Explants of Tomato  
(*Lycopersicon esculentum* Mill.) as Influenced by Sodium Salt**

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Salinity is one of the most severe problems in global agricultural production systems. It has an effect on plant growth. In conventional propagation, salinity is one of the major constraints for tomato production. This study was carried out to determine the effect of different concentrations of NaCl on cotyledon explants of tomato under *in vitro* conditions. Cotyledons were excised from 12-day-old *in vitro* grown seedlings and placed directly on MS medium containing 1 mg L<sup>-1</sup> NAA and 1 mg L<sup>-1</sup> BAP with the presence or absence of NaCl (0, 20, 40, 60 Mm). This experiment was carried out in the Completely Randomized Design (CRD) with 3 replications. The data obtained were subjected to analysis of variance (ANOVA) and the treatment means were compared using Tukeys test at 5% significant level. After 7-days of inoculation, yellowish green calli were initiated on control medium (0 Mm) at the cut ends and after 4 weeks, calli formed gradually from the culture. Similar changes were observed after 13-days of inoculation on medium containing 60 mM NaCl level. There was no change in colour of explants on control treatment i.e. green colour but colour of explants on medium containing 60 mM NaCl was turned to brown. The results showed that the fresh weight, dry weight and water content of cotyledon calli were significantly ( $P < 0.05$ ) influenced by the different treatments after 4 weeks of culture. The explants, which were exposed to highest NaCl level (60 mM), gave the maximum reduction of water content. Chlorophyll a (0.208 mg g<sup>-1</sup>), chlorophyll b (0.322 mg g<sup>-1</sup>) and total chlorophyll content (0.53 mg g<sup>-1</sup>) of cotyledon calli were significantly ( $P < 0.05$ ) higher in control treatment than the NaCl treatments. The production of callus from *in vitro* cotyledon explants of tomato was affected by sodium salt in the nutrient medium.

**Keywords:** Callus, Chlorophyll, Cotyledon, NaCl, Tomato

**Effect of Panchagavya on Growth and Yield Components in Rice  
(*Oryza sativa* L. Variety BG 300)**

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Panchagavya, which is an organic liquid fertilizer, may have a potential to promote growth, yield, and immunity in plants. A study was conducted to evaluate the efficacy of panchagavya on the growth and yield of rice (*Oryza sativa* L. variety BG 300). Five treatments such as (i) neither panchagavya fertilizer nor inorganic fertilizer, control (T1), (ii) 2.5% panchagavya, 200 mL/pot (T2), (iii) 5.0% panchagavya, 200 mL/pot (T3), (iv) 7.5% panchagavya, 200 mL/pot (T4), and (v) urea, triple super phosphate (TSP) and muriate of potash (MOP), 2.5:0.6:0.7 g/pot, respectively (T5), were applied in a complete randomized design (CRD) with four replicates (n = 4) and each replicate comprised of twenty eight plants. Soil samples were analyzed for pH, organic matter content, nitrogen (N), phosphorous (P), and potassium (K) before planting and after harvesting of rice. Plant height, root length, panicle length, number of spikelets per panicle, and number of filled grains per panicle were measured. Further, number of tillers per plant, number of panicles per plant, weight of 1000 seeds per plant, and seed yield were also measured. Results indicate that soil pH, organic matter content, N, P, and K were not significantly different ( $P > 0.05$ ) among five treatments. All plant growth and yield components in the control was significantly lower ( $P < 0.05$ ) compared to all other treatments. Most of the growth and yield components in T2 and T3 were significantly lower ( $P < 0.05$ ) compared to those of T4 and T5. The pots treated with 7.5% panchagavya (T4) showed the highest plant height (84.4 cm), root length (15.9 cm), panicle length (28.3 cm), number of spikelets per panicle (20.0) and number of filled grains per panicle (101.0) whereas inorganic fertilizer application (T5) gave the highest number of tillers per plant (9.0), number of panicles per plant (12.0), weight of 1000 seeds per plant (23.1 g), and seed yield (243.8 g m<sup>-2</sup>). As observed in the present study, application of 7.5% panchagavya seemed to increase the growth and yield of BG 300 rice variety; however, this should be proven with further studies especially at the field level.

**Keywords:** Panchagavya, Inorganic fertilizer, Rice variety BG 300, Rice Growth, Rice Yield

### **Screening of Resistance to Bacterial Wilt Caused by *Ralstonia solanacearum* in Selected Tomato Lines**

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Bacterial wilt caused by *Ralstonia solanacearum* is a major constraint of tomato cultivation worldwide. The most effective way of controlling the disease is cultivation of resistant varieties. The objectives of the study were to identify local isolates of *Ralstonia solanacearum* with morphological, biochemical and molecular methods, to study virulence of the isolates and to identify resistant tomato lines to local isolates of *Ralstonia solanacearum* from selected tomato lines obtained from Horticultural Crops Research and Development institute (HORDI), Gannoruwa. Symptomatic tomato plants were collected from four different locations Matale, Ragala, and two vegetable fields in Gannoruwa area. Colony morphology of all four isolates were studied on Tetrazolium Chloride (TZC) and Sucrose Peptone Agar (SPA) media. All the isolates exhibited the typical colony morphology of pathogen by producing the colonies with pinkish red centers and cream white margins on TZC media and cream white colour colonies on SPA media. Polymerase Chain Reaction (PCR) based identification with the RALS-F and RALS-R specific primers confirmed all the isolates were consisted with the pathogen by giving an amplification of 400 bp fragment. Pathogenicity test conducted under greenhouse conditions exhibited the highest virulence in isolate collected from vegetable fields of HORDI by producing more than 80% of wilt incidences within two weeks after inoculation. The highest virulent isolate was used for the screening of 13 selected tomato lines under greenhouse conditions. Resistant variety Katugasthota Wilt Resistant and a susceptible variety Goraka Thakkali were used as the controls. All the screened tomato lines exhibited more than 30% of wilt incidences 14 days after inoculation. There was no significant difference in resistance of screened tomato lines to the bacterial wilt disease.

**Keywords:** Bacterial wilt, *Ralstonia solanacearum*, Resistant varieties, Tomatoes, Variety screening

### **Evaluation of Girth and Yield Performance of New *Hevea* Genotypes from 1998 Hand Pollination Programme**

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Department of Genetics and Plant Breeding in the Rubber Research Institute of Sri Lanka is accountable for the development of genetically improved clones to the industry, mainly through conventional breeding procedure; which will take nearly 20 - 25 years up to register a novel genotype as a new clone. The objective of this study was to evaluate the girth and yield performance of new *Hevea* genotypes obtained from 1998 hand pollination (HP) programme, over a period of 14 years, established in the small scale trials in the year 2001. Sixty five new genotypes were evaluated along with the control clones named RRIC 121, RRIC 130 and RRISL 205. Dry rubber yield (grams per tree per tapping) for a period of six years, annual girth at the 14<sup>th</sup> year and annual girth increment were evaluated. According to the results, 62.5% of the genotypes are significantly higher or same average yield compared to the control clones. 98 - 80 and 98 - 219 were the top ranking genotypes, which were recorded average yield of 53.66 g and 52.05 g per tree per tapping, respectively. The 98 HP progeny consists with good yielders parallel to RRIC 121, is a good sign for the future high yielding clone development research. 82% of the genotypes showed significantly higher or parallel mean girth at the 14<sup>th</sup> year than to controls and genotypes named: 98 - 276 (80.66 cm) and 98 - 68 (76.5 cm) were the top most at the final year of evaluation. 18 % of genotypes having more than 70 cm of mean girth was an indicator for development of vigorous timber clones in the future; moreover, these genotypes represented a high yield. Girth increment of all genotypes showed a higher increment before the opening of trees for tapping than after the opening. Based on the results, there were numerous valued genotypes generated from the 1998 HP programme and those genotypes will be evaluated further at the Estate/Rubber Research Institute in collaborative trials, to produce precious genetically improved clones to uplift the rubber industry in future.

*Keywords:* Genotypes, Girth, Hand pollination, *Hevea*, Yield

## Effect of Different Earthworms Feeding Materials on Physicochemical Characteristics of *Vermiwash* and Growth Performances of Tea

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*Vermiwash* is a liquid extract consisting of macro and micro nutrients, plant growth hormones, and beneficial microorganisms and which is used as an organic fertilizer. Sri Lankan organic tea farmers currently use wild sun flower (*Tithonia diversiflora*) as the earthworms feeding material for production of *Vermiwash*. Selection of different earthworms feeding materials would increase the *Vermiwash* production and quality. This study was conducted at Idalgashinna Bio Tea Garden, Sri Lanka to identify the effect of different earthworms feeding materials on physicochemical characteristics of *Vermiwash* and to determine the effect of foliar application of it on growth performances of mature tea (*Camellia sinensis* (L.) O. Kuntze). In the first experiment, four different feeding materials, namely, decomposed *Gliricidia sepium*, *Tripsacum laxum*, *Cymbopogon confertiflorus* and refuse tea were used as the treatments. The physicochemical characteristics were compared with the standard test sample (control) prepared by *Tithonia diversifolia* at the 5<sup>th</sup>, 7<sup>th</sup> and 9<sup>th</sup> weeks after establishment of *Vermiwash* unit. The second experiment was conducted using organically grown tea cultivars CY 9, DN, and TRI 2025 at their mature phase in the Up Country Intermediate Zone. Two levels of the standard *Vermiwash*, 10 and 100% were applied in comparison with the control (0%) to evaluate the growth performance of tea cultivars. The results showed significant differences in macro and micro nutrient contents between treatments with time. The highest mean nitrogen was recorded with *G. sepium* (121.8 mg ml<sup>-1</sup>) followed by refuse tea (116.5 mg ml<sup>-1</sup>). Magnesium and Potassium contents were similar and Phosphorus was slightly different among all treatments. pH (5 to 8.4) and Electrical Conductivity (EC) (1.6 to 5.4 mS cm<sup>-1</sup>). Color of *Vermiwash* progressively decreased with time. The overall results indicated that *Gliricidia sepium*, *Tripsacum laxum* and refuse tea can be used as an alternative feeding material to *Tithonia diversifolia* for production of *Vermiwash*. The fresh weight of shoots (g), mean fresh weight of one bud and two leaves (g), shoot density of one bud and two leaves and immature bud (Shoot per m<sup>2</sup>) of three cultivars showed better performances with both application levels of *Vermiwash* as compared to 0% application level. Field experiment should be further carried out to identify the long-term effects and the consistent response pattern of mature tea cultivars.

**Keywords:** *Vermiwash*, Feeding materials, Growth performance, Tea

### **Evaluation of Morpho-physiological Variations in Wild Relatives of Eggplant under Water Stress Conditions**

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Eggplant (*Solanum melongena* L.) that belongs to Genus *Solanum* and Family Solanaceae is a vegetable crop related to a large number of wild species that are source of variation for breeding programs. This research was aimed to evaluate morpho-physiological variations in selected eggplant wild relatives under water stress conditions. The study was carried out under control environment with twelve accessions of eggplant wild relatives (*S. insanum*, *S. anguivi*, *S. torvum*, *S. dasphyllum*, *S. lichtensteinii*, *S. sisymbriifolium*, *S. incanum*, *S. linnaeanum*). Three water levels, 100, 50 and 25% of daily water requirement were used as treatments for five weeks and data were collected from five to seven weeks after transplanting. Results revealed that plant height, relative water content in leaves and shoot to root length ratio were reduced significantly ( $p < 0.05$ ) in all wild relatives. Number of prickles and leaf area did not show any significant ( $P > 0.05$ ) variations. There was a significant ( $P < 0.05$ ) interaction between treatments and accessions in relative greenness and number of leaves. In interaction effect, two accessions reduced their number of leaves significantly at 50 and 25% water levels. Seven accessions reduced their number of leaves at 50% but there was no any significant difference between 50 and 25% levels. Three accessions reduced their number of leaves when water level was reduced up to 25%. Five accessions reduced their relative greenness at 50% but they did not show significant ( $P > 0.05$ ) difference between 50 and 25% levels. When five accessions reduced their relative greenness only at 25%, two accessions did not show any significant ( $P > 0.05$ ) variation under different treatments. Wild relatives change and reduced their height, relative water content in the leaves, shoot to root length ratio, and each interacted with different water levels up to 25% of water requirement differently and changed relative greenness and number of leaves. Number of prickles and leaf area are species-specific traits.

**Keywords:** Morpho-physiological, Variations, Water stress, Wild relatives



**Determination of Optimum Spacing Pattern for Cultivation of Ash Pumpkin  
(*Benincasa hispida*)**

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Ash pumpkin is a monotypic genus belongs to family Cucurbitaceae. It is called as ash guard, wax guard, winter melon and white gourd because of the powdery white flakes of wax that coats the fruit surface. As a traditional vegetable and due to high demand in processing industry, farmers tend to cultivate ash pumpkin in Dry and Intermediate Zones in Sri Lanka. However, there is no proper agronomic package for cultivation of ash pumpkin. Hence, present study was carried out to determine the optimum spacing pattern for ash pumpkin cultivation in Sri Lanka. The research was conducted using four different spacing treatments: T1 = 3 x 3 m (20 plants), T2 = 2.5 x 2 m 36 plants:, T3 = 2 x 2 m 42 plants:, T4 = 1.5 x 2 m 60 plants: in a Randomized Complete Block Design (RCBD) with three replicates at the field of Regional Agricultural Research and Development Centre, Makandura, Sri Lanka during August to December, 2016. Different parameters, namely, number of days for first flowering, 50% flowering, 100% flowering, number of flowers per vine, number of fruits per vine and yield per hectare were recorded. Results revealed that different spacing patterns did not significantly ( $P > 0.05$ ) affect on number of days for first flowering, 50% flowering, and 100% flowering. Significantly ( $P < 0.05$ ) higher average number of flowers and fruits per vine were recorded in 1.5 x 2 m and 2 x 2 m spacing systems. However, the highest yield per hectare was recorded in 2 x 2 m spacing and this spacing was found to be as the optimum spacing pattern for ash pumpkin cultivation in Sri Lanka. As Ash pumpkin is cultivated in the open field under various environmental interactions throughout the year, it is suggested to extend this experiment during other months of the year and in other geographical areas as well.

*Keywords:* Ash pumpkin, Flowering, Fruits, Spacing pattern, Yield

**Antagonistic Effect of *Trichoderma* spp. Against Fungal Strains Isolated from Tea (*Camellia sinensis*) Leaves**

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Tea plant is attacked by a number of pests and diseases, which are the major limiting factor in crop productivity. A majority of tea diseases are of fungal origin. Diseases in leaves are more important due to the obvious reason that tea plant is cultivated for its young succulent leaves. The frequent use of chemical fungicides used to control causative pathogens leads to environmental pollution is hazardous to human and may leads to development of new chemical resistant pathogenic strains. Ecofriendly, economical and sustainable, biological control organisms can be an alternative to fungicides. *Trichoderma* species are the most widely studied bio control agent against many economically important plant pathogens. Hence, an attempt was made to investigate the antagonistic effect of *Trichoderma asperellum*, *Trichoderma viride* and *Trichoderma harzianum* strains on six fungal strains isolated from diseased tea leaves. *Pestalotia* spp, *Phomopsis* spp, *Curvularia* spp, two types of *Colletotrichum* spp were identified at their genera level based on the cultural characteristic and reproductive characteristics. Eventhough *Phomopsis* spp, *Curvularia* spp were isolated from tea leaves, those are not categorized as foliar pathogens. *Trichoderma* strains were tested. under *in vitro* conditions for their antagonistic effects against six isolated fungi by dual culture test. Inhibition rates were calculated by using the equation described by Vincent and Budge. The results obtained from dual culture tests showed the inhibition rate of *Trichoderma asperellum*, *Trichoderma viride* and *Trichoderma harzianum* as 63.41% to 79.76%, 75.75% to 88.88, and 73.11 to 82.51%, respectively. In conclusion, all the tested . *Trichoderma* strains showed more than 50% of antagonistic effects against foliar fungal pathogens under investigation. Biocontrol agent *Trichoderma* spp. were effective against tested fungal stains. Further study is required to confirm field applicability of *Trichoderma* spp. against tested fungal stains.

**Keywords:** Antagonistic effect, Bio control agents, Dual culture test, plant pathogen, *Trichoderma* spp

**Performance of Fine Coir Dust as a Growing Medium for Okra  
(*Abelmoschus esculentus*)**

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In the process of coir bales, disks and slabs production, fine coir dust is disposed as waste. Major chemical substance of this fine coir dust is lignin and it can be remained in the environment without decaying for long time creating environmental problems. Hence, fine coir dust can be used as a growing medium, as it is the waste coming from sieving coir pith, which is presently used as a growing medium in commercial Horticulture. This study was designed to evaluate the performance of fine coir dust as a growing medium for okra. The pot experiments were conducted in the protected house at Growrite Substrate Pvt Ltd, Sri Lanka. The experimental design was Complete Randomized Design (CRD) with five treatments and five replicates. Treatments were T1 - fine coir dust only, T2 - coir pith only, T3 - fine coir dust: coir pith 1:1, T4 - fine coir dust: coir pith 2:1 and T5 - fine coir dust: coir pith 1:2. Average plant height, number of leaves after the 7<sup>th</sup> week of planting, average number of flowers, average pod length, total number of pods harvested and maximum rooting depth after uprooting at the 9<sup>th</sup> week were reordered as plant parameters. Out of the assessed plant parameters, the plants in fine coir dust have formed significantly ( $P < 0.05$ ) higher number of flowers than the plants grown in growing medium with only coir pith. The growing medium only with fine coir dust has performed better than the growing media only with coir pith when considering plant height and number of leaves at maturity without the significant ( $P > 0.05$ ) difference. The growing media only with fine coir dust and growing media only with coir pith have performed equally when considering total number of pods. The growing media only with fine coir dust and growing media only with coir pith have performed similarly when considering average pod length without a significant ( $P < 0.05$ ) difference. Fine coir dust has a good potential to use as a growing medium for Okra, while solving the environmental problems that can be created by remaining it as a waste.

**Keywords:** Coir pith, Fine coir dust, Growing media, Okra, Plant parameters

## **Screening of Rice Varieties for Heat Tolerance Based on Their Agronomic and Physiological Traits**

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Rice is the staple food of Sri Lankans. However, the rice production in Sri Lanka is threatened by the increasing air temperature. A continuous warming has occurred since 1930s in major agro ecological zones in Sri Lanka. Use of heat-tolerant rice varieties is an effective way to sustain the rice production in the future. Nineteen rice varieties including both newly improved and traditional varieties were screened inside a thermo-gradient chamber to identify rice varieties with high temperature tolerance based on their agronomic and physiological traits. Three temperature treatments (30 – 34 °C, 35 – 37 °C and 38 – 42 °C, mean temperatures from 10:00 am to 1:00 pm) were given during the flowering period using the naturally fluctuating thermo gradient inside the chamber. The yield per hill, filled grain percentage, average thermal stability and the chlorophyll content of the rice varieties were recorded. Bg 304 had high filled grain percentage (80 – 95.4%) and yield per hill (7.0 – 9.7 g) in all treatments and selected as the best performed variety. Bg 305 also had higher filled grain percentage (76.4%) and yield per hill (11.4 g) at temperatures of 35 – 37 °C. Bg 94-1, Bg 352 and Bg 370 recorded poor performances for all traits evaluated and found to be very susceptible to high temperature. Bg 359, Suwandal, Pachchaperumal and Pokkali started flowering before 7:30 am while Bg 357, Bg 358, Bg 360, Bg 369 and Kalu heenati flowered during 7:30 – 10:30 am. These varieties should be further screened in target environments before used. Selected varieties can also be used in developing heat-tolerant rice varieties for future cultivation.

*Keywords:* Filled grain percentage, Flowering period, Heat stress, Yield

**Evaluation of Yield Variations of True Cinnamon  
(*Cinnamomum zeylanicum* Blume) in Different Agro-Ecological Regions in  
Matara District**

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*Cinnamomum zeylanicum* Blume of family Lauraceae is one of the major spice crop in Sri Lanka, which is considered superior to the other types of cinnamon available in the global market. Due to the unique characteristics of true cinnamon, such as quality, colour, flavor and aroma, there is a high demand for Sri Lankan true cinnamon. Yield variations of cinnamon in different agro-ecological regions are important to identify potential areas for cultivation and for markets, whilst harnessing the lands effectively. This research was conducted at National Cinnamon Research and Training Center, Palolpitiya, Thihagoda, Sri Lanka to identify the yield variations of cinnamon in different agro-ecological regions in Matara District. Leaf and stem samples were randomly collected from 24 different places in selected Grama Niladhari Divisions in Matara District covering eight agro ecological regions (IL1a, IL1b, WL1a, WL2a, IM2a, WM1a, WM1b and WU1). Collected stem and leaf samples were subjected to steam distillation and oil extracted was quantified. After collection of samples, length of the stem (cm), girth of the stem (cm), thickness of the bark (mm), bark dry weight per unit length of stem (g), leaf dry weight per unit length of stem (g), leaf oil percentage (%) and bark oil percentage (%) were recorded. ANOVA technique was used to identify yield variations of true cinnamon among different agro-ecological regions using Mini tab 17 software. Result revealed significantly ( $P < 0.05$ ) higher cinnamon bark yield (30.06 g per 1 m stem) and leaf yield (339 g per 1 m stem) was found in IL1a region. Similarly, the oil percentage in cinnamon bark (3.27%) was significantly ( $P < 0.05$ ) higher in IL1a region than the other seven regions. Further, significant amount of cinnamon leaf oil (4.099%) was found in cinnamon, cultivated in IM2a region. Therefore, there is a higher potential of giving high yield of true cinnamon in IL1a region than that of the other agro-ecological regions in Matara District.

**Keywords:** Agro-ecological regions, Cinnamon, Leaf and bark oil, Steam distillation, Yield

**Analysis of Nitrate Accumulation in Spinach (*Abelmoschus esculentus*)**

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Leafy vegetables are an important component of the human diet. It is considered to be a high source of nitrate accumulator accounting for 72 – 94% of the total nitrate intake of humans. Nitrate by itself is relatively non-toxic; however, it may be transformed to nitrite. Nitrite can react with amines and amides to produce nitroso compounds, which have been related to an increased risk of diseases. A pot experiment was conducted to analyse nitrate accumulation percentage in spinach provided under same nitrate percentage but in different frequencies. Spinach plants were cultivated in plastic pots under poly tunnel condition and 1% urea solution was applied for the plants as a foliar application after 33 days from seeding. Application frequencies were changed as follows: (i) without application (control) (T1), (ii) every 1 day interval (T2), (iii) every 3 days interval (T3), (iv) every 7 days interval (T4), and (v) every 12 days interval (T5). After 21 days from urea application, spinach plants were harvested and accumulated nitrate content (% dry weight basis) in plants was determined. According to the results, average nitrate accumulation percentage in spinach was higher in T2 (0.65%) over the other treatments: 0.32, 0.47, 0.42, and 0.41% in T1, T3, T4, and T5, respectively. However, a significant ( $P < 0.1$ ) difference was observed between only T1 and T2. It is concluded that increased of urea solution application frequencies for spinach plant can increase the level of nitrate accumulation in spinach. Further research is suggested for confirming the findings.

*Keywords:* Nitrate accumulation, Spinach, Urea fertilizer

## **Identification of Potential Tobacco (*Nicotiana tabacum*) Varieties for Yala Season in Sri Lanka**

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At present K 326 is the only commercially cultivated tobacco (*Nicotiana tabacum*) variety for cigarette production in Sri Lanka. As one variety is currently being cultivated, there is a need to broaden the genetic diversity under field conditions. Therefore, this study was conducted to identify potential tobacco varieties for Yala season in Sri Lanka by evaluating the growth and yield performances, disease incidence of five new tobacco varieties against the currently cultivated variety, K 326 under Sri Lankan conditions. Tobacco genotypes, K 326, LK 01, NC 297, GF 318, CC 67 and CC 27 were grown under field conditions in a Randomized Complete Block Design (RCBD) with 4 replicates in 3 locations (Galewela, Polonnaruwa and Mahiyanganaya - Dry and Intermediate Zones) in Sri Lanka. Survival percentage of the seedlings, total leaf area, leaf area at topping, time taken to reach the harvesting stage, fresh leaf yield and disease incidences (number of infected plants per plot) was determined to evaluate the selected varieties. The results revealed that the survival percentage of the seedlings of all tested varieties was statistically similar as that of K 326 at topping and harvesting. All the varieties reached the harvesting stage at the same time and there were no differences among the varieties in relation to growth parameters at topping, except leaf area. The variety LK 01 had the highest leaf area at this stage. The disease incidences of the plants of six varieties was also not significantly ( $P > 0.05$ ) different. The highest fresh leaf yield was recorded in LK 01, which was greater than that of the control (K 326) and the lowest leaf yield was recorded in CC 27. It was clearly evident that the variety LK 01 was the best variety in terms of yield and leaf area. All the new cultivars except the variety CC 27 performed better than or in par with the currently recommended variety K 326 in terms of fresh leaf yield. This suggests that there is a potential of growing other varieties (LK 01, NC 297, GF 318, CC 67) in selected agro climatic regions and field conditions in Sri Lanka in addition to the most popular variety K 326.

**Keywords:** Genetic diversity, Tobacco, Topping, Variety, Yield

### **Evaluation of a Rapid Multiplication Method for Citronella (*Cymbopogon spp.*) Using Root Suckers**

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Citronella is an aromatic grass which belongs to family Poaceae there is a great interest due to its commercially valuable essential oils extensively used in soap, perfumery, cosmetic and flavoring industries. Citronella is more rapidly propagated by root suckers but technology for efficient root sucker propagation is limited due to lack of research. Present study was carried out to evaluate a rapid multiplication method for Citronella using root suckers. Coir dust, soil and sand mixture (2:1:1 ratio) was used as the potting medium with four different types of root cuttings by which the mother root sucker is cut in to two halves, four pieces, six pieces and eight pieces. Two *Cymbopogon* species:, *Cymbopogon nardus* (Heen pengiri) and *Cymbopogon winterianus* (Maha Pangiri) were used. The experiment was conducted in Complete Randomized Design (CRD) with four replicates. Time taken for sprouting (days), sprouting percentage, number of sprouts per cutting, plant height (cm), root length (cm), number of leaves per plant and leaf size were recorded. The minimum time taken for sprouting (9 days), the highest sprouting percentage (100%), highest number of sprouts per cutting (2.00), highest shoot height (3.1 cm) and highest root length (13.5 cm) were recorded in *Cymbopogon nardus*, in which mother root sucker cut in to two halves. Similarly in *Cymbopogon winterianus*, minimum time taken for sprouting (7 days), highest sprouting percentage (100%), the highest number of sprouts per cutting (2.00), the highest shoot height (3.68 cm) and the highest root length (16.25 cm) were recorded in which mother root sucker cut in to two halves. Results revealed that mother root sucker cut in to two halves is suitable for rapid multiplication of *Cymbopogon nardus* (Heen pengiri) and *Cymbopogon winterianus* (Maha Pengiri).

**Keywords:** *Cymbopogon nardus*, *Cymbopogon winterianus*, mother root sucker, Rapid multiplication, Sprouting



**Study on Sulfur Use Efficiency in Radish (*Raphanus sativus* L.)**

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Plants need sulfur (S) mainly for the production of proteins, volatile compounds, and sulfates and the amount needed varies significantly according to the family and genera of plants. Radish is one of the important root crops that belongs to brassicaceous family and is reported to increase its yield with S. A pot experiment was conducted to study the S use efficiency of radish using Reddish Brown Latosolic and Regosol soils. Treatments consisted with four levels of sulfur, 0, 3, 6, 9, and 12 kg ha<sup>-1</sup> applied as (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>. Measurements were undertaken to record radish root yield (g), total fresh weight (g), total dry weight (g), total plant sulfur uptake (g), and plant sulfur uptake efficiency (%). According to the results, the effect of fertilizer level on total dry weight was significant (P < 0.05) and also, there was a significant effect of soil type on plant S uptake efficiency (P < 0.001). Further, the plots amended with (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> at the rate of 6, 9, and 12 kg ha<sup>-1</sup> showed a significantly (P < 0.05) higher total dry weight compared to the control. However, there was no significant (P > 0.05) effect of either soil type or fertilizer level on radish root yield, fresh weight and total plant S uptake. No significant (P > 0.05) difference could also be seen between the control and fertilizer level of 3 kg ha<sup>-1</sup>. As determined, S use efficiency in Reddish Brown Latosolic soil was significantly (P < 0.05) higher than that of the Regosol soil. Application of S in radish seems to increase the level of S in the plant. Also, S use efficiency depends on level of S amended and the type of soil. Field level studies are further suggested to confirm the results.

*Keywords:* : Radish yield, Sulfur uptake, Sulfur uptake efficiency

**Evaluating Bio Efficacy of Aqueous Solution of *Michelia champaca* Seeds in Controlling Common Weeds in Agricultural Lands**

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The use of herbicides is the commonest practice for controlling weeds in tea lands, but becoming restricted due to the hazardous effects on environment. Therefore, it is high time for contemplating the use of botanicals. Chemical compounds with allelopathic potentials in plant parts cause to kill or inhibit the growth of several weeds. This study was aimed to evaluate bio efficacy of aqueous *M. champaca* Seeds in Controlling Common Weeds. Previous studies confirmed the presence of alkaloids, saponins, tannins, glycosides, carbohydrates, amino acid, flavonoids and sterols in both leaves and flowers of *M. champaca* L. There may be some allelopathic compounds in seeds of *M. champaca* L. locally known as Ginisapu. Thus, seeds were blended with distilled water and supernatant was filtered. Additives such as coconut oil, kerosene oil and Maltodextrin were tested to minimize the adhesiveness of solution against centrifuging. Prepared solutions were tested with raddish seeds in *in-vitro* bioassay and 100% inhibition was shown in 60 and 80% and more than 50% in 30 and 40% aqueous solutions. All the solutions were sprayed to a field where there are many tender weeds at university premises (Uva Wellassa University of Sri Lanka) with negative control. Field application was done to evaluate the bio efficacy of 30% and 40% of aqueous solutions which were centrifuged at TRI (Tea Research Institute) Sri Lanka, Passara. Visual injury symptoms in the weed were observed and scored in 1, 3 and 5 days after application (DAA). Partially and totally dead plant percentages were counted at 7, 14, and 21 DAA. Dry weight of viable weeds was measured at 21 DAA. Results showed that the better performance in controlling weeds can be observed in centrifuged solution after removing adhesiveness. 51.6 (51.6 +/- 0.3) and 57.5% (57.5 +/- 0.3) dead plants were recorded with 30 and 40% centrifuged aqueous solution of *M. champaca* seeds at 21 DAA, respectively. Therefore, aqueous solution of *M. champaca* L. seeds can be considered as a source of bio herbicides.

**Keywords:** Adhesiveness, Allelopathy, Botanical, *Michelia champaca*, Seeds

**Assessment and Mapping Soil Erosion Risk Hazard Zones in Anuradhapura, Polonnaruwa and Vavuniya Districts of Sri Lanka**

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Soil erosion is a serious problem as it gradually degrades most vital and limited natural resources in Sri Lanka. This is accelerated by human activities, with diverse negative effects. The study was carried to identify soil erosion risk hazard zones within Anuradhapura, Polonnaruwa and Vavuniya districts. Remote Sensing, Geographical Information Systems (GIS) and Revised Universal Soil Loss Equation model, which is one of most widely used erosion equation proposed to forecast long-term average annual soil loss, were used to identify and map potential erosion risk areas in Anuradhapura, Polonnaruwa and Vavuniya districts. The model computes soil erosion as a product of six factors representing rainfall erosivity, soil erodibility, topography, cover management practices, and control conservation practices. All data were produce using UTM projection in WGS 84 format in 44 North datum and discrete GIS files were built for each of parameters. Annual soil loss was estimated by interpolation of annual total rainfall, topography by Digital Elevation Model, Soil erodibility by soil map, vegetation cover by satellite image (2014) and erosion control practices by land use map. Application of model was by using raster calculator function in ArcGIS spatial analyst function, and multiplying parameters, to get one output as annual soil loss. Rainfall erosivity ranged from 130.33 to 1121.57 MJ mm ha<sup>-1</sup> hr<sup>-1</sup> yr<sup>-1</sup>. Slope length varied from 0.789 to 5.302 and slope gradient from 0.33 to 26.36. Cover factor ranged between 0.11 to 1.28. Land-use factor values of study area ranged from 0.0 to 1.0. Soil loss stretched from 0.00 to 1366.09 t ha<sup>-1</sup> yr<sup>-1</sup>. Annual soil erosion risk is slight to moderate in Vavuniya. Severity increases to Western and Southern Polonnaruwa from south-eastern parts of Anuradhapura. Management practices implemented during minor severe conditions must be implemented because the cost of practice is more affordable and applicable at the early stages.

*Keywords:* Anuradhapura, GIS, Erosion, Polonnaruwa, Vavuniya

### **Evaluation of Plant Nutrient Source Derived From Coconut Husk**

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Coconut is a perennial crop, which has a higher demand for potassium (K). As coconut tree gives yield throughout the year it removes soil (K) in a large amount. K fertilizers used in coconut cultivation tend to be more expensive in the recent past. Also inorganic K sources cannot be recommended for organic cultivation. Therefore, unavailability of organic K sources for coconut cultivation is an issue. The objective of this experiment was to evaluate the tender coconut husk as a supplementary K source, which can be used together with commonly used organic manure for coconut cultivation. A field experiment was conducted in a young coconut plantation on Madampe soil series. The treatments were no fertilizer (T1), young palm mixture (T2), completely burnt coconut husk + poultry manure (T3), sulphate of potash + poultry manure (T4). Soil samples were collected after two weeks of treatment application and analyzed for exchangeable K, exchangeable calcium (Ca), exchangeable magnesium (Mg) and available phosphorus (P). Results indicated that among the treatments, T3, the processed tender coconut husk added as a supplement of K source together with poultry manure, showed significantly ( $P < 0.05$ ) higher K ( $529.62 \text{ mg Kg}^{-1}$ ), Ca ( $377.93 \text{ mg Kg}^{-1}$ ) and Mg ( $94.88 \text{ mg Kg}^{-1}$ ) contents in two weeks. Even though the pH of burnt tender coconut husk was pH of  $10.07 \pm 0.38$  significantly ( $P > 0.05$ ) it did not significantly change the bulk soil pH. This indicates that burnt tender coconut husk can be used as a supplementary K source with poultry manure for young coconut palms. However, long term observations and measurements are needed to further confirm these results.

*Keywords:* Nutrient supplement Potassium source, Organic cultivation

### **Study on Nutrient Removal in Black Pepper (*Piper nigrum* L.) at Different Stages of Harvesting**

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The relationship between nutrient removals with different harvesting stages of pepper (*Piper nigrum* L.) is poorly understood and therefore, such information is important for the soil nutrient management practices especially related to the immature harvesting of pepper. Changes in the status of plant nutrients in pepper berries with four selected maturity stages (three, five, seven and eight months after flower initiation) were investigated in two cultivars namely, local selection MB 12 and Panniyur-1. Pepper spikes with berries were harvested at above harvesting stages and spikes and berries were separated. Amount of moisture, plant nutrients such as nitrogen (N), phosphorous (P), potassium (K), magnesium (Mg), zinc (Zn), copper (Cu), iron (Fe) and boron (B) were evaluated. Initial nutrient content in index and mature leaves and soil nutrients of rhizosphere of experimental vines were also evaluated. The study, showed a significant ( $P < 0.05$ ) difference in nutrient removal in immature harvesting (three and five months after flower initiation) and mature harvesting (seven and eight months after flower initiation). Both MB-12 and Panniyur-1 showed a similar pattern of moisture reduction over the maturity. Amount of N removal at mature harvesting of MB-12 and Panniyur-1 were 18.1 and 18.0 kg ha<sup>-1</sup>, respectively, and those values were three fold greater than that of the immature harvesting of the two cultivars. High amount of tissue N (%) determined throughout the berry production indicates the importance of N in berry production. Tissue P (%) in berries became lower with maturity and amount of P removal in mature berries of MB-12 and Panniyur-1 were 1.05 and 1.45 kg ha<sup>-1</sup>, respectively. Potassium removal in mature berries of MB-12 and Panniyur-1 was 10.4 and 12.8 kg ha<sup>-1</sup>, respectively, and those values were three times greater than that of the immature harvesting. Both spikes and berries of the two cultivars had low Mg removal especially at the maturity of eight months: 1.44 and 2.63 kg ha<sup>-1</sup> in MB-12 and Panniyur-1, respectively. Overall, the study showed N and K are the elements that are needed in large quantities in berry production. Repeated evaluation of these findings and modification of current soil nutrient management practices especially at reproductive stage will be needed to confirm the findings.

**Keywords:** Black pepper, Maturity stage, Nutrient removal, Nutrient management

## **Isolation of Efficient Halo-Tolerant Phosphate Solubilizing Microorganisms from Saline Soils**

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Phosphorus (P) is the second most essential macro-nutrient required by plants. Isolation of phosphate solubilizing microorganisms (PSMs) with the genetic potential for increasing tolerance to high salt concentration is an important factor for the enhancement of crop production in salt accumulated lands. The present study was undertaken to isolate efficient PSMs, which can solubilize the insoluble phosphate in the wide ranges of soil salinity. Five PSMs possessing the ability to solubilize insoluble phosphate were isolated from soil samples collected from saline soils in Polhena and Madiha areas in the Matara district. Phosphate solubilizing capacity of the strains was assessed under high pH (7 to 9) and high salt concentration (0 to 10% NaCl) in the NBRIP (National Botanical Research Institute Phosphorous) liquid medium. Results clearly showed that all five strains were proved to be effective in solubilizing inorganic phosphates in varying degrees. Out of them, PSB2 exhibited the highest phosphate solubilization ( $627 \text{ mg l}^{-1}$ ) followed by PSB1 ( $558 \text{ mg l}^{-1}$ ). Solubilization of phosphate in the broth cultures by different isolates were accompanied by a significant drop in pH from an initial pH of 7. An inverse relationship between pH of the medium and solubilized P were observed in this study. The isolated strains proved the ability to solubilize inorganic phosphate under a wide range of pH (7 to 9), and salt concentrations (0 to 10% NaCl). According to the results the identified phosphate solubilizing microorganisms can be used to increase the availability of phosphorus in saline soils and can enhance the crop production in salt accumulated lands.

*Keywords:* Phosphate solubilizing Microorganisms, Saline soil, Phosphate solubilization

**Short-term Effect of Biodynamic Vitalizer Application Pattern on Yield of Tea (*Camellia sinensis* (L.) O. Kuntze)**

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Biodynamic farming differs from other organic approaches given the usage of unique vitalizers following moon rhythms. A field study was conducted at Bio Tea Garden, Haldummulla, Sri Lanka to evaluate the effect of biodynamic vitalizer application pattern on yield of selected tea cultivars (TRI 2025 and CY9). Cow Pat Pit (CPP), which is a widely used vitalizer, was applied as both soil manure (rate of 25.00 g L<sup>-1</sup>) and foliar manure (rate of 13.21 g L<sup>-1</sup>). Measurements were undertaken in two consecutive ascending descending moon cycles. Two vitalizer application patterns were used as proper application and opposite application. As the proper application, foliar manure application was practiced in ascending period and soil manure was applied in descending period whereas as the opposite application, foliar manure was applied in descending period and soil manure in ascending period. Control plots were maintained without vitalizer application. The experiment was performed in a split plot design with three replicates. Yield parameters were recorded every week as yield (kg ac<sup>-1</sup>), mean shoot weight (g shoot<sup>-1</sup>), and shoot density (shoot number ft<sup>-2</sup>). Soil and leaf chlorophyll analyses were undertaken after two months from first application of CPP manure. Moisture, pH, electrical conductivity (EC), organic carbon(C), and nitrogen contents(N) were taken as soil parameters in addition to estimating soil microbial biomass Carbon and Colony Forming Unit (CFU) of soil fungi at the end of the experiment. Results revealed that there was no significant difference ( $P > 0.05$ ) in yield and soil parameters, before and after vitalizer application in both cultivars, after two cycles of CPP manure application. However, mean values obtained for yield, mean shoot weight, and total chlorophyll content were 4.78 kg ac<sup>-1</sup>, 0.529 g shoot<sup>-1</sup> and 67.88, respectively. In the soil, organic carbon content, organic matter content, microbial biomass carbon content, total nitrogen content, CFU of fungi, pH and EC gave the mean values of 1.54%, 2.61% , 0.045%, 0.083%, 26.91103, 6.01 and 122.12 103 mS, respectively. The findings indicate that there was no short term effect of biodynamic vitalizer application pattern on yield parameters of tea with respect to given cultivars, leaf parameters and soil parameters.

**Keywords:** Ascending and descending moon, Biodynamic vitalizer, Cow Pat Pit(CPP) manure

**Effect of Different Soil Compaction Levels on Growth Parameters of Cowpea  
(*Vigna unguiculata* (L.) Walp)**

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Soil compaction is a worldwide problem in modern agriculture and has been recognized as the main form of soil degradation. Soil compaction may increase soil strength and compacted soil layers can affect growth and yield of crops. The aim of this research was to investigate the effect of soil compaction on growth of cowpea (*Vigna unguiculata* (L.) Walp). This experiment was conducted during *Maha* season in 2015 at the crop farm, Eastern University, Sri Lanka. This experiment was a pot experiment and there were four treatments based on different bulk density levels (1.33, 1.60, 1.80, and 2.00 g cm<sup>-3</sup>) arranged in a completely randomized design (CRD) with nine replicates. Cowpea variety Wijaya was used for the experiment. All agronomic practices were followed as recommended by the Department of Agriculture, Sri Lanka. Growth parameters such as maximum root length, number of nodules and active nodules per plant, plant height, number of leaves, leaf area and plant dry weight were measured. The results revealed that soil compaction significantly ( $p < 0.05$ ) influenced on the growth parameters such as maximum root length, number of nodules and active nodules, plant height, number of leaves and leaf area of cowpea. The highest plant height and active nodules number per plant were recorded at the treatment of 1.33 g cm<sup>-3</sup> bulk density (control) 49.67 cm and 50, respectively. Negative correlation was observed between these parameters and the level of soil compaction. It can be concluded from the results of this study that soil compaction level greater than 1.60 g cm<sup>-3</sup> significantly affects the growth of cowpea.

*Keywords:* Active nodule, Bulk density, Root growth, Soil strength



### A Survey on Problematic Weeds in St. Coombs Tea Estate in Talawakelle

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Weeding is an important and cost effective agronomic practice in tea cultivation. Herbicides usage for weeding is the most convenient and effective method among various weeds management techniques. Chemical herbicides such as Glyphosate and Glufosinate Ammonium have been banned by the government regulations recently. Hence, identification of prominent problematic weeds in tea lands could be a new information to the tea researchers to screen new herbicide formulations for weed management in a sustainable manner. A survey was carried out in selected tea fields in order to evaluate major problematic weed species in St.Coombs tea estate, Talawakelle. Purposively, sampling method was carried out to select tea fields which are highly hosted by weeds. Twenty five plots were laid out with the area of  $3 \times 3$  m. Twenty five quadrate ( $1 \times 1$  feet) samples were obtained from each plot randomly. All weeds species were separated for identification and counted for the study. Eighteen problematic weed that species that belong to eleven families and two soft weeds; *Oxalis barreleri* (*Embiliya*) and *Phyllanthus debilis* (*Sudu pitawakka*) that belong to *Oxalidaceae* and *Euphorbiaceae* families, respectively were detected in the selected tea field. Among eighteen problematic weeds, *Ageratum conyzoides* (*Hulanthala*), *Bidens pilosa* (*Letiya*), *Commelina diffusa* (*Girapala*), *Crassocephalum crepidioides* (*Kadupahara*), *Drymaria cordata* (*Kukulupala*) and *Boreria latifolia* (*Geta-kola*) were prominent in selected three fields. Based on the results of this study it can be suggested that morphological and ecological characters of problematic weeds such as *Hulanthal*, *Letiya*, *Girapala*, *Kadupahara*, *Kukulupala* and *Geta-kola* weeds species need to be highly considered when recommending herbicides to the above tea fields.

**Keywords:** Herbicides, Tea, Weeds

## **The Effects of Poly Mulch Application on Weed Control, Morphological Traits and Grain Yield in Rice**

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A field experiment to investigate the effect of poly mulch application on weed control, grain yield and morphological traits in rice cultivation was conducted at the Rice Research and Development Institute, Bathalagoda, during the months of July to November, 2016. The experiment comprised of five treatments, T1 (Mulched with polythene 25 Microns gauge, Black color) and dibbling seedlings on open patches, T2 (Initially mulching with same/removal of it 04 weeks after, followed by dibbling rice seedlings), T3 Bare land (weedy)-Control, T4) Broadcasting of rice followed by hand weeding, T5) Broadcasting of rice followed by no weeding. Plot size of each was 3.0 m × 1.5 m. Experiment was laid out in a Randomized Complete Block Design (RCBD) with three replicates. Rice variety Bg 300 were used as the medium Weed density (06) and weed dry weight (0.009 g) were significantly ( $P < 0.05$ ) reduced by 25 micron polythene (T1) compared to that of Control (356 and 16.409 g). There was no any significant ( $P > 0.05$ ) difference in morphological traits such as plant height, leaf length, leaf width and panicle length of rice between other four treatments. Polythene mulch (25 microns, gauge) (T1) resulted in the highest mean number of filled grains in a panicle (589.33) thereby mean grain weight (133.3 g) and the lowest mean number of unfilled grains in a panicle (54.33). Weeds can successfully be controlled by using poly mulch (25 microns gauge) in rice fields and it causes to enhance rice yield. However, plant height and other morphological characteristics were not affected by the treatments.

*Keywords:* Broadcasting, Dibbling, Morphological Traits, Polythene mulch

### **Improving Phosphate Retention in Sandy Soil**

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Phosphorus (P) is one of the essential plant nutrient that is required for a sustainable crop production. The loss of P by leaching in sandy soil is an important issue. Nutrient retention capacity is important to maintain soil with high fertility. A column experiment was conducted in sandy soil to study the effect of gypsum and cow dung on the movement of phosphate in infiltrated water. Eighteen undisturbed soil columns (PVC tubes) with the dimension of 30 cm height and 5.4 cm diameter were hand excavated from the experimental site. All treatments and control were incubated with triple super phosphate (TSP) at the rate of 100 kg ha<sup>-1</sup> for two weeks. Cow dung and gypsum was chosen as amendments, cow dung was applied at the rate of 10 tons ha<sup>-1</sup> and gypsum was applied at the rate of 5 tons ha<sup>-1</sup>. The treatments were (1) control, (2) sole gypsum, (3) sole cow dung, (4) cow dung amended with 75% of the application rate of gypsum, (5) cow dung amended with 50% of the application rate of gypsum and (6) cow dung amended with 25% of the application rate of gypsum. Treatments were arranged in a Completely Randomized Design (CRD). Four leachate fractions were collected by applying four pore volumes of water at two weeks interval. Leachate was analyzed for available phosphate by UV/VIS spectrophotometer. At the end of experiment soil sample was extracted by Borax solution and P was determined by vanadomolybdate blue method using UV/VIS Spectrophotometer. Results showed that combine treatments reduced the P leaching and greatly improved phosphate retention in sandy soil. Minimum amount of leaching was recorded for cow dung amended with 50% of the application rate of gypsum (5.481 mg L<sup>-1</sup>). Among the treatments cow dung + 75% gypsum retained high amount of phosphorous (52.59 mg kg<sup>-1</sup>) in soil. The overall conclusion of this study is that to reduce P transport, it is necessary to apply cow dung and gypsum to the sandy soil.

*Keywords:* Cow dung, Gypsum, Leaching, Phosphate

## **Biomass Energy Production in Northern Province, Sri Lanka**

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The study analyzed socioeconomic impact of biomass production in Northern Province Sri Lanka since it is a livelihood of the households . Biomass has the potential of reduction in greenhouse gas and net zero carbon (C) emissions. The primary data collected from 100 biomass producers by simple random sampling, in Vavuniya, Mullaitivu, Kilinochchi, Mannar and Jaffna of Northern Province in early 2016 were utilized. Multiple regression model used to find the effect of education level, family laboring, experience in paddy and biomass farming, number of livestock and biomass supply amount per month on biomass income. 64% producers were farmers. 50% contributed 10 to 20 hours week<sup>-1</sup> family laboring. 914% earned more than Rs. 10,000 annum<sup>-1</sup> by marketing biomass. Gliricidia (69%) and wood plants (16%) were the major bio mass sources than paddy husk, and dung and saw dust. Raised in paddy land (78%), home gardens (16%) and fences (6%). Mean market price of gliricidia, saw dust, wood timber, paddy Husk and animal dung were Rs. 2.37, 2.36, 2.21, 1.33 and 1.3 kg<sup>-1</sup>. Mean supply of above were 1152, 600, 842,816 and 1100 kg per month respectively. Economic benefits: income increased (61%) and used for child education, electricity and water charges, increased employment (64%) and community participation (53%). 38% felt no sustainable income. Environmental benefits: reduced fossil fuel usage (54%), climate change mitigation strategy (70%), renewable source of energy (67%) and soil erosion control (59%) among the responses. While 58% directly affected by deforestation during harvesting. 73% responded biomass fulfill the national requirement of energy. The model was significant at 5% level. Number of livestock and supply amount month<sup>-1</sup> were significant (p <0.05). While keeping all other factors constant in the model one-unit increase in livestock kept caused 397.14 units reduction in income. While all other constant, one-unit increase in biomass supply caused 30.20 units increase in income.

*Keywords:* Biomass energy sources, Economic benefits, Environmental benefits

### **Crown Gall Disease of Rose: Isolation, Characterization and Chemical Control**

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Crown gall disease is an economically important bacterial disease in rose. *Agrobacterium tumefaciens* is a soil-borne bacterium that causes the crown gall disease, by forming crown gall tumors on dicots and some monocots. This study was focused to isolate pathogen from crown gall infected rose plants and characterize the pathogen by biochemical and pathogenicity tests. In addition, effect of selected antibiotics and copper on the isolates was investigated. Two crown gall samples were collected and isolated separately as Isolate 1 (Neluwa) and Isolate 2 (Haputale) at Regional Agricultural Research and Development Center, Bandarawela, Sri Lanka. The isolates were selected based on their morphological characteristics after 48 h at 28 °C on Yeast Mannitol Agar (YMA) medium. The selected colonies were transferred to same medium for purification. Colonies of isolate 1 and isolate 2 were translucent, mucoid, white to cream colored, circular with entire edges. The optimum growth was between 25 °C and 27 °C. Potassium hydroxide (KOH) solubility test, mobility test and catalase production test were conducted to characterize the isolates. The isolates were gram negative, and positive for mobility, catalase. The pathogenic nature of the organism was confirmed by a bioassay on carrot disks. Green colour tumor formation was observed on carrot disks by isolate 2 after 24 days of incubation and tumors were not formed by isolate 1. Test of determining growth inhibition ability of antibiotics and copper on isolates was conducted using poison plate technique. The effects of four antibiotics (Neomycin Sulphate, Streptomycin, Rifampicin, and Ampicillin) and Copper (Cu) on isolate 2 were evaluated. Neomycine Sulphate indicated the highest inhibitive activity. Rifampicin indicated the lowest inhibitive activity. Copper at 6 g L<sup>-1</sup> indicated the highest inhibitive activity. Based on the results of biochemical tests and pathogenicity tests, the isolate 2 was confirmed as *Agrobacterium tumefaciens*.

**Keywords:** *Agrobacterium tumefaciens*, Antibiotics, Crown gall, Pathogenicity test, Rose

### **Use of Tea Waste as a Growing Medium for Mushroom Cultivation**

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Paddy straw and saw dust are the currently recommended medium for mushroom production in Sri Lanka and their scarcity have lead to consider other possible alternatives. Therefore, a study was conducted to determine the feasibility of using Tea Waste as a medium for mushroom production in Sri Lanka. The varieties of American Oyster and Makadura White were used for the experiment at the Regional Agricultural Institute, the Department of Agriculture, Makadura, Gonawila, Sri Lanka (North Western Province). There were seven treatment media Tea waste (T1), Paddy straw (T2), Saw dust (T3), Saw dust + Tea waste (T4), Saw dust + Paddy straw (T5), Tea waste + Paddy straw (T6) and Saw dust + Tea waste + Paddy straw (T7). Treatments were arranged in a Complete Randomized Design (CRD) with three replicates. Growth rate of mycelium and fresh weights of the yield were recorded. The .The results revealed that the Tea Waste alone treatment did not produce any yield in both tested varieties. The treatment, Saw dust + Tea waste (T4) reported the highest mycelium growth rate and fresh yield for Makadura White which is significantly ( $P < 0.05$ ) greater than those of other treatment media. The current recommended medium, Saw Dust (T3) showed the highest mycelium growth rate and fresh yield for American Oyster variety and the fresh yields of Saw Dust alone, Saw dust + Tea waste (T4) and Paddy straw + Tea waste (T6) are comparable. It is thus concluded that, Tea waste alone is not suitable as a medium for mushroom cultivation, but tea waste incorporated with saw dust or paddy straw is found to be suitable media for mushroom cultivation.

*Keywords:* Mycelium growth rate, Paddy straw, Saw dust, Tea waste



# **Water Science and Technology**





## Simple and Cost Effective Method to Remove Heavy Metals from Industrial Wastewater in Rubber Industry

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Wastewater from rubber processing factories may contain heavy metals (Cr, Hg, Cu and Zn) which can be accumulated in water sources. Biosorption is a novel method to remove heavy metals from aqueous solutions. Fish scales can be used as a good biosorbant owe to their complex three dimensional composite structure with collagen and hydroxyapatite with high porosity and crystalline structure. This study was carried out to find the feasibility of mullet (*Mugilidae spp.*) fish scales and to compare with activated carbon to be used as a biosorbant and to find a simple and cost effective method to remove heavy metals from synthetic and industrial wastewater from rubber factories. Heavy metal analysis was conducted using Atomic Absorption Spectrophotometer and 03 g of damaged 1-2 cm<sup>2</sup> size fish scales which were oven dried at 80 °C for 24 hrs were used as the optimum parameters for fish scales and 25 % (w/w) CaCl<sub>2</sub> treated coconut shell charcoal powder (oven dried at 100 °C for 30 minutes) were used as the optimum parameters of activated carbon. For analysis, 50 ml volume of samples were used and for the synthetic wastewater 100 ppm concentrated samples were used each from above mentioned elements. Industrial wastewater (pH = 7.44) was obtained from a local rubber glove factory. As with results with the industrial wastewater, heavy metal Cr absorbance of fish scale was high (93.92 %) compared to activated carbon (68.10 %). With the synthetic wastewater, heavy metal absorbance of fish scales were 99.74 ± 0.08 for Cd, 99.60 ± 0.06 for Cr, 98.79 ± 0.06 for Cu, 97.75 ± 0.41 for Pb and absorbance of activated carbon were < 95 for Cd, 99.16 ± 0.20 for Cr, 99.61±0.26 for Cu, 98.75 ± 0.12 for Pb. The research disclosed that there is a high potential to develop an efficient and cost effective biosorbant from mullet fish scales to remove heavy metals from industrial wastewater effluents of rubber processing factories.

**Keywords:** Activated carbon, Biosorption, Fish scale, Heavy metal

**Analysis of Water Quality Parameters in Reverse Osmosis Treated Water in Chronic Kidney Disease of Unknown Aetiology Affected Areas**

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Reverse Osmosis filtration has become a leading technology for drinking water treatment in chronic kidney disease of unknown aetiology affected areas in Sri Lanka since several studies conserved that high concentration of agrochemicals in drinking water can be the reason for this disease. Even though the necessity of post treatment for reverse osmosis filtration has been shown by many studies, majority in kidney disease prominent regions prefer to use reverse osmosis treated water without post treatment. But, there are no any research carried out in Sri Lanka to analyse water quality parameters in reverse osmosis treated water. The present work was devoted to study whether the reverse osmosis treated water satisfy the Sri Lankan standards for potable water, study whether reverse osmosis treatment reduces the essential mineral content from treated water and the effect of raw water quality on reverse osmosis filtration. Water samples were collected from Anuradapura, Vavuniya and Puttalam districts. pH, alkalinity, total dissolved solids, chloride, nitrate, sulphate, phosphate, fluoride, lead, iron, sodium, potassium, magnesium, calcium, hardness, cadmium, copper, zinc and arsenic were analysed. The analysis shows that the reverse osmosis treatment removes most of the quality parameters less than the standard maximum allowable limits for potable water. But, it also reduce pH, alkalinity, total dissolved solid, calcium, magnesium, hardness, fluoride, phosphate from drinking water even less than the standard minimum desirable levels which have been published by research to prevent health impacts due to long term usage of such water without mineral addition. For most of the water quality parameters there is a linear relationship between raw water quality and reverse osmosis treated water quality. Therefore, post treatment for reverse osmosis treated water based on the treated water quality parameters can be used to avoid the off taste problems and long-term health impacts.

*Keywords:* Reverse osmosis treatment, Chronic kidney disease of unknown aetiology, Drinking water, Post treatment, Reverse osmosis treated water

## Efficiency of Constructed Wetland in Treating Small Scale Reverse Osmosis Rejects

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Natural ecosystems like water and soil in developing countries are frequently exposed to potential hazardous due to contamination by human waste and industrial pollutants. Improper waste disposal due to lack of awareness on proper waste disposal techniques is one of the main contributing factors. This is particularly noted in small or rural scale water supply systems. Reverse osmosis have been used as a major treatment technology in small scale treatment plants to remove hardness in ground water in the chronic kidney disease vulnerable villages. However, treatment of reverse osmosis rejects (concentrated residue of reverse osmosis process) has not been implemented yet. The present study was carried out to test the efficiency of constructed wetlands in treating the reverse osmosis plant rejects of the pioneer reverse osmosis plant at Madukantha operated by National Water Supply and Drainage Board, Vavuniya. As the first step, a horizontal sub-surface flow constructed wetland model was created at a hydraulic retention time of 4 days with dimensions of 2m x 0.5m x 0.5m and using *Typha Latifolia* as vegetation. Then the applicability of constructed wetland for the treatment of the reverse osmosis rejects was evaluated by introducing reverse osmosis rejects to the model and examining the water quality in the influent and effluent to quantify the nutrient removal efficiency. Results showed that hardness, calcium, electric conductivity, fluoride, manganese, alkalinity, total dissolved solids, nitrates, phosphates and sulphates removal efficiencies were up to 31.2, 35.0, 38.1, 28.4, 25.4, 25.3, 38.1, 18.6, 12.9 and 19.4% respectively. Results indicate that the constructed wetland system is capable of nutrient removal. Removal efficiencies are increasing with the plant growth. As this type of constructed wetlands can be easily implemented in small scale, it is suitable as a cost-effective and ecofriendly treatment method to treat small scale reverse osmosis rejects.

**Keywords:** Reverse osmosis, Constructed wetlands, Chronic kidney Disease, Hardness

### **Adsorption of Crystal Violet Dye in Textile Wastewater Using Biochar Derived from Rice Husks**

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The textile industry is one of the largest industries in which various types of dyes are used. Dye contamination has become a serious environmental and social problem due to increasing harmful effects on natural ecosystems when they are discarded into wastewater. This study aimed to investigate the removal of Crystal Violet cationic dye in textile waste water using eco-friendly low cost biochar derived from rice husk and determination of the optimum operational parameters for the adsorption process. Biochar is produced via pyrolysis at temperatures of 700 °C for 3 h with a constant heating rate of 7 °C min<sup>-1</sup> in muffle furnace. In the batch adsorption studies, the optimum operational parameters such as dosage of adsorbent (0.5-5.0 g L<sup>-1</sup>), pH (3.0-9.0), contact time (5.0 min - 24.0 h) and initial dye concentration (5-150 mg L<sup>-1</sup>) were studied. The samples were agitated in linear shaker for 12 h at 110 rpm and centrifuged samples were analyzed in UV-Visible spectrophotometer at 590 nm wavelength. The FTIR analysis was carried out to identify the availability of functional groups. Adsorption was modeled using Freundlich, Langmuir and Hill Isotherm models. Maximum adsorption capacity of 8.44 mg g<sup>-1</sup> was result at 6.6 pH, 2 mg L<sup>-1</sup> optimum dosage, and 12 hours contact time at 27 °C temperature. The adsorption process is highly pH dependent. The best fitted model was Langmuir and thus the adsorption is mainly governed with physisorption. Therefore, rice husk biochar can be used as a sorbent to treat crystal violet cationic dye.

*Keywords:* Adsorption, Biochar, Crystal violet, Dye removal, Wastewater management

**Identification of Treatment Efficiency and Performance Evaluation of Selected Water Treatment Processes of Greater Kandy Water Treatment Plant**

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Water is the most important resource owing to the necessity of the wide consumption of water. Water quality has become a global concern due to the increasing population and the activities that has over exploit and polluted the water resources. Providing safe drinking water is a challenge and research on issues related to water quality and development of novel technologies for water purification should be priority areas to develop the country. Safe drinking water is a key requirement and an internationally accepted human right. This study aims to assess the water quality, identify the limitations and hazardous effects of Greater Kandy Water Treatment Plant (GKWTP) to study the performance analysis along with water quality testing and sociological analysis. The study was conducted by assessing the unit processes capability, operation and maintenance potential. Water quality parameters such as pH, turbidity, color, electrical conductivity, total suspended solid, hardness, alkalinity, chemical oxygen demand, nitrate, phosphate, ammonia and heavy metals were analyzed. Analytical procedures as described in the standard methods were implemented for chemical analysis of the samples. The results of the assessment found that some units didnt have the capability to satisfactorily treat water. The results obtained showed that most of the drinking water quality parameters were within the SLS 614: 2013 guidelines for drinking water while the nitrate values were increasing along the treatment process and ammonia value was beyond the permissible limits. The sociological analysis highlighted the factors limiting the performance of the treatment plant based on design, operational and maintenance and also the awareness of the respondents about their tasks. Finally, the root factors limiting the optimum performance were identified and improvement options and suggestions were proposed to modify the treatment process and upgrade management procedures.

*Keywords:* Performance analysis, Drinking water, Permissible limits, Sociological analysis

## **Synthesis and Characterization of Local Bone Charcoal and Their Application in Waste Water Purification**

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In recent years, the environmental pollution has increased with the improper management of solid and liquid wastes in many countries. Among the water pollutants, pollution with heavy metals has become one of the most serious environmental problems. Adsorption is one of the concepts used to remove heavy metals in waste water. Therefore, the present study was carried out for synthesis and characterization of local bone charcoals and find their application in waste water purification. Bone charcoals based on chicken and bovine bones were prepared by removing adhering meat manually and moisture at high temperature (600 °C) and characterized by several methods. The particle size and chemical composition of the prepared charcoals were obtained using digital particle size analyzer and X-ray fluorescence spectroscopy, respectively. In addition, the crystalline phases of different charcoals were determined using X-ray diffraction. The structure i.e. types of bonds and functionality was identified using FT-IR spectroscopy. The surface morphology was obtained using Scanning Electron Microscope (SEM). The results were compared with commercial active carbon. Water quality parameters in waste water including pH, dissolved oxygen (DO) level, biological oxygen demand (BOD), total dissolved solids (TDS) and chlorophyll contents and reduction in Pb content in synthetic waste water were determined after adding prepared charcoals and commercial active carbon to respective water samples. The results showed that chicken and bovine bone charcoals consist of oxygen, calcium, phosphorous, carbon, sodium, magnesium and aluminum and are mostly composed of hydroxyapatite, calcium phosphate and a small amount of carbon. Chicken and bovine bone charcoals showed similar adsorption capacity for Pb when compared with active carbon ( $P > 0.05$ ). DO, BOD and chlorophyll content of waste water are comparable, irrespective of the charcoal type added ( $P > 0.05$ ). However, pH and TDS content of bone charcoal added waste water are lower than those of active carbon added waste water ( $P < 0.05$ ). It can be concluded that local bone charcoal produced from chicken and bovine bones can replace commercial active carbon in waste water purification.

**Keywords:** Heavy metal, Adsorption, Hydroxyapatite, Bone charcoal, FT-IR spectroscopy

**Removal of Cu (II) Ions from Industrial Waste Water using low cost Biosorbent Prepared from Jackfruit (*Artocarpus heterophyllus*) Leaf Powder**

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The presence of heavy metals in industrial waste water has become a major concern of environmental pollution. In recent years, various technologies for heavy metal removal from industrial wastewater have been developed. In this regard, adsorption of heavy metals on solid surfaces has gained a growing interest. Activated carbon is widely used to adsorb heavy metal ions, but the high cost of activated carbon restricts its use in developing countries. As a result, the process of heavy metal removal by adsorption has diverted to the use of lower cost adsorbents. The main objective of this study is to investigate the efficiency of Cu (II) ion removal from wastewater by using jackfruit leaf powder (JLP) and chemically modified JLP. It is much suitable to use JLP as a biosorbent because of its abundant availability without any commercial value and the ability to be disposed after the use without need for expensive regeneration. Batch adsorption technique was utilized for the removal of Cu (II) ions in aqueous solution by JLP under different experimental conditions. The effect of various process parameters including biosorbent dose, contact time, pH, particle size and various initial copper concentration were investigated and optimized. Maximum sorption for copper was reached at pH 5. The efficiency of adsorbent for copper removal was 98.8% for dilute solutions at 1 g /50 ml<sup>-1</sup> adsorbent dose. Equilibrium data were successfully fitted to the Langmuir model. The maximum adsorption capacity onto JLP was found to be 48.85 mg / g<sup>-1</sup> for Cu. JLP was treated using HNO<sub>3</sub> acid to chemically modify its surface. The adsorption efficiencies of untreated JLP and HNO<sub>3</sub> treated JLP were compared. Treatment using HNO<sub>3</sub> has slightly increased the Cu ion removal efficiency of the adsorbent. The results confirm that untreated JLP is a promising biosorbent for the removal of Cu (II) due to its high efficiency, economic feasibility and simplicity of preparation.

**Keywords:** Industrial wastewater, Jackfruit leaf powder, Batch adsorption technique, Adsorption, Biosorbent.



## Adsorption of Lead (II) Ion by Chemically Modified Banana Stem Fibers

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Effluents with heavy metals have been a persistent environmental hazard associated with the rapid industrial development. Of the various metal ions that are detected in effluents lead (Pb) is prominent. This study investigates sorption of aqueous Pb(II) ion onto banana stem fibers modified with citric acid treatment. Adsorptive capacity was tested as a function of pH, contact time, initial metal ion concentration, adsorbent dosage and agitation speed and particle size. Adsorption was found to be prominent at an optimum pH of 4.5, with initial input concentration of 2 mg L<sup>-1</sup> where 99.5% of Pb(II) was adsorbed. Equilibrium was achieved in 90 minutes of contact time with an effective agitation speed of 180 rpm. The effective particle size and the adsorbent dosage were found to be below 63  $\mu$ m and 3 g respectively. Final Pb(II) ion concentration was measured by using Atomic Adsorption Spectrophotometer. Results of Fourier Transform Infrared Spectroscopy analysis show that banana stem fibers consist of functional groups such as hydroxyl and carboxylic groups which play a major role in the adsorption process. With citric acid modification the peak intensity slightly increased compared to that of unmodified banana stem fibers. Langmuir isotherm model fitted well with the results obtained with a R<sup>2</sup> value of 0.992 and q<sub>max</sub> of 20.12 mg g<sup>-1</sup> whereas Freundlich isotherm model was unable to describe the process satisfactorily. Desorption studies revealed that the regeneration capability of used banana stem fibers for the re-utilization was promising. The optimum desorption was approximately 85% in 90 minutes of contact time in 0.1 mol L<sup>-1</sup> hydrochloric acid. Overall results suggest that banana stem fibers modified with citric acid can be used as an effective low-cost, eco-friendly adsorbent for the removal of Pb(II) ions from aqueous solutions.

*Keywords:* Pb(II), Banana stem, Adsorption, Desorption, Isotherms

## **Identification of Algae Types, Counts and Their Effects on Purified Water Quality of Two Different Water Treatment Plants Situated in Wet and Dry Zone of Sri Lanka**

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Eutrophication due to the algal growth has caused adverse impact for water quality. This has become a barrier for the treatment process, causing issues including: disruption of floc settling, pH fluctuations etc. This study was to investigate the variation of algae types, counts and their effects on the purified water quality of Greater Kandy water treatment plant and Dambulla water treatment plant situated in wet and dry zone of Sri Lanka. The water quality parameters (nitrate, phosphate, pH and alkalinity) were measured using standard methods for drinking water and the algae count enumeration was done using Sedge wick rafter cell (Counting algae in mixed assemblages - Low-tech method). Samples were taken from treatment units of each treatment plant. The algae species such as *Melosira granulata*, and *Pediastrum simplex* were observed at the intake of the both water treatment plants. Species such as *Cocconeis scutellum*, *Cosmarium galeritum*, *Scenedesmus quadricauda* were observed only in the intake of Dambulla water treatment plant. Highest total algae count was observed in the intake of the Dambulla water treatment plant. Further, the relationship between algae count with the nitrate concentration has resulted in the increment of Filamentous type algae in several treatment units of Greater Kandy water treatment plant. However the impact from algae for the final water quality is negligible in Greater Kandy water treatment plant while algal removal efficiency is higher in the Dambulla water treatment plant. Obviously a significant fluctuation of nitrate concentration was observed due to the oxidation and reduction processes of nitrogen species due to treatment process. The study concluded that there was a variation of algae types, counts with zonal location while the growth of algae was mostly depending on the pH value, clarity of water, sunlight transmission and amount of nutrients.

**Keywords:** Eutrophication, Sedge wick rafter cell, enumeration, Filamentous type algae, Sun light transmission

**Acknowledgement :** Laboratory facilities provided by the National Water Supply and Drainage Board, Kandy are acknowledged

## **Investigation of Groundwater Contamination in Puthukkudiyiruppu Area in Mullaitivu District**

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Intense farming, unplanned waste disposal and erratic human settlement have significantly contributed to increased groundwater contamination. Types and sources of contamination are numerous and varied. Groundwater quality in many parts of Sri Lanka has been extensively studied. Consumption of groundwater with excessive concentration of fluoride, nitrate and heavy metals is becoming a crucial issue on human health. Dental fluorosis and Skeleton fluorosis are the major health impacts based on excessive amount of fluoride. However, the areas that experienced decades long civil conflict have not been adequately investigated. Hence this research focuses on investigating the groundwater quality in Puthukkudiyiruppu area in Mullaitivu District. Forty well water samples were collected from the study area where there is anticipated intense water pollution. Nitrate ion distribution in groundwater is mostly controlled by anthropogenic activities such as unplanned waste disposal and excessive fertilizer application. Toxic trace metals in water are expected due to agricultural chemicals as well as potential explosive residuals in the region. In addition there are natural causes like mineral dissolution. Electrical conductivity and pH of the samples were measured at the sampling point. Colorimetric method was used for the detection of fluoride concentrations. Ultra Violet spectrometer was used for the detection of nitrate concentration and Atomic Absorption Spectrophotometer was used for the detection of the heavy metals. Groundwater of the study area was found to be heavily polluted with cadmium, iron, fluoride and chromium. Calcium ion concentration exceeded Sri Lankan standards. The findings clearly indicate the abundance of fluoride in groundwater. Lead and nitrate concentrations were below Sri Lanka standards while electrical conductivity of 26.6% of the samples in the study area exceeded the standard value.

*Keywords:* Water contamination, Heavy metals, Fluoride, Dental fluorosis

## **Investigation of Water Quality Parameters in Selected Prevalence Areas of Chronic Kidney Disease due to Unknown Etiology (CKDu) in Anuradhapura District**

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Chronic Kidney Disease due to Unknown Etiology (CKDu) is a highly pronounced health issue in Anuradhapura District. Rising number of CKDu patients continue despite numerous research efforts to find its origin and remedial measures. Spatial distribution of patients shows that Anuradhapura District can be zoned into CKDu high prevalence, moderate prevalence, low prevalence and non-prevalence areas. This research investigates possible correlation between different physiochemical parameters of potable water with different CKDu prevalence areas. Colour, turbidity, electrical conductivity and pH were taken as physical parameters while chloride, total alkalinity, total dissolved solids, nitrate, sulfate, fluoride, total hardness, total iron and heavy metals such as chromium and lead were selected as chemical parameters. Sampling locations were selected from Medawachchiya, Talawa and Galnewa Divisional Secretariat Divisions (DSDs) representing high-, moderate- and low- CKDu prevalence areas, respectively. Nikaweratiya DSD of Kurunegala District was selected as the experiment control area. Socioeconomic, health and behavioral data were collected from the communities at each sampling location. It is shown that nitrate and hardness have a moderately positive correlation with CKDu prevalence. Hardness values of all the CKDu prevalence areas have exceeded the standard limit ( $250 \text{ mg L}^{-1}$ ) with a minimum of  $308 \text{ mg L}^{-1}$ . However, the nitrate concentration in water does not exceed maximum permissible level for drinking water. Higher fluoride concentration in water does not show any significant relationship with CKDu prevalence. Two CKDu clusters were identified in Medawachchiya DSD as Etaweeragollewa (Kongollewa) and Kumbukgollewa. About 60 CKDu patients have been reported from Etaweeragollewa CKDu cluster. Another CKDu cluster was identified in Talawa (Karagahawewa) DSD. Majority of the CKDu clusters reveal that common drinking water sources are used by the affected communities.

*Keywords:* Chronic kidney Disease due to unknown etiology, physiochemical parameters, prevalence level



# **Academic Presentations**



## **Use of Sri Lankan plant derived inulin-type fructans as prebiotic sources in food industry**

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Prebiotics have become promising candidate of functional foods, and well recognized to promote the gastrointestinal health and immune functions. The use of prebiotics along with probiotics (synbiotics) to improve gastrointestinal health has been in great interest of the scientists as well as food manufacturers.

Prebiotics are non-digestible carbohydrates that provide beneficial physiological effects to the host by selectively stimulating the growth or activity of favorable bacteria in the gut (Gibson and Roberfroid, 1995). Prebiotics can be described also as non digestible carbohydrates which resist digestion in human small intestine, thus reach the colon intact and subject to fermentation by microorganisms in the colon. These prebiotics have the ability to selectively stimulate the growth and activity of the beneficial bacteria in the colon. Thus give various beneficial health effects such as immunomodulation, reduced risk of intestinal infections, anti-constipation effect, improved dietary mineral absorption, reduced risk of cardiovascular disease and anti-carcinogenic effect (Roberfroid et al., 2010; Schaafsma and Salvin, 2015).

Inulin and fructooligosaccharides (together often known as inulin-type fructans) have been extensively studied and proven as prebiotics. Chemically, inulin-type fructans are linear polydisperse fructose polymers consisting mainly of  $\alpha$ -(2-1) fructosyl-fructose linkages (Roberfroid, 2007b). Molecules with degree of polymerization (DP) between 3 and 9 are referred to as fructooligosaccharides, and those with a DP between 10 and 65 are known as inulin (Kolida and Gibson, 2007). Humans do not possess enzymes to digest inulin-type fructans, thus they are passed onto colon without being digested. In the colon inulin-type fructans are fermented by colonic bacteria that possess  $\alpha$ -fructofuranosidase enzymes (Roberfroid et al., 2010). Therefore, both inulin and fructooligosaccharides illustrate the properties of prebiotics. Inulin-type fructans are naturally occurring in many food plants such as asparagus, chicory, jerusalem artichoke, globe artichoke, banana, wheat, and oats (Singh and Singh, 2010). However, most of these foods contain only small amounts of inulin, thus consumption of large portions of these foods are required to attain the levels of inulin at which prebiotic efficacy may occur (5-8 g/day) (Kolida and Gibson, 2007). Therefore, extracting inulin from plant sources and make it available as a functional food ingredient, which can be incorporated into more frequently consumed food products, has become a very important aspect (Gibson et al., 2010). Furthermore, in the last few decades inulin has become an attractive ingredient to the food industry due to its unique functional attributes as a viscosity modifier, sugar replacer, fat replacer, bulking agent and a fiber enhancer in food systems (Barclay et al., 2010; Nair et al., 2010).

At present, widely marketed commercial inulin is solely extracted from Chicory plant



(*Cichorium intybus*), which is not grown in tropical countries, including Sri Lanka. Currently, commercial inulin and fructooligosaccharides are manufactured mainly from Chicory roots, and produced at a large scale in Belgium, France and The Netherlands (Franck and Leenheer, 2002).

Sri Lanka imports inulin from European countries at a high cost to incorporate in to prebiotic foods, such as milk powder and dairy products. However, the use of inulin is limited in Sri Lankan food industry, due to the high cost of inulin ingredient, which upsurge the cost of production. Therefore, inulin derived from locally available plant sources, would be economical for the food industry and would increase the scopes of potential functional food products market in Sri Lanka.

## **Common Method Variance in Behavioral Research in Management**

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Most of the management theories used in applied industrial psychology are based on the premise where behavior is a function of individuals' attitudes, beliefs, and perceptions of the situations in which they find themselves. For practical reasons, tests intended to verify theories such as Vroom's (1964) Expectancy theory of motivation and Fishbein and Ajzen's (1975) theory of reasoned action often have cross-sectional rather than longitudinal designs. This means that the individuals' reports of their internal states or perceptions are collected at the same time as the reports of their past behavior relating to those internal states. Consequently, the possibility arises that method variance (MV) has inflated the observed correlations between these two types of variables artifactually. Common Method Variance (CMV) refers to the amount of spurious correlations shared among variables in a study due to the common method used in collecting data. While CMV can inflate or attenuate relationships, it is usually expected to cause inflation when the method variance components of the individual measures are more positively related than the underlying true relationships.

Further, one of the main sources of systematic measurement error is method variance that may arise from a variety of causes. These are common rater effect, item characteristic effect, item context effect and measurement context effect.

Apart from that when considering the remedies employed to control common method variance, the two primary ways to control method biases are through (a) the design of the study's procedures and/or (b) statistical controls. The key to controlling method variance through procedural remedies is to identify what the measures of the predictor and criterion variables have in common and then eliminate or minimize same through the design of the study. The connection between the predictor and criterion variable may come from (a) the respondent, (b) contextual cues present in the measurement environment or within the questionnaire itself, and/or (c) the specific wording and format of the questions.

Although the strength of method biases may vary across research contexts, a careful examination of the literature suggests that common method variance is often a problem and researchers need to do whatever they can do to control it. As scholars have discussed, this requires carefully assessing the research setting to identify the potential sources of bias and implementing both procedural and statistical methods of control.

## **Multi-dye coated electrodes for solid-state dye-sensitized solar cells**

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The estimated total world energy consumption was 3.89 10<sup>20</sup> Joules or equal to an average power consumption of 12.3 Terawatts, in 2013. Ninety-percent of energy consumption is fulfilled by fossil resources. Fossil resources will be completely depleted in one day. Therefore, searching new kind of energy resources is scientific hurdle. The entire earth receives solar irradiation of 164 Watts/meter<sup>2</sup> over a 24-hour day. If we were able to convert of this free, clean green energy into viable form of electricity, no energy crises in the world.

Dye sensitized solar cells are 3rd generation solar cells meeting both high efficiency and low-cost. In dye-sensitized solar cells, dyes absorb unique portion of visible light and finally converts into electricity. Several types of dyes and pigments have been employed to study sensitization process of this type of solar cells. The efficiency of the cell is governed by several physical parameters. An enhancement of efficiency of this type of solar cells could be expected by appropriate coupling of several dyes as a result of fully coverage of visible spectrum. A comparable study of multi-dye systems was carried compare to that of mono-dye systems.

Aggregates of dye molecules disperse excited energy gathered by dye molecules via quenching of dye molecules of these systems. Spreading appropriate organic molecules as spacers among the dye molecules could be minimized quenching in dye-sensitized solar cells. However, enhancement of efficiency of such systems is not significant due to decrement of number of dye molecules, in the system. The maximum light to electricity conversion efficiency of was achieved by coupling of Black dye with N719 solid-state dye-sensitized systems.



# **UWU Research Awards 2015**



## **UWU Research Awards - 2015**

### **Full Article/s Published in a Refereed Non-indexed Journal**

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2. Ms. H.A.S.L. Jayasinghe (1 paper; Department of Export Agriculture)
3. Dr. P.M. Sirimanne (1 paper; Department of Science and Technology)

### **Full Article/s Published in a Refereed Indexed Journal**

1. Dr. D.K.D.D. Jayasena (10 papers; Department of Animal Science)
2. Dr. H.M.S.K. Herath (3 papers; Department of Export Agriculture)
3. Dr. E.D.N.S. Abeyrathne (2 papers; Department of Animal Science)
4. Dr. P.B. Rathnaweera (2 papers; Department of Science and Technology)
5. Dr. D.C. Mudannayake (1 paper; Department of Animal Science)
6. Dr. W.A.J.P. Wijesinghe (1 paper; Department of Export Agriculture)
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3. Department of Science and Technology : Dr. P.M. Sirimanne

**Vice Chancellor's Award for the Most Outstanding Young  
Researcher of the Year**

Dr. D.K.D.D. Jayasena : Department of Animal Science

**Vice Chancellor's Award for the Most Outstanding Senior  
Researcher of the Year**

No qualified applicants for the year 2015