

IRSUWU 2018



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Ministry of Science, Technology and Research



2nd International Research Symposium

"Emerging Technologies for an Innovative Green Economy"

February 1–2, 2018

Uva Wellassa University
Badulla
Sri Lanka



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Acknowledgement

The 2nd International Research Symposium of Uva Wellassa University (IRSUWU 2018) that leaves behind a remarkable memory in the history of Uva Wellassa University would not have been a success without the contribution, devotion and wishes of a large number of personalities.

The Vice Chancellor, Director/Research Committee and the Organizing Committee pay sincere gratitude to Mr. Susil Premajayantha, Hon. Minister of Science, Technology and Research for gracing IRSUWU 2018 as the Chief Guest. The Ministry of Science, Technology and Research (MOSTR) collaborated as the co-organizer of IRSUWU 2018 with a colossal fund allocation. Contribution of MOSTR in organizing IRSUWU 2018 is gratefully acknowledged. The Guest of Honor Prof. Ajith De Alwis (COSTI-MOSTR), the three Keynote Speakers, Prof Grish Nath Jha (India), Prof L.C. De Silva (Brunei) and Prof. Shireen Assem (Egypt) are extended a special thank for their contribution and participation in this event.

All Chairpersons and Panel Members of the 12 Technical Sessions are appreciated and acknowledged for their expert inputs leading to thought-provoking discussions during the symposium.

The presenters and authors who have reviled new avenues explored under the IRSUWU 2018 Theme are gratefully acknowledged for staging persuading scientific deliberations.

To maintain the standards of the proceedings the Editorial Board and Reviewers devoted their invaluable time and effort in reviewing and editing abstracts meeting deadlines. Their dedication and unstinted cooperation are highly appreciated.

A special gratitude is paid to the sponsors, well-wishers and all others who assisted the IRSUWU 2018 financially when it was really needed.

Without the track coordinators and event coordinators and their assisting teams, this event would have been impossible. Their untiring efforts and dedication throughout the time are highly appreciated.

Last but not least, sincere thank goes to all academic, administrative and non-academic staff members of Uva Wellassa University as well as to all who took part in the IRSUWU 2018 extending their greetings.

IRSUWU 2018

Uva Wellassa University (UWU), which has engraved unique features in Sri Lankan higher education sector, leads the theme of value addition to national resource base. Taking the pride in producing well-rounded graduates to the nation, UWU has developed innovative solutions to bridge the gaps in the knowledge among undergraduates through research and technology, while contributing to the national economic development.

The 2nd International Research Symposium under the theme of “Emerging Technologies for an Innovative Green Economy” is the pinnacle event that encourages researchers to discuss, share and disseminate research findings where intellectualities actively engaged in keeping footprints in the journey of Sri Lanka’s sustainable development and regaining economic prosperity.

For IRSUWU 2018, six hundred and forty one (641) abstracts were received from local and international researchers including countries such as India and Korea. The abstracts underwent a thorough reviewing and editing process resulting in only 274 oral and 146 poster presentations, respectively under the following tracks.

- Animal Science and Crop Production Technology
- Aquaculture and Fisheries
- Biotechnology and Bioprocess Technology
- Computing and Information Sciences
- Economics and Statistics
- Entrepreneurship and Management
- Environmental Science
- Food Science and Technology
- Hospitality, Tourism and Event Management
- Humanities and Social Sciences
- Material and Mineral Sciences
- Mechanical Engineering and Mechatronics

Prof. Ajith De Alwis, Chairman, COSTI, Ministry of Science, Technology and Research has been invited as the Guest of Honour of the IRSUWU 2018 and will speak on “Nature-The Final Frontier”. Prof. Girish Nath Jha (India), Prof. L.C.De Silva (Brunei) and Prof. Shireen Assem (Egypt) are going to deliver keynote speeches on “Smart Homes, Internet of Things and Leading to Internet of Trees”, “India’s Diversity: Challenges for Big Linguistic Data and Language Informatics”, “Molecular Breeding and Genome Editing: Modern Opportunities for Food Security”, respectively in the inaugural session that will be chaired by Prof. Ajith de Alwis.

There will be 12 parallel technical sessions with both oral and poster presentation sessions after the inaugural session on the Day 1 till 5.30 pm. Technical sessions will be followed by the Cultural Show together with the Symposium Dinner. Technical sessions will continue till 12.00 pm on the Day 2 followed by the Workshop on “Market Your Research Output through IPR & Commercialization” by Dr. Thamara S. Dias, Additional Director, National Science Foundation, Sri Lanka and Dr. Manjula Sandirigama, Senior Lecture, Faculty of Engineering, University of Peradeniya.

The Closing Ceremony of IRSUWU 2018 will be held in the evening of February 2, 2018 where the best presenters from both oral and poster sessions in each track will be awarded. Also, Scientific Awards for the selected academic staff will be granted considering their contribution in research. Four academics of Uva Wellassa University representing each faculty will deliver talks on their resent research findings at the Closing Ceremony. This session will be chaired by the Vice Chancellor of Uva Wellassa University.

Chancellor's Message



I wish you all the success in this promising gathering of scholars and their futuristic thinking on the 2nd International Research Symposium 2018 (IRSUWU 2018) on “Emerging Technologies for an Innovative Green Economy”.

Ignorance leads towards darkness, while knowledge leads towards enlightenment. Knowing and sharing the knowledge enable the continuation of sustainable development of human journey toward the ultimate livelihood of the human existence.

The 2nd International Research Symposium 2018 (IRSUWU 2018) brings scholars together to share knowledge, the knowledge which enhances the pathways of the very existence of mankind.

The Causality is universal; understanding the truth behind lying causes and interconnected results would bring the conscience into consciousness. There will be no exclusions no matter what tangible or intangible, animate or inanimate, waves or particles, energies or matters, what so ever the form it represents through formation or transformation, subjective or objective, factual revelation of these compound relationships and their disclosure is research.

Standardization of research work is inevitable; Reliability and validity of any research work is crucial and it must be contextual time bound and ethical in all considerations. Researcher must acknowledge the existing literature recognizing the intellectual contributions genuinely. Systemic approach and methodological elaborations must be well-defined. Altogether, uncertainty has to be accepted in lowest arithmetic by statistical applications. These concealed hard-works should not be suppressed. They must be expressed in appropriate forums to make others enlightened.

The Symposium is the knowledge sharing platform of scholars. It is a remarkable event of academic endeavours.

Uva Wellassa University being the centre of excellence for value addition to national resource base an iconic academic institution among the university culture. I take this opportunity to express my bliss to the Vice Chancellor, Academic Staff, Non-academic staff, and the researchers in up bringing this academic forum.

Most Venerable

Bengamuwe Sri Dhammadinna Nayake Thero

Chancellor

Uva Wellassa University

Vice Chancellor's Message



It is a great honour and privilege for me to send my earnest greetings to the IRSUWU 2018, organized by the Uva Wellassa University (UWU).

International Research Conferences are great opportunities not only for researchers and scientists, but also for students, policy makers and other stakeholders as well. International Research Conferences provide a great opportunity to connect with the participants from different perspectives and views, learn from them and make new relationships. Research Conferences pave the way for scientific cooperation by meeting and connecting with researchers from different countries. Furthermore, presenting your research in a conference helps you in different ways. It presents your work to the scientific community and helps you to improve your work by getting feedback from the experts in your field.

I do believe that IRSUWU 2018 under the theme of “Emerging Technologies for an Innovative Green Economy” would provide a fruitful platform to share the research findings and exchange views for wider interaction among scholars from different countries. Of course, presenting the results of a research work is not a single day’s effort. It is an outcome of hard work at several stages, namely the problem identification, observation, experimentation and exploration, rigorous analysis and making recommendations. This exercise needs a considerable time, patience, courage and enthusiasm. I congratulate all the presenters, who will share their findings at IRSUWU 2018, and in turn, contribute for the creation of novel knowledge.

Finally, I wish to express my sincere gratitude to the Organizing Committee of and all the members of UWU Family for their untiring efforts to make the IRSUWU 2018 a success.

Dr. J.L. Ratnasekera
Vice Chancellor
Uva Wellassa University

Research Committee Chairman's Message



It is with great pleasure and pride I am forwarding this message on the occasion of the second International Research Symposium of Uva Wellassa University, IRSUWU 2018, which is held under the theme of "Emerging Technologies for an Innovative Green Economy".

Since the inception, Uva Wellassa University takes the responsibility of producing graduates who could make a significant contribution to the economic development of the country. Thus, the University provides entrepreneurial education together with other core subjects for all undergraduates in their respective curricula delivering the knowledge and skills requested by employers of the industry. The theme of the University - Value Addition to National Resources Base - has been put forward with the impression of making this contribution to the economy.

However, the theme of IRSUWU 2018 requests us to have a certain emphasis on environmental sustainability while doing economy-oriented research so that green to greener becomes a reality. In reaching to a green economy, reduction of environmental risks and ecological scarcities should be targeted aiming a sustainable development without degrading the environment. Therefore, I believe that the set theme of the IRSUWU 2018 has led the research community in particular within the University to bring forward with technological advancements and entrepreneurial developments being self-disciplined and to frontline green economy concepts as per the present demand of the world.

It can be expected that IRSUWU 2018 will provide a platform for graduating students and other scholars to present their valuable research findings and interact with experts in the sector, peers, and prospective stakeholders. Also, this will no doubt provide an opportunity to enhance the research culture within the University. More importantly, the research findings presented by research community of the University will witness at last the progress of last decade in Uva Wellassa University especially in research and related activities.

I take this opportunity to congratulate all organisers and the presenters of IRSUWU 2018 for their contribution to succeed this event.

Prof. (Dr.) H.M.S.K. Herath
Chairman/Research Committee
Uva Wellassa University of Sri Lanka

IRSUWU 2018 Coordinator's Message



In the present era of knowledge with its rapid pace of technological advancement, one cannot escape globalization, which now embraces all aspects of our lives. With the expectation of contributing to the country's technological development, Uva Wellassa University is proud to host its 2nd International Research Symposium under the theme of "**Emerging Technologies for an Innovative Green Economy**", which is to be held in February 1-2, 2018, at the university premises. The Emerging Technologies are for all disciplines and are

equally applicable to simple day-to-day life as to highly sophisticate industrial products and communication technologies. The objective of IRSUWU 2018 is to endow with a platform for researchers to discuss, share and disseminate research findings in this high forum of intellectuals actively engaged in keeping footprints in the journey for regaining Sri Lanka's economic prosperity.

I am personally honored as the coordinator, having persuaded an increasing number of researches and experts to submit their research articles to the IRSUWU 2108. The scientific committees completing a thorough and timely peer-review process, 423 presenters (275 oral presentations and 148 poster presentations) are expected to present their research findings in 18 sessions under 12 tracks, which will be exploited by the participants to create platform to exchange and discuss valuable scientific ideas to be developed later into more meaningful interactions.

The role of the symposium coordinator by no means is a simple task. This immense responsibility on me would have never been achieved without the talents, dedication and great support rendered by all the academics and non-academics together with the undergraduates of Uva Wellassa University. I would like to specially mention the proper guidance of Dr. J.L. Ratnasekera, the Vice Chancellor, Uva Wellassa University towards the organization of this huge event. The organizing committee, both event coordinators and track coordinators with their members have done a wonderful job in organizing this symposium, and I would like to thank them for their enormous support,

continuous interest as well as constructive suggestions to make this event a successful one. Reviewers deserve special thanks for reviewing abstracts and all editors who contributed immensely for bringing this publication out within a short period. I wish to sincerely thank all distinguished speakers who have helped in the preparation and organizing the conference from the start and they are here with us to see it through, despite being occupied with their other obligations. I also wish to extend my sincere gratitude to our co-partner Ministry of Science Technology and Research and all other sponsors for extending their generous supports to make this event success.

I wish the IRSUWU 2018 to be a great success and hope that you will find it fruitful with exciting new ideas for teaching and research in many areas and hope you have a pleasant and enjoyable time in Badulla in a salubrious environment.

Dr. K.W.S.N. Kumari
Coordinator/ IRSUWU 2018
Uva Wellassa University

Chief Guest's Message



I am indeed privileged to be the Chief Guest of one of the most significant annual events of Uva Wellassa University, the Annual Research Symposium. Uva Wellassa University has set novel trends in higher education by emphasizing technopreneurship. I am a firm believer in the pivotal role of science and technology and its power in leading Sri Lanka toward economic prosperity. The need to deploy emerging technologies and the innovative abilities of our scientists and researchers is an imperative today. Sri Lanka with its widening trade gap, falling export revenue, with the dismal performance in hi-tech exports can only be turned around with investing and ensuring innovation led economic growth. In this backdrop Uva Wellassa University has taken praiseworthy and timely measures to introduce more technology-oriented and market-driven courses. It is very encouraging to observe the outcomes of numerous research spread over a broad spectrum of disciplines are being discussed at this pinnacle event.

Our ministry with a stated programme on Innovating Sri Lanka has mobilized its entire research and development infrastructure along with strategic investment in this direction. Thus the ministry decided to take part in the 2nd International Research Symposium of Uva Wellassa University collaborating as the co-partner. I trust that this initiative of the ministry will be symbolic in its commitment toward a more practical coexistence with the academia while removing barriers for researchers to fulfill their tasks and realize aspirations. I send my warm greetings to IRSUWU 2018 and earnestly hope that it will be a remarkable success.

Susil Premajayantha
Minister of Science, Technology and Research
Democratic Socialist Republic of Sri Lanka

Speech of the Guest of Honour

Nature – The Final Frontier



We may have evolved with nature but as time passed and our human attitude turned into a more arrogant way towards conquering what we like, the desire for domination arose. To us Sri Lankans, respecting nature should not be an alien concept though today we may need to have major plans, special school programmes and investments to get people to understand the importance. It appears we too have shifted away towards the dominance effect via pursuing economic growth at any cost.

It was Rachael Carson, the US marine biologist, whose book 'Silent Spring' awoke the United States to perils of unbridled action with the use of chemical pesticides on the part of humans.

She was to point out that man is in a unique position in this world. Though it is important for man to have birds and butterflies for his survival, the necessity for us to be present is not important for the birds and butterflies. The way the world is turning around, they actually may prefer the most intelligent species, as we termed ourselves, to be absent!

Significant disparities

We know that the world is far from perfect. Yet we see significant disparities between communities and countries sharing this earthly patch.

It is interesting to note one of the recent findings published by the Institute of Development Studies, that two thirds of the world's poorest (1,275 billion people who earn less than US\$1.25 a day) live in five populous middle-income countries – India, China, Nigeria, Indonesia and Pakistan. While some may be rising up the ladder, this indicates more may be sinking down.

Today Sri Lanka too is getting richer in per capita terms, and has seen us getting reclassified. Watching the 'Arab Spring' unfolding across many countries on a TV screen may be a surreal experience, though the underlying causes should be important for all of us.

It is clear that the world may have been told to head in a sustainable direction, but the path taken appears to be anything but that. We still continue to hear the same classical set of economic indicators, while green reporting may be a CSR activity enacted with awards in mind. We should not allow the spectra of Gini-coefficient to haunt us.

Waves of successful innovations

Development as we see has come in as a result of series of industrial revolutions with some embedded innovations. Today perhaps more than any time in the world's history we can boast of our abilities – to go faster, to see further, to split atoms and to splice genes among so many.

Waves of successful innovations have brought us to this position, while some equally now appear to threaten the very existence. Hence today with the sustainable mindset, we may have to drive innovation differently. No longer can we afford to enjoy success via conquering the environment or reaching for resources in ever-increasing quantities. Today, nature may be our final frontier.

Biomimicry

For most of the time nature has been a source of innovation rather than inspiring innovation. With the mandate to live lightly, the time has come to understand from nature how we should plan our future growth.

The buzz word biomimicry is well-espoused by Janine Benyus. She speaks of making use nature as a model and as a mentor and finally nature as a measure. The latter is to make use of what is present in nature to measure one's own systems as what is present today in nature after all are results of 3.8 billion years of evolution.

Thus, nature knows what lasts and what does not and trying to outsmart such a learning process can be quite challenging. Hence, why not compare notes of what we design with what exists in nature?

To give a simple example, we try to use expensive solar cells produced at enormous material and energy costs while nature harness energy neatly within leafy matter.

Nature's catalyst of chlorophyll is far superior to our own platinum, which is limited and expensive. The question is, when can we develop a solar cell inspired by a leaf? There are many research groups searching for that answer today.

Cue from nature

Hence, innovation for a sustainable world may come from nature and signs are that this is already happening. Instead of dominating nature, respectful imitation is coming in and this may well turn out to be the smartest move that we can make today.

Photosynthesis is what renewable energy researchers want to emulate. Self assembly is the aim of nanotechnologists. Any nanotechnologist may openly state how important is to know the lotus effect of water repellence when water falls on to a lotus leaf. In the process the leaf is also kept clean.

Today many are attempting and working on creating the lotus effect in a multitude of ways on engineered surfaces and materials. Self sustaining ecosystems are what cyclical economies are trying to emulate. The word industrial ecology has thus become quite fashionable.

Termite towers have today inspired building designers. Check the Eastgate Centre building in Harare, Zimbabwe for an actual implementation. Termites have developed their living system to have a constant temperature condition while the values around the tower change dramatically.

To create uniformity in a normal building system, we spend enormous amounts of energy and effort and still the control systems are not perfect. Termites have humbled building engineers and that is one more example of biomimicry.

Worshipping nature

The message is that worshipping nature is taking place again – nature as a rich source of ideas. The interest of many has again come closer to the very environment that surrounds us.

Are we as Sri Lankans to again take these ideas from outside or should we be part of the process of innovation? As a country with one of the highest biodiversities in the world and many unknown wonders, how many pointers for sustainable innovation process may be lurking around us?

Up to now engineers may have ignored ecologists. No longer is this possible. What ecologists are unravelling is of utmost importance to the engineer in design. For this new innovation system to be beneficial to Sri Lanka, we must not separately study biology and mathematics.

Our system still pursues the concept of biology for medicine or bioscience fields and mathematics for engineering or physical science.

Students are forced to think of some supreme occupations, forgetting the value of any other. The radicals may turn to humanities or fashion design, but these numbers are not great. Aspiring naturalists are very much rarer.

Nature abhors vacuum and is equally quite dismissive with monocultures. Yet we do have student populations growing up with few key occupations in mind. There is no interaction and no cross fertilisation of ideas. This is a recipe for a sterile mindset, not understanding what surrounds you or what moves this world.

Even without biomimicry making an entry, this division has caused us many problems, though we have not really understood the damage. It is time for change in education and attitude if we are to benefit from this new frontier chase. The best of this scenario is the answers are around us. We just need to open our eyes with understanding to the natural world.

Prof. Ajith de Alwis
Project Director
Coordinating Secretariat for Science, Technology and
Innovation (COSTI)
Sri Lanka

Keynote Speech 1

Smart Homes – Energy Efficient and Safe Living with Ease Internet of Things (IoT) Leading to Internet of Trees (IoT)



In this talk a review of the state of the art of smart homes using sensor technologies and Internet of Things (IoT) will be presented. At first a look in to the research work related to smart homes from various viewpoints will be discussed. This includes looking from the view point of specific techniques such as smart homes that utilize computer vision based techniques, smart homes that utilize audio-based techniques and then smart homes that utilize multimodal techniques. Then I will look at it from the view point of specific applications of smart homes such as eldercare and childcare applications, energy efficiency applications and

then in the research directions of multimedia retrieval for ubiquitous environments. Using a survey we found out that some well-known smart home applications like video based security applications has seen the maturity in terms of new research directions while some topics like smart homes for energy efficiency and video summarization are gaining momentum. Finally I will present some of our recent attempts to apply IoT into connected forests leading to coining the phrase “IoT - Internet of Trees”.

Humans interact with the environment that surrounds them, in numerous ways. They perceive the environmental conditions and act, react or adjust accordingly. If the environment can be made to reciprocate this behavior and respond to human behavior, it can produce some useful outcomes. Such behavior can automate various tasks that humans have to perform manually, and also provide novel services and facilities. A smart home is a home- like environment that possesses ambient intelligence and automatic control, which allow it to respond to the behaviors of residents and provide them with various facilities.

The standard approach for building smart homes is to computerize them. A set of sensors gather different types of data, regarding the residents and utility consumption of the home. Computers or devices

with computing power (e.g.: micro-controllers) analyze these data to identify actions of residents or events. They then respond to these actions and events by controlling certain mechanisms that are built in to the home. A simple example for such smart behavior is turning the lights on when a person enters a room. However, more complicated tasks such as detecting if an elderly resident is alone and not feeling well are also desired.

Smart homes have been researched for nearly a couple of decades. The pioneering work in this area is the Smart Room implemented by the MIT Media Lab by Alex Pentland's group. Thereafter, several researches have investigated this topic with a wide range of prospective applications. At the current state, there are many types of smart homes with three major application categories.

The first category aims at providing services to the residents by detecting and recognizing their actions or by detecting their health conditions. Such smart homes act as information collection test beds to support the wellbeing of the residents of the home. These smart homes can be further divided into three types; smart homes that provide eldercare, smart homes that provide healthcare and smart homes that provide childcare.

The second category of smart homes aims at storing and retrieving of multi-media captured within the smart home, in different levels from photos to experiences. One might argue that the issue of privacy of such type of information collection, but it will be a matter of acceptance in to once lifestyle with time.

The third category is surveillance, where the data captured in the environment are processed to obtain information that can help to raise alarms, in order to protect the home and the residents from burglaries, theft and natural disasters like flood etc. A few researches attempted to combine these functions into one smart home.

Apart from the 3 types of smart homes we have discussed there is an emerging trend of a special type of smart homes which can help the occupants to reduce the energy consumption of the house by monitoring and controlling of the devices and rescheduling their operating time according to the energy demand and supply.

With recent advances in electronics and computing, sensing technologies and computing power; smart home controllers can be built in small size, low price and they can be energy efficient. However, providing the ambient intelligence that is required to make decisions for

smart behavior is still a challenging task. Human behavior at home is highly unstructured. Multiple sensory modalities are required to sense such behavior. Advance pattern recognition techniques are required to recognize the behavior of multiple residents. Privacy becomes an important issue once the systems store the data. Due to such challenges, smart room technologies at the current state are far from being matured.

In this talk I will present the state of the art of smart home technologies from several perspectives. The talk organizes the related researches as follows. Before going into specific application categories I will first look at different techniques used in smart homes namely; video based techniques, audio based techniques and multimodal techniques. Then I will outline video based techniques for human activity detection in smart environments followed by audio-based techniques. Subsequently I will investigate how to combine multiple sensory modalities to recognize actions and events that take place in a smart home. Thereafter I will look at specific applications of smart homes such as for eldercare and childcare followed by an investigation of smart home applications that make homes energy efficient.

Finally I will look into the research directions on Multimedia Retrieval for Ubiquitous Environments. A Ubiquitous Sensor Room is an environment that captures data from both wearable and ubiquitous sensors to retrieve video diaries related to experiences of each person in the room. A paper by Jaimes et al. (Jaimes, Omura et al. 2004) utilized graphical representations of important memory cues for interactive video retrieval from a ubiquitous environment. The Sensing Room is a ubiquitous sensing environment equipped with cameras, floor sensors and RFID sensors for long-term analysis of daily human behavior. Matsuoka et al. (Matsuoka and Fukushima 2004) attempted to understand and support daily activities in a house, using a single camera installed in each room and sensors attached to the floor, furniture and household appliances. In their paper de Silva et al. (de Silva, Yamasaki et al. 2008) presented their techniques for experience retrieval in a smart home. The smart home they have analysed was equipped with 19 cameras, 25 microphones and pressure-based sensors mounted on the house floor. Hierarchical clustering of pressure sensor data followed by video handover automatically created videos tracking residents as they walked to and from different rooms. Video summarization reduced these videos to sets of key frames, for faster

viewing. Sound source localization followed by supervised machine learning facilitated video indexing by audio events. In the talk I will explain this in more details.

In conclusion of the talk I will summarize the research work related to smart homes from various viewpoints including application of IoT in Internet of Trees (IoT) arena. In the future we can envisage that more and more computer power given to smart sensors researchers will make use of them in home area distributed sensor networks with IoT. Each sensor will either report in real time to the host or they will keep the information in the memory for offline processing. In order to address complex situations in smart rooms, multiple agents based intelligent and distributed software/hardware frameworks have been proposed recently. Some top software companies are building application specific software targeted for smart homes so that existing infrastructure can be upgraded with added intelligence and decision making support. In the future our homes will not be the same. A simple example is our mobile phones. About 10 years ago it was just a phone that can make calls. Now the number of functions it has is countless among the calling facility. This analogy can be easily applied to our homes. One day it will be a robot inside out. The house will look at us from many directions to protect us from potential dangers due to our forgetfulness or due to other physical disabilities. Then we will always have a friend to live in with us who will care for us and give advises and attend to routine work on behalf of us.

In the same note of using IoT in homes, use of IoT in the forests in the form of Internet of Trees (IoT) will give an added benefit to the living beings and plants in the jungle. Internet of Trees can help us to produce an equivalent of the “Facebook” in the jungle; a “Jungle-book”.

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Prof. Liyanage C. De Silva
Professor of Engineering
Dean, Faculty of Integrated Technologies
University of Brunei Darussalam
Brunei

Keynote Speech 2

India's diversity: challenges for Big Linguistic Data and Language Informatics



India is a linguistic continent with more than 1700 languages in 5 distinct families. Out of these only 22 are currently recognized as “scheduled” languages in the Indian constitution. As per unconfirmed reports, at least 37 new languages are waiting to be considered for the “scheduled” status. Besides these, India has heritage languages like Sanskrit, Pali, Prakrit and classical languages which have enormous heritage literature. The age of information technology and a fierce competition among languages, pose challenges for the Language Technology development efforts of the Government of India (GOI) and industry in terms of the enormity of tasks, diversity, lack of standards and deeper questions like linguistic community and ownership. The GOI has to also struggle with issues like major/minor languages, providing basic tools and localized content for governance, education, health etc in each of the languages. While the GOI with its various agencies and institutions is working hard to support languages, there are obvious bottlenecks typical of a government setup. The industry is now beginning to invest big bucks in the Indian language technology development which has tremendous potential considering the fact that English is still not used by more than 10% Indians.

From the language technology perspective, the earlier model of language processing which worked on grammar/lexicon based parsing/generation is no longer viable. The current dominant paradigm in AI based technology development is based on statistical machine learning models which require huge quantities of Structured Language Resources (SLRs) to train language models for tools development. However, the unavailability or un-usability of SLRs is slowing the progress of technology development in Indian languages. Since all of these require sustained resources and trained manpower, the government has to have its priorities and a well coordinated plan to achieve these critical goals.

The talk will address these issues and will focus on India's language diversity, Big data and language informatics tools, Structured Language Resources (SLRs) and standards, Opportunities and challenges in diverse India and Heritage computing - Sanskrit, Pali and Prakrit texts. Furthermore GOI initiatives and work done at JNU, Indian Language Corpora Initiative (ILCI) at Jawaharlal Nehru University (JNU) and Demo of tools and the ILCI platform developed at JNU will be presented.

Prof. Girish Nath Jha
Professor of Computational Linguistics
Director, International Collaboration
Jawaharlal Nehru University
New Delhi

Keynote Speech 3

Molecular Breeding and Genome Editing: Modern Opportunities for Food Security



With global population expected to exceed 9 billion by 2050, food security-producing enough food of sufficient quality and making it accessible and affordable for consumers around the world-is one of the most important policy objectives of our time (World Bank 2008). The United Nations estimates that global food demand will double by 2050 and the world will then need to feed 2.3 billion more people. These populations will be increasingly affluent and will demand more, different, and better food. Meeting this demand requires agricultural production to grow 60% by 2050 (Baulcombe 2010).

The improvement of Agricultural crops using traditional methods is very slow and at the same time there is limited arable land base around the world and increased health demands for human and animal.

Climate changes and global warming are great challenges facing the improvement of agricultural crops productivity worldwide.

The global challenge is how can agricultural production rise to meet the demands in a framework of equitable, environmentally, socially, and economically sustainable development while providing all required health and nutritional benefits?

Attaining greater yields requires selecting, developing and growing the most productive and durable crop varieties. At first, science contributed tools like the principles of Mendelian inheritance for trait selection and cross breeding. Such “conventional” breeding methods have led to significant increases in yield potential of crops, but they are limited by the intra-specific mating and the time it takes hybrid varieties to grow and exhibit the desired trait.

With evidence now emerging that yield gains of major cereals is slowing down, conventional breeding may not be able to deliver the genetic gains required to achieve higher yields and meet rising food demand.

With the advances in molecular biology, marker assisted selection (MAS), structural and functional genomics, bioinformatics, genetic

engineering and related fields, biotechnology offers new opportunities for improving agricultural crops quality and productivity.

The application of modern biotechnology to plant breeding is considered to be more efficient and quicker than conventional breeding techniques in the development of new improved crop varieties.

MAS is a variation of traditional plant breeding wherein DNA sequence differences are used to identify plant varieties that carry the desired traits. Using MAS, science can assist farmers in selecting a crop variety for their given needs prior to even growing the selected variety. It offers considerable cost savings compared to conventional selection methods.

Plant genetic engineering (GM technology) involves the introduction of an isolated gene into plant cells in such a manner that it is stably inherited through subsequent generations.

Genome-wide Selection (GWS), also called Genomic Selection (GS), is one of marker-assisted selection (MAS), in which dense SNP genotypes covering the entire genome are used to predict the genetic value of a trait or individual. It allows the breeder to identify desired genes of interest quickly, reliably and efficiently.

Genome editing is a novel genetic engineering approach in which DNA is inserted, removed or replaced at a precise location within the genome. genetically edited (GE) crops are considered non-GM and overcome the GM crops constraints.

Therefore, biotechnology-based tools allow the production of crops similar to those developed by conventional breeding; this makes them promising and extremely versatile for providing sustainable productive agriculture for better feeding of rapidly growing population in a changing climate.

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Contents

Animal and Crop Production Technology

Oral

The Effect of Wood Apple Bark Extract (<i>Limonia acidissima</i>) on Internal and Sensory Attributes of Chicken Eggs Stored under Room Temperature <i>S.V.A.P. Samaranayake, A.L.Y.H. Aruppala, H.M.J. Pitawala and E.D.N.S. Abeyrathne</i>	2
Evaluation of Test Cross Combinations to Identify the Potential Restorers and Maintainers for Hybrid Rice Production in Sri Lanka <i>R.P.D.H. Hemachandra, W.S.Priyantha, D.D. Witharane and D.M.N.D. Dassanayake</i>	3
Priming with Nitric Oxide Donor Sodium Nitroprusside Enhances Germination and Storage Life of Recalcitrant Rubber (<i>Hevea brasiliensis</i>) Seeds <i>N.M.C. Nayanakantha, K.A.U. Madushani, B. Karunaratna, P. Seneviratne and B.M.S.S. Panditharathna</i>	4
Evaluation of Physiochemical Changes in Raw Chicken Eggs Stored at Room Temperature <i>H.H.R. Pathirana, A.L.Y.H. Aruppala, H.M.J.C. Pitawala and E.D.N.S. Abeyrathne</i>	5
Effectiveness of the Approach Grafting Over the Other Vegetative Propagation Methods of Nutmeg (<i>Myristica fragrans Houtt.</i>) <i>A.A.C.H. Dharmasena, H.M.P.A. Subasinghe and P.I. Yapa</i>	6

DNA Based Analysis for Distribution of <i>Meloidogyne</i> Species in Selected Crop Plants in Different Geographical Locations in Sri Lanka <i>D. Paramalingam, G.H.C.M. Hettiarachchi and R.V.D.U.P. Rajapakse</i>	7
Effect of Major Socio-Economic Factors on Dairy Cattle Milk Production in Maho Veterinary Region in Kurunegala District <i>W.A.M.P.M. Dissanayake, J.M.D.R. Jayawardana, J.M.P. Jayasinghe, A.M. Samaraweera and D.A. Mapitiya</i>	8
Foliar Application of Seaweed Liquid Extracts on Growth Performance of <i>Glycine max</i> (L.) <i>B.W.L.W. Bandara, S. Sutharsan and S. Srikrisnah</i>	9
Effect of Coloured Cellophane Shading on Seed Germination, Plant Growth and Fruit Quality Characteristics of Tomato (<i>Solanum lycopersicum</i> L.) <i>D.H.D.M. Sugathapala P.K. Dissanayake and W.G.C. Wekumbura</i>	10
Evaluation of the Relationship between SPAD Reading and Biochemical Profile of Fresh Leaves of Selected Tea Cultivars (<i>Camellia sinensis</i> (L.) O. Kuntze) <i>K.G.B.A. Samarasinghe, H.A.S.L. Jayasinghe and A.G.A.W. Alakolanga</i>	11
Effect of Different Irrigation Levels on Flower Initiation and Some Yield Attributes of Black Pepper (<i>Piper nigrum</i> L.) <i>R.W.I.B. Priyadarshana, H.M.P.A. Subasinghe, H.M.S.K. Herath and S.R.W.M.C.J.K. Ranawana</i>	12
Comparison of DNA Isolation and Dominant and Co-dominant Molecular Markers to Reveal the Genetic Sex of <i>Gallus domesticus</i> (Domestic Chickens) <i>W.K.R. Nirmali, L. Warnakula, R. Cooray, N.S. Hapuarachchi and M. Magamage</i>	13
Effect of Storage Conditions on Seed Dormancy and Vigor of Newly Developed Rice Varieties <i>R.M.S.N. Rathnayaka, T.K. Illangakoon, P.E. Kaliyadasa and S.R.W.M.C.J.K. Ranawana</i>	14

Yield Response of Cowpea (<i>Vigna unguiculata</i> L. Walp) to Different Soil Compaction Levels <i>G. Thadshaini, S. Nishanthi and T. Geretharan</i>	15
Application of Gamma Irradiation as a Quarantine Treatment to Control Fruit Fly (<i>Bactrocera dorsalis</i>) Prevailing on Export Potential Mango Fruits in Sri Lanka <i>U.G.L.Madhushani, L.C.Hewage, A.N.R.Weerawansa and W.A.J.P.Wijesinghe</i>	16
Effect of Selected Plant Aqueous Extracts on Controlling of Brown Plant Hopper (<i>Nilaparvatalugens</i>), Paddy Bug (<i>Leptocorisaoatorius</i>) And Rice Leaf Folder (<i>Cnaphalocrocismedinialis</i>) <i>E.M.A.U. Ekanayake, S.R. Sarathchandhra, A.N.R. Weerawasnsa and P.E. Kaliyadasa</i>	17
Comparison of Two different Commercially Available Vitamin-Mineral Premixes in Broiler Diets on Growth Performance and Meat Quality of Broiler Chicken <i>W.M.S.S. Weerasinghe, K.G.U.I.P Gunawardana, S.P.M. Priyadarshana, S. Anand Kumar, P.G.J.C De Silva, N.M.N. Nambapanan and D.K.D.D. Jayasena</i>	18
Effect of Different Levels of a Commercially Available Acidifier on Growth Performance, Meat Quality and <i>Escherichia coli</i> Count in the Ileum of Broiler Chicken <i>K.G.U.I.P. Gunawardana, W.M.S.S. Weerasinghe, S.P.M. Priyadarshana, S. Anand Kumar, P.G.J.C. De Silva, N.M.N. Nambapanan and D.K.D.D. Jayasena</i>	19
Effect of Polybag Size on Growth and Physiological Attributes of Rubber (<i>Hevea brasiliensis</i>) Seedlings <i>N.D.K. Gayashan, N.M.C. Nayanakantha, P. Seneviratne, A.M.W.K. Senavirathna H.A.S.L. Jayasinghe and B.M.S.S. Panditharathna</i>	20
Effect of Deep Litter and Slatted Floor Systems on Broiler Breeder Performance of, Hatchability, Fertility and Exterior Quality of Eggs <i>K.A.D.H.Kasthuriarachchi, G.A.S.N.Gamlath and N.M.N.Nambapanan</i>	21

Status of Natural Parasitism of Rice Yellow Stem Borer, <i>Scirpophaga incertulas</i> in Bathalagoda Region, Sri Lanka <i>M.A.B.R.P. Bandaranayake, G.D.S.N. Chandrasena, A.N.R. Weerawansha and L.M.H.R. Alwis</i>	22
Effect of Phytase Supplementation on Growth Performance, Bone Mineralization, and Fecal Phosphorus Excretion in broilers fed Phosphorus Deficient Diet <i>S. Karthika, S. P. Macelline, S. S. Wikramasuriya, R. M. H. Tharangani, L. Ang, D. D. Jayasena and J. M. Heo</i>	23
Evaluation of Different Methods of Reducing Night Temperature in Seed Potato (<i>Solanum tuberosum</i> L.) Production in Simplified Nutrient Film Technique <i>H.L.K. Kanchana, J.M.D.D.E. Jayamanne, S.R. W.M.C.J.K. Ranawana and N.S. Withanage</i>	24
Evaluating the Effect of Selected Synthetic Chemicals on the Growth of <i>Pseudomonas spp.</i> in Nitrile Latex <i>M.D.T.K. Senarathne, E.A.S. Kumara, G. Chandrasena and P.D.P.M.D. Silva</i>	25
Effect of Organic and Conventional Management of Tea [<i>Camellia Sinensis</i> (L.)O. Kuntze] Cultivation on Soil Productivity and Crop Response of Tea on the Fifth Pruning Cycle <i>M.P.N.N. Vijayangani, K.M. Mohotti, H.A.S.L. Jayasingha and H.M.S.K. Herath</i>	26
Analysis of Pesticide Residues in Fruits and Vegetables exported to the European Union and determining the effect of Chlorine Treatment on Diazinon Residues <i>M.A.S. K. Mallikaarachchi, M.C. Magamage, K.G. Premathilake and A.N.R. Weerawansha</i>	27
Selection of Elite Hybrids of Rice Based on Combining Ability and Heterosis <i>G.K.S.N. Gajanayake, W.S. Priyantha and L.M.H.R. Alwis</i>	28

Field Evaluation of Different Coffee Cultivars (<i>Coffea sp.</i>) Against Infestation of Coffee Berry Borer (<i>Hypothenemus hampei Ferrari</i>) <i>M.A. Dishan, M.K.S.R.D. Samarasingha, A.N.R. Weerawansha and L.M.H.R. Alwis</i>	29
Development of Fumigation Protocol for Liquid Phosphine for the Control of Rice Weevil (<i>Sitophilus oryzae</i>) in Stored Milled Rice <i>K.A.T.L.S. Seelawansha, I.K. Warshamana, L. Nugaliyadde, A.N.R. Weerawansha and H.M.S.K. Herath</i>	30
Assessment of Avocado as a Potential Alternative Host Plant for <i>Colletotrichum gloeosporioides</i> Causing Nutmeg Leaf Fall Disease <i>P.S.A. Rupasinghe, W.M.R.W.B. Wijekoon, G. Chandrasena and P.D.P.M.D. Silva</i>	31
Effect of Propagator Height on Growth and Survival Rate of Black Pepper (<i>Piper nigrum L.</i>) at Nursery Stage <i>K.I.M. Wijerathne, P.G.A.L. Kumara, S.R.W.M.C.J.K. Ranawana and H.A.S.L. Jayasinghe</i>	32
Comparison of High Performing Seedlings and Vegetatively Propagated Tea Cultivars in Selected Tea Estates in Badulla. <i>M.M.N.T. Bandara and L.M.H.R. Alwis</i>	33
Investigating the Association between Vesicular Arbuscular Mycorrhiza (VAM) and <i>Commelina benghalensis</i> <i>H.M.P.M. Gunasena, K.G. Premathilake and A. Balasooriya</i>	34
Poster	
Effects of Moisture Stress on Selected Biochemical Parameters and Yield of Three Tomato (<i>Solanum lycopersicum Mill.</i>) Cultivars during the Flowering Stage <i>M.S.K. Beham, S. Mahendran and S. Puvanitha</i>	35
Assessment of Environmental Impact of Selected Herbicides Used in Rice Farming in Sri Lanka <i>R.M.U.S. Bandara, H.M.M.K.K.H. Dissanayaka, Y.M.S.H.I.U. De Silva, D.M.C.B. Dissanayake and D.D. Witharana</i>	36

Effects of Selected Growth Regulators and Botanical Extracts on the Growth and Flowering of Anthurium (<i>Anthurium andeanum</i> L.) <i>S. Srikrishnah and S. Sutharsan</i>	37
Induction of Mycorrhizal Associations in <i>Piper nigrum</i> L. <i>W.A.G.A.B. Chandrasena, C.M. Nanayakkara and T.E. Weerawardena</i> 38	
Pesticide-Related Risks Associated with the Crop Management Practices Performed by Small-Scale Tomato Growers in Mid Country, Sri Lanka <i>V.N.D. Bulathsinhalage, D.M. De Costa and P.W.Y. Lakshani</i>	39
Determination of Differences in Heat Tolerance of Exotic Coconut (<i>Cocos nucifera</i> L.) Cultivars by <i>In vitro</i> Pollen Germination <i>K.P.I. Madushani, A.D. Nainanayake and L.P. Vidhana Arachchi</i>	40
Effects of Different Population Densities on the Growth and Yield of Maize (<i>Zea mays</i> L.) var. ‘Bhadra’ in the Batticaloa District of Sri Lanka <i>M. Rameskaran and S. Srikrishnah</i>	41
Identification of Factors Affecting Milk Production of Dairy Cattle at Galenbindunuwewa Veterinary Region in Anuradhapura District <i>N.L.K. Ilangasingha, J.M.P. Jayasinghe, J.M.D.R. Jayawardana and W.A. Nihal Wedasingha</i>	42
Effect of Graded Shade Levels on the Growth and Quality of <i>Polyscias guilfoylei</i> ‘variegata’ in the Batticaloa District of Sri Lanka <i>S. Srikrishnah, S. Sutharsan, K. Narmhikaa and J. Mayoory</i>	43
Effects of Different Levels of Dietary Vitamin Premix (ENHALOR) in Diets on Growth Performance and Meat Quality of Broiler Chicken <i>S.P.M. Priyadarshana, W.M.S.S. Weerasinghe, K.G.U.I.P. Gunawardana, S.P. Macelline, S. Anand Kumar, Li Ang, N.M.N. Nambapana and D.K.D.D. Jayasena</i>	44
Evaluation of the Quality of Cinnamon Quills (<i>Cinnamomum zeylanicum</i> Blume) after Primary Processing in Matara District: A Case Study <i>W.G.M. Dilani, A.A. Wijeweera, H.A.S.L. Jayasinghe and P.W. Jeewanthi</i>	45

Use of Lried Caged Layer Litter for Replacing Molasses in Total Mixed Rations (TMR) for Dairy Cattle <i>A.G.M.Kalhara, J.M.P Jayasinghe and Shaman De Silva</i>	46
Evaluation of Refused Tea as an Alternative Medium for Coir Dust in Potting Mixtures using Hot Pepper (<i>Capsicum chinense</i> Jacq) <i>D.D.I.D. Mihindukula, K.N. Kannangara and H.M.S.K. Herath</i>	47
Survey on Consumer Behavior and Egg Quality Parameters in Badulla District among the Consumers Age between 15-44 years <i>W.M.S.K.B. Weerakoon, J.M.D.R. Jayawardana and E.D.N.S. Abeyrathne</i>	48
Analysis of Chemical Composition and Oil Yield of <i>Cymbopogon nardus</i> and <i>Cymbopogon winterianus</i> in Thanamalwila Area <i>T.G.K.M. Gamage, H.A.E.N. Ariyasinghe and A.G.A.W. Alakolanga</i>	49
Detection of Fungal Contaminations in Export Coir Consignments <i>W.H.T.P. Weerapura, M.H.A.D Subhashini, G. Chandrasena and P.D.P.M. De Silva</i>	50
Effect of Vitamin E and Selenium Supplementation on Hatchability, Fertility and Performance of Broiler Breeders <i>P.N.N.Kumari, N.M.N.Nambapana and N.Amunugama</i>	51
Effect of different levels of Stocking Density and Dietary Sodium Bicarbonate (NaHCO ₃) on Performance, Meat Quality and Organ Weights of Broiler Chicken <i>P.N. Benjamin, N.M.N. Nambapana, S.P. Macelline and Li Ang</i>	52
A Study on Health Management Practices in Free Range Chicken Farming in Batticaloa District <i>A.S.M.Imras and M.S. Kurukulasuriya</i>	53
Effect of Eco-friendly Growth Media on Survival Percentage of Tea [<i>Camellia sinensis</i> (L.) O. Kuntze] to Mitigate Short Term Drought at Nursery Level <i>K.L.A.Y.D. Bandara, S.N Bandara, N.S. Withanage and H.A.S.L. Jayasingha</i>	54

Effect of Rainfall Changes on Tea Yield Using Standardized Precipitation Index in Badulla <i>T. Kiruththika, P.W. Jeewanthi and L.M.H.R. Alwis</i>	55
Statistical Analysis of Determinants of Black Tea Quality <i>S.Tharaga, K.W.S.N. Kumari and D.D.C. Wanniarachchi</i>	56
 Aquaculture and Fisheries	
 Oral	
Determination of Geographical Variations of Heavy Metals in Swordfish (<i>Xiphias gladius</i>) and Yellowfin Tuna (<i>Thunnus albacares</i>) <i>D.A.S.U. Digoarachchi and C.N. Walpita</i>	59
Comparative Analysis of Morphological Characters of Blue Swimming Crab, Portunus pelagicus (Linnaeus, 1758) Populations of Western and North-Western Regions in Sri Lanka <i>A.V.H.R. Disnika, J.D.M. Senevirathna, N.P.P. Liyanage and S.C. Jayamanne</i>	60
Comparison of Blue Swimming Crab, Portunus pelagicus (Linnaeus, 1758) populations from Batticaloa and Trincomalee areas in Sri Lanka using Morphometric Parameters <i>W.A.D. Soyza, J.D.M. Senevirathna, N.P.P. Liyanage and S.C. Jayamanne</i>	61
Effect of Four Formulated Diets on Colour Enhancement of Platy Fish, (<i>Xiphophorus maculatus</i>) <i>K. K. K. Premawansha1, A.C.W.W.M.C.L.K. Coswatte1 and N. P. P. Liyanage1, M. P. K. S. K. de Silva</i>	62
Identification of suitable hardening medium for micro-propagated <i>Lagenandra thwaitesii</i> species in the Tilapia based aquaponic system <i>J.A.R.A. Jayasinghe, A.C.W.W.M.C.L.K. Coswatte, J.D.M. Senavirathna and N.P.P. Liyanage</i>	63
Effect of Methyltestosterone Treated Feed on Growth and Gonadal Histology of Red Blonde Guppy Fish (<i>Poecilia reticulata</i>) <i>S.N.T.L. Sampath and M.P.K.S.K. De Silva</i>	64

Preliminary Study of the Elasmobranch Fishery in Valaichchenai, Sri Lanka <i>T.N. Dharmakeerthi¹, I.U. Wickramaratne, S.C. Jayamanne, D. Fernando, A.V. Tanna and R.M.K. Bown</i>	65
Determination of the Appropriate <i>Oryza sativa</i> (Rice) Straw Fertilizer Loading Level to Enhance Survival Rate of <i>Catla catla</i> (Catla) Post Larvae <i>M.A.D.U. Maddumaarachchi, K.M.D.M. Somarathna and N.P.P. Liyanage</i>	66
Effect of Raw <i>Spirulina platensis</i> Supplement on the Growth Performance of Guppy Fish - Red Blonde (<i>Poecilia reticulata</i>) <i>M.A.D.P.I Sarathchandra, A.S. Mahaliyana, A.C.W.W.M.C.L.K. Coswatte and S.C. Jayamanne</i>	67
Determination of Suitable Breeding Substrate for Redside Barb (<i>Puntius bimaculatus</i>) in Captive Conditions <i>G.K.Y. Wajiramala, A.S. Mahaliyana, W.P.R. Chandrarathna and S.C. Jayamanne</i>	68
Impact of Thermocline Variability on Yellowfin Tuna Catch Rates of Sri Lankan Long-Liners <i>S.M.B. Sinhakula, J. Rajapaksha, G.G.N. Thushari and K.P.G.K.P. Guruge</i>	69
Identification of Factors affecting to the Blue Swimming Crab (<i>Portunus pelagicus</i>) Harvest in Eastern Province, Sri Lanka <i>A.A.F.S. Infaas, N.P.P. Liyanage, I.U. Wickramaratne, J.M.D.R. Jayawardana and P.C.B. Dias</i>	70
Potential use of the skin of <i>Canthidermis maculata</i> (Bloch, 1786) as a value added product – A preliminary investigation for a cheaper and greener method <i>S.S. Williams and D.H.N. Munasinghe</i>	71
Growth Performance of Black Tiger Shrimp (<i>Penaeus monodon</i>) Based on Three Different Brood Stock Collecting Areas Handala, Beruwala and Mulathivu in Sri Lanka <i>E.M.H.Y. Ekanayake, J.A. Athula, A.M.D.N.S. Atapaththu and R.M.N.P.K. Ranathunga</i>	72

Poster

Preliminary study of Infectious Spleen and Kidney Necrosis Viral (ISKNV) disease in Asian sea bass (<i>Lates calcarifer</i>) using histopathological method in Sri Lanka <i>U.L.N.S. Ekanayake, M.N.M. Fouzi, R.R.M.K.K. Wijesundera, J.D.M. Senevirathna, M.S. Kurukulasuriya, W.R. Jayaweera, W.M.L.A. Wanasinghe and V. Sakajamary</i>	73
Freshness identification of marketable frigate tuna (<i>Auxis thazard</i>) using physical and chemical parameters under market storage conditions <i>T.K. Walpola, P.C.B. Dias, J.D.M. Senevirathna and N.P.P. Liyanage</i>	74
Study of Growth Performance of <i>Oreochromis niloticus</i> (Nile Tilapia) Fed by Formulated Diet Incorporated with Phytase Enzyme <i>B.R.M.P Bandara, P.M Withanage, A.C.W.W.M.C.L.K Coswatte and J.A Athula</i>	75
Breeding performance of <i>Pterophyllum scalare</i> (Angelfish) fed with enriched <i>Daphnia magna</i> <i>M.R. Mohamed Rashath, A.C.W.W.M.C.L.K. Coswatte, P.M. Withanage and N.P.P. Liyanage</i>	76
Study on impacts of shade and substrates on optimum growth of micropropagated <i>Cryptocoryne wendtii</i> . <i>M.T.R.V. Lakmali, A.C.W.W.M.C.L.K. Coswatte, V. Pahalawattaarachchi and S.C. Jayamanne</i>	77
Study on Effects of Substrates for Captive Breeding of Dankolapethiya (<i>Dawkinsia singhala</i>) <i>W.M.N.K. Walisundara, A.S. Mahaliyana, S.C. Jayamanne and W.P.R. Chandrarathna</i>	78
Fishery Independent Assessment of the Size on Maturity of the Palk Bay Blue Swimming Crab Fishery (<i>Portunus pelagicus</i>) in Jaffna District <i>M.Manivannan, A.P. Abeygunawardana, Steven Creech and S.C. Jayamanne</i>	79

Biotechnology and Bioprocess Technology

Oral

Antifungal Activity of <i>Bacillus amyloliquefaciens</i> Ethyl Acetate Extract and Fractions Against the Fungus <i>Khuskia oryzae</i> <i>G.P. Lohanathen, J.M.N.M. Jayasundara, P.B. Ratnaweera and E.D. de Silva</i>	82
Molecular mapping of leaf rust resistance in C14.16/Aus91433 RIL population <i>K. Pakeerathan, H.S. Bariana and U.K. Bansa</i>	83
Antibacterial Activities of Endophytic Fungi of <i>Cyperus iria</i> Collected from Matale District <i>J.M.N.M. Jayasundara, P.B. Ratnaweera and E.D. de Silva</i>	84
Control of <i>Colletotrichum gloeosporioides</i> L. Caused Anthracnose Using Isolated Yeast Species <i>R.A. W.U. Ranasinghe and M.M.S.N Prematilake</i>	85
Enhancement of Cellulolytic Activity through Biofilm Action for Bioethanol Production <i>M.G.L.W. Jayathilaka, A.P. Henagamage, C.M. Peries and G. Seneviratne</i>	86
Comparison of Antioxidant Activity of Hydrolysate Products of Crude Collagen Extracted from Chicken Egg Shell Membrane Using Different Methods <i>K.S.M. Dissanayake, A.L.Y.H. Aruppala and E.D.N.S. Abeyrathne</i>	87
Extraction of Crude Bone Collagen from Yellowfin Tuna (<i>Thunnus albacares</i>) and Determination of Anti-oxidative Activity of Its Hydrolysates <i>W.M.M.P. Wijekoon, A.L.Y.H. Aruppala, M.G.T.R. Kariyawasam and E.D.N.S Abeyrathne</i>	88
Biological Activities of Polysaccharides Extracted from <i>Vernonia cinerea</i> and <i>Vernonia zeylanica</i> <i>W.M.C.N.K. Wickramasinghe, A.P. Henagamage and A.G.A.W. Alakolanga</i>	89

Studies Towards the Isolation of Antibacterial Compounds from Endophytic Fungi of <i>Cyperus rotundus</i> <i>S.K. Fazeen, S.D. Herath, J.M.N.M. Jayasundera, P.B. Ratnaweera and E.D. de Silva</i>	90
Production of Biodiesel from Yellowfin Tuna (<i>Thunnus albacares</i>) Fish Skin Wastage <i>G.V. Amangilihewa, A.S. Mahaliyana, M.G.T.R. Kariyawasam, E.D.N.S. Abeyrathne and T.N.B. Etampawala</i>	91
Antioxidant and Metal Chelation Activities of Fish Protein Hydrolysates Produced from (<i>Scomber japonicus</i>) Pacific Mackerel Canned Fish Processing Fin Wastage <i>T.K. Ediriweera, A.L.Y.H. Aruppala and E.D.N.S. Abeyrathne</i>	92
Somatic Embryo Induction from in vitro Leaf Callus of Tea [Camellia sinensis (L.) O. Kuntze] Cultivars, 'TRI2024' and 'TRI2043' <i>S. Sukirtharuban, K.K. Ranaweera, M.A.B. Ranatunga and G. Thirukkumaran</i>	93
Phytochemical Screening and Antioxidant Activities of Selected Tropical Underutilized Fruits <i>R.P.D.D. Chathurangi, H.P.T. Wathsara, K.W. Samarakoon, P. Ranasinghe and P.K. Dissanayake</i>	94
Determination of Genetic Purity of the Yellow Dwarf Coconut Seedlings Rejected from Nurseries Using SSR Markers <i>W.L.H. Wijewickrama, M.K. Meegahakumbura, D.P.S.T.G. Attanayaka and L.M.H.R. Alwis</i>	95
Degradation of Cellulose and Pectin in Organic Wastes by Developed Fungal-Bacterial Biofilms <i>K.C. Wickramage, I.D. Singhalage and G. Seneviratne</i>	96
Poster	
Unexplored Plant Family (Violaceae) in Sri Lanka; Potential for Bioactive Cyclic Peptides <i>R. Sanjeevan, N.B.S. Deshani, S.D.W. Mohotti, S. Gunasekera and C.M. Hettiarachchi</i>	97

Antioxidant Activity of Selected Ten Underutilized Fruit Species <i>V.J. Dilani and I.D. Singhala</i>	98
Anti-oxidant Activities of Bioactive Compounds Extracted from <i>Pterygoplichthys pardalis</i> (Scavenger Fish) Harvested at Digana, Central Province, Sri Lanka <i>B.B.A.N.S. Perera, A.L.Y.H. Aruppala and E.D.N.S. Abeyrathne</i> . .	99
Antioxidant Activity of the Crude Extract of <i>Ulva lactuca</i> (Sea Lettuce) Collected from the South Coast of Sri Lanka <i>K.L.G. Rumeshani, A.L.Y.H. Aruppala and E.D.N.S. Abeyrathne</i> . .	100
Effects of Different Cooking Methods on Antioxidant Activity of Selected Underutilized Tuber Crops of Sri Lanka <i>P.P.M. Perera and K.B. Wijesekara</i>	101
Effect of Methanolic Extracts of <i>Emilia sonchifolia</i> (Lilac tassel flower), <i>Ageratum conyzoides</i> (Billy goat weed) and <i>Mikania micrantha</i> (Bitter vine) on Protease Enzyme Inhibition <i>M.N. Nisrina, A.G.A.W. Alakolanga, M.M.S.N. Premetilake and K.B. Wijesekara</i>	102
Detecting Mislabelling of Packaged Frozen Seafood Products in Sri Lanka: A DNA Barcoding Approach <i>A.G.D.M. Perera, A.A.D.G.U. Amarakoon, D.R. Herath, J.D.M. Senevirathna and N.P.P. Liyanage</i>	103
Protein Overexpression in Different <i>E. coli</i> Strains for Industrial Scale Drug Development in Sri Lanka <i>R. Cooray, N.S. Hapuarachchi and L. Warnakula</i>	104
Genome Analysis on Drought Resistance of <i>Hevea brasiliensis</i> <i>R.L.P.N.D.Rajapaksha, A.R. Weerasinghe, D.P.S.T.G. Attanayaka, C.R. Wijesinghe and L.M.H.R. Alwis</i>	105
Effect of Solvent Type and Extraction Time on Yield and Purity of Lotus (<i>Nelumbo nucifera</i>) Leaf Wax <i>H.K.A.E. Prasadika, N.P.P. Liyanage, H.M.J.C. Pitawala and J.D.M. Senevirathna</i>	106

Computing and Information Science

Oral

- An Accurate Multiple Sequence Alignment Algorithm for Biological Sequence Sets with High Length Variations
J.A.D.T.B. Jayasingha and C.T. Wannige 109
- Sixty Seconds Robot - An Effective Development Approach for Robot Programming
E.A.I.Priyanga, H.M.P.Praneeth Jayarathna, Buddhika P.De Silva and Sanjeewanie Senanayake 110
- Resource Creation for English-Maithili Machine Translation (EMMT) - A Divergence Perspective
Ritu Nidhi and Tanya Singh 111
- Optimizing Boyer Moore Algorithm using Parallel Processing Techniques
S.Y.D. Pathiranage, T.S. Ediriweera and D.R.V.L.B. Thambawita . 112
- Characterization of the Mechanical Behavior of Packaging Material Using Digital Image Processing
H.M.P.K. Herath, A.G.C. Karunaratne, R.L. Liyanage, T. Kartheeswaran, T. Etampawala and R.M.I.S. Ranasinghe 113
- Deeper Emotional Capture and Extraction of Discussion Pathways in Twitter Data
K.V. Epaliyana, K.N.A. Jayatissa, A.J.H. Liyanage and K.G.L. Sandeepa 114
- Vision Based Autonomous Micro Areal Vehicle with Graphic Processing Unit Acceleration
D.C. Basnayake, V.N.M. Rathnamalala, M.A.D.E. Manchanayaka, D.R.V.L.B. Thambawita and D.G.P.N. Madusanka 115
- Artificial Conversational Agent Based Tour Guide System
S.B.G.J.S. Bandara, J.M.K.H. Jayasundera, U.H.N. Udayanga, P.A.A. Illoshini and K.P.P.S. Pathirana 116

An E-Management Solution for the Sri Lankan Police Department to Improve the Efficiency of Service <i>A.D.C. Alahakoon, K.G.H. Abeywardhana, S.S.W. Karunaratna and S.H.D. Senanayake</i>	117
Location Based Exploratory Decision Support Approach for Midwifery and Grama Niladhari Divisions in Hunuwala-North: Ratnapura District, Sri Lanka <i>W.B.P.L. Wickramasinghe, K.L.G.A.M. Ariyaratna and S.T.C.I. Wimaladharma</i>	118
A Novel Method to Measure The Water Content of The Leaves Using Digital Image Processing <i>I.A. Wagachchi, R.D.K. Rassagala, B.B.D.S. Abeykoon, T. Kartheeswaran and D.P. Jayathunga</i>	119
Smart Dustbin with a Web Based Point Reward System for Waste Management <i>G.K.C.D. Maduranga, W.A.L. Gayanthika, A.I.S. Silva, S.D.H.S. Wickramarathne and R.M.I.S. Ranasinghe</i>	120
Digital Forensic Steganalysis of Encrypted Information with Special Reference to the MP4 Videos <i>S.L. Palliyage, N.D. Kankamange and H.M.S.N. Ariyadasa</i>	121
An Intelligent Postal Mail Sorter: Sinhala Hand Written Address Recognition Method Using Geometric Feature Extraction Technique and Artificial Neural Network <i>B.P.S.R. Sri Darshana, A.M.U.L. Attanayake, A.A.L.A.C. Perera and S.T.C.I. Wimaladharma</i>	122
Poster	
Online Event Organizing System for Cultural Programme <i>G. Shobika, Y. Yogaseelan and M. Ramanan</i>	123
Process re-engineering of Sri Lanka's Downstream petroleum industry stock planning operations. <i>J.G.J.W. Dharmaprema and W.V. Gunasekara</i>	124

Small and Medium Enterprises' Adoption of E-Commerce in Sri Lanka Case Study on Hospitality and Tourism Industry <i>T.M.L.T. Jayawardhana, J.S. Hettiarachchi, R.M.K.P. Rajapaksha, C.S.D. Ellepol and R.M.I.S. Ranasinghe</i>	125
Artificial Intelligent Base Virtual Learning Assistant <i>K. Vimalan, U. Banusharma and N.E.C. Jayasekera</i>	126
Recognition of Vowel Distribution for Sri Lankan Traditional Pirith Chants Using Formant Variation <i>M.A.C.P. Gunawardana and S.S.N. Gamage</i>	127
Analysing Critical Factors Associated with Perceived Risk for Major Types of Cancers in Sri Lanka – using Data Mining Techniques <i>M.L. Parakrama, K.A.K.D. Kodikara and S.H.D. Senanayake</i>	128
Dynamic Offloading Algorithm for Cyber Foraging <i>J.A.S. Wijeratna, K.M.C.M. Karunaratne, G.A.N. Priyadarshani and H.I. Nilwakka</i>	129
A Conceptual Framework for Flood Early-Warning System for the Lower Flood Plains of Kalu Ganga Using Twitter Crowd-sourcing and Internet of Things <i>T.B.B.M. Ranasingha, D.W.R. Chathuranga, K.M. Gunasekara and S.T.C.I. Wimaladharma</i>	130
Preliminary Study on ICT Applications in Agriculture to Enhance Information System using Mobile Crowdensing <i>R.S.I. Wilson, M.D.J.S. Goonetillake and A.I. Walisadeera</i>	131
A Personalized Content-Based Recommendation on Knowledge Level of Learner <i>Daminda Herath and Lakshman Jayaratne</i>	132

Economics and Statistics

Oral

Social cost of crime: a simple model of human interdependence <i>T. N. Herath</i>	135
Determination of Pesticide Usage and Its Environmental Impact Quotient in Vegetable Cultivation in Kalpitiya Divisional Secretariat Division of Puttalam District of Sri Lanka <i>K. Prasannath and M.F.F. Nasla</i>	136
Tendencies in Production, Imports and Per Capita Availability of Potato and Its Challenges in Sri Lanka <i>V. Prasannath</i>	137
Minimizing the Cutting Damages While Maximizing the Cutting Efficiency in the Apparel Industry <i>A.M.S.M.C.M. Aththanayake, S. B. Siyambalapitiya and A. Meegama</i>	138
Factors Affecting Adoption of Organic Farming: A Case of Pepper Farmers in Udadumbara DS Division of Kandy District <i>H.M.P. Madushani and S. H. P. Malkanthi</i>	139
Present Status of Rural Home Gardens and their Impacts on Rural Livelihoods: A Study on Balangoda DS Division <i>S.U. Pinnagoda and S.H.P.Malkanthi</i>	140
Integer Non-Linear Programming Technique to Solve Examination Timetable Scheduling <i>K.K.M.N. Prasanthika and W.B.Daundasekara</i>	141
An Application to Project Management to Minimize Fabric Printing Processing Time <i>H.A.T. Gunarathne and W.B. Daundesekara</i>	142
Modeling and Forecasting on Foreign Exchange Rates <i>J.K.H. Sampath and S.P. Abeysundara</i>	143
International Remittances and Household Expenditure Patterns in Sri Lanka <i>S. Niroshini, P.H.T. Kumara and G.H. Abeyweera</i>	144

An Implementation of Goal Programming Model to Analyze the Factors Affecting on Early Childhood Development; A Case Study <i>P.H.R.B.D. Kumarihamy, D.M. Samarathunga and J.S.K.C. Priyangika</i>	145
Strategic Asset Allocation for Central Bank's Reserve Management <i>A.K. De Silva, R.K Liyanaarachchi, L.R. Perera, W.S.S. Sankalpa, K.G. Weerakoon, S.M.N. Chathurangani and M.H. Warnasooriya</i>	146
Relationship between Foreign Direct Investment and Selected Macro Economic Variables in Sri Lanka – An Econometric Analysis <i>K.W.K Gimhani</i>	147
Household Level Impacts of Uma Oya Development Project <i>K.M.S Bandara, R.A.P.I.S Dharmadasa, H.M.S.K Herath and N.S Withanage</i>	148
Willingness of Consumers to 3 in 1 Instant Milk Tea Sachet Packets <i>D.H.I.S.Ranaweera, R.A.P.I.S.Dharmadasa, A.M.C.Amarakoon and U.D.S.Kulasiri</i>	149
Determinants of Manufacturer's Price of Silver Tips <i>E.M.C.P.K. Ekanayaka, R.A.P.I.S. Dharmadasa, A.M.C. Amarakoon and C. Dissanayaka</i>	150
Adoption of Machinery in Tea Cultivation and Management by Tea Small Holders in Kalutara District <i>U.M.Karunathilaka, R.A.P.I.S.Dharmadasa, K.G.Premathilaka and D.M.J.Nakandala</i>	151
The Impact of Migration and Remittances on Education of Children Left-behind: Evidence from Rural Sector of Sri Lanka <i>J.I.U.Jayalath , R.A.P.I.S.Dharmadasa, K.K.H.M.Rathnayake and H.M.T.R.Herath</i>	152
Determinants of Turnover Intention of Officers in Charge: A Case Study of Kurunegala Plantations Limited <i>M.M.B.S. Silva, S.M.M. Samarakoon and R.A.P.I.S. Dharmadasa</i>	153

Valuation of Glyphosate in Tea Sector of <i>Uva</i> Region in Sri Lanka <i>W.G.R.L. Samaraweera, P.M.M. Fernando, I.M.B. Sewwandi, L.G.T. Kariyawasam and H.T.A.B. Senarathna</i>	154
Site-specific Fertilizer Application in Paddy: Implementation Guidance for Policy Makers of Sri Lanka <i>H.S.N.L. Wimalaweera, V.D.N. Ayoni, B.C.H. Maduwawanthi and H.M.S.K. Herath</i>	155
Poster	
An Analysis of Factors Affecting on Tourism Receipts in Sri Lanka after the Liberalization of the Economy <i>G.S.P. Gunarathne, P.D.M.V. Perera</i>	156
Effectiveness of Purchasing Managers' Index as an Indicator of the Economic Growth in Sri Lanka <i>H.R.A.C. Thilanka</i>	157
Study on Farmers' Perception on Providing Cash Grant Instead of Fertilizer Subsidy in Paddy Cultivation: A Study in Badulla District <i>T. M. S. K. Thennakoon, S. H. P. Malkanthi and A. B. M. Wijayathunga</i>	158
Agricultural, Economical and Ecological Importance of <i>Phoenix pusilla</i> (Ceylon Date Palm) and Its Future Research Perspectives <i>N.S. Hapuarachchi, L. Warnakula, R. Cooray, D.A.R.K. Dayaratne and M.I.S. Safeena</i>	159
Variance-Covariance Method and the Historical method to Measure Value at Risk of a Portfolio: A Case Study on Sri Lanka Stock Exchange <i>D.D.P. Gallage and R.A.B. Abeygunawardana</i>	160
Impact of Socio-economic Status of Tea Smallholders on the Production of Tea Lands in Passara Tea Inspector (TI) Range <i>Y.M.S.K.B. Yapa, K.G. Premathilake, R.A.P.I.S. Dharmadasa and U. Thalagoda</i>	161

Entrepreneurship and Management

Oral

Systemic Challenges Faced by the Administrative Officers of the Higher Educational Institutions in Sri Lanka <i>R. Sharveswara</i>	164
Impact of Compensation Management Practices on the Performance of Small and Medium Enterprises in Western Province of Sri Lanka <i>M.A.U. Balasuriya and J. Sutha</i>	165
Assessing the Antecedents and Consequences of Work Life Imbalance (With Special Reference to Female Nurses in Government Hospitals) <i>K.H. Biyagamage and J. Sutha</i>	166
Study of Emotional Factors Influencing Professionals' Adoption to E-Payment in Sri Lanka <i>T.K.D.D.De Silva and J.Sutha</i>	167
The Effect of Ethnocentrism and Patriotism on Consumer Preference (Special Reference to Handloom Products in Sri Lanka) <i>Y.K.H.D. Costa, P.I.N.Fernando and U.A.S.Yapa</i>	168
Comparative Study on theEffect of Formal and Informal Mentoring on Job Involvement with Special Reference to Apparel Industry in Sri Lanka <i>H.P.L.P Pathirana and J.Sutha</i>	169
Factors Affecting to Success of Micro Enterprises (With Special Reference to Kandy District) <i>H.G.K.K Pitakotuwa, K.M.M.C.B Kulathunga and P.G.M.S.K Gamage</i>	170
Examining the Relationship between Organizational Culture and Employee Commitment of Government School Teachers in NorthWestern Province Sri Lanka <i>P.A.B.H Amarathunga and S. Pathirathna</i>	171
Motives and Characteristics of Social Entrepreneurship in Sri Lanka: A Case Study from the Handloom Industry <i>A.B.D.C Gunaratne, T.G.D.V Thudugala and M.S.S Karunarathna</i>	172

Determinants of the Profitability of Listed Finance Companies in Sri Lanka <i>H. W. O.N. Aluvihare and Y.M.C. Gunarathna</i>	173
A Study on the impact of Capital Structure on Financial Performance of Listed Companies in Sri Lanka - Evidence from Beverage Food and Tobacco Sector <i>P. A. R. M. Perera and Y. M. C. Gunarathne</i>	174
The Impact of Job Insecurity on Organizational Commitment (With special reference to International Non-Governmental Organizations [INGOs] in Northern Province of Sri Lanka) <i>K .Abilashini and J. Sutha</i>	175
Impact of Working Capital Management on Financial Performance of Diversified Holdings Companies in Sri Lanka: A Panel Data Analysis <i>L. Kengatharan</i>	176
Causes for Internal Audit Outsourcing in Sri Lanka, Evidence from Listed Companies in Colombo Stock Exchange <i>P.G Madamawickrama and Y.M.C Gunaratne</i>	177
Stories of the Educational Development Initiatives in the Government Schools in Sri Lanka <i>Dr. C. Kasturiarachchi and T.T.K.Kasturiarachchi</i>	178
Impact of Leader Member Exchange Relationship on Turnover Intention in the Apparel Industry (With Special Reference to Operational Level Employees in the Katunayaka Export Processing Zone) <i>E.M.C.D.Ekanayaka and J.Sutha</i>	179
Do Female Directors Improve Firm Performance in Sri Lanka? <i>P. Pratheepkanth</i>	180
The Inter correlation Between Organization Culture and Employee Effectiveness in Sri Lankan Public Sector Organizations <i>R.C. Ketipe Arachchi</i>	181

The Impact of CSR Practices Adopted By Commercial Banks in Sri Lanka on Customer Attraction and Customer Retention <i>M.R.L Upendra, J.Sutha and P.G.M.S.K Gamage</i>	182
Impact of Perceived Organizational Support on Employee Retention of Private Banking Sector in Sri Lanka <i>M.A.M.Sandaruwani and J.Sutha</i>	183
Impact of Vehicle Branding on Customer Purchasing Behaviour (Special Reference to Film Industry in Sri Lanka) <i>A.K.D.Chathurika and C.J.P.Kulathilaka</i>	184
An Empirical Study of the Impact of Brand Personality on Brand Commitment: Evidence from Sri Lankan Smartphone Market <i>A.G.P.M.Kumari and Y.M.C.Gunarathne</i>	185
A Study on Career Aspirations of Undergraduates in Sri Lanka <i>A.W.G. Madurangi, J. Sutha and P. Wachissara</i>	186
Impact of Green Supply Chain Management on Competitive Advantage of Business Organizations in Sri Lanka <i>A.R Sadurdeen and J. Sutha</i>	187
A Study on Impact of Job Stress on Employee Retention of Private Banking Sector in Sri Lanka <i>D.K.S.N.Senarathne and J. Sutha</i>	188
The Impact of Salesperson's Perceived Behaviour on Consumer's Purchase Decisions (with Reference to Apparel Retail Shops, in Sri Lanka) <i>L.P.D.R.Yapa and P.I.N.Fernando</i>	189
Impact of Human Capital Attributes on SMEs Success (With Reference to SMEs Owner Managers in Badulla Divisional Secretariat) <i>W.A.N.Lanka and K.M.M.C.B. Kulathunga</i>	190
Effect of Macroeconomic Variables on Profitability of Commercial Banks in Sri Lanka <i>L. Kengatharan</i>	191

Impact of Macro- Economic Factors on Banking Sector Development in Sri Lanka	
<i>F.S. Raffaideen and K.M.M.C.B. Kulathunga</i>	192
Impact of Firms' Adaptation of Eco-Friendly Product Innovations on Firm Performance (The Case of SMEs in Kurunegala District)	
<i>H.M.T.D. Bandara, S.F. Fasana and Y.M.C. Gunaratne</i>	193
Is Commitment a Sign of Leave or Remain? The Role of Educational Qualification of the Relationship between Employee Commitment and Turnover Intentions	
<i>N. Kengatharan</i>	194
Do Committed Employees Evince High Performers? Relationship between Commitment to Occupations and Organisations and Employee Performance	
<i>N. Kengatharan</i>	195
Impacts of Perceived Integrated Marketing Communication (IMC) Mix on Consumer Purchase Intention of Green Products (With Special Reference to FMCG Sector in Sri Lanka)	
<i>H.L.H. Perera, P.I.N. Fernando and S.F. Fasana</i>	196
The Impact of Organizational Learning Culture on Organizational Citizenship Behavior in Apparel Industry in Sri Lanka (With Special Reference to Gampaha District)	
<i>M.A.S.R. Manchanayaka, S.F. Fasana and K.M.M.C.B. Kulathunga</i>	197
Intellectual capital on Financial Performance: Sri Lankan Market	
<i>P. Pratheepkanth</i>	198
Impact of Fashion Involvement and Hedonic Consumption on Impulse Buying Tendency of Sri Lankan Apparel Consumers: The Moderating Effect of Age and Gender	
<i>V.K. Colombage and D.T. Rathnayake</i>	199
Motivational Factors that Induce Sri Lankan IT Undergraduate to Engage in E-Lancing	
<i>M.S.A. Perera, S.F. Fasana and J.Sutha</i>	200

Impact of Board Practices of Corporate Governance on Corporate Risk of the Companies Listed in Colombo Stock Exchange <i>T.K.G. Sameera</i>	201
Factors Influence to Select a Bank for Financing by Small and Medium Scale Enterprises: Evidence from North Central Province <i>A.A.D.P Bandara and D.D.K Sugathadasa</i>	202
Factors Influencing Telecommuters' Satisfaction: A Study of Telecommuting Practitioners in IT Industry, Sri Lanka <i>I.P. Kaluarachchi</i>	203
Impact of Micro Finance on Performance of Women Entrepreneurs in Sri Lanka: Evidence from Batticaloa District <i>S.Jeyan Suganya and R.Yogendarajah</i>	204
It's a Tough Nut to Crack: Consequences of Mutual Interference of Work and Family <i>N. Kengatharan</i>	205
Exploring Critical Project Management Resources in NGOs: An Empirical Study in Sri Lankan NGOs. <i>Y.Nanthagopan and N.LWilliams</i>	206
Poster	
Consumers Behavior and Its Impacts on Green Banking Practices in Banking in Sri Lanka <i>C. David and ALMA. Shameem</i>	207
A Study of Key Factors Affecting to Consumer Buying Behavior on Bottled Drinking Water (Special Reference to North Central Province in Sri Lanka) <i>D.M.N.H. Wijethunga and P.I.N. Fernando</i>	208
Identify the Customers' Purchase Intention towards the Sponsored Products (Special Reference to Reality Shows) <i>W.K.L.D. Jayasundara and P.I.N. Fernando</i>	209

Impact of Workplace Diversity on the Employees' Performance in Private Banks <i>Luckmizankari. P</i>	210
Impact of Social Network Advertising towards Consumer Purchase Intention (Special Reference to Apparel Products Advertising in Facebook) <i>K.H. Senanayaka, Dr. P.I.N. Fernando and P.G.M.S.K. Gamage</i>	211
Impact of Television Advertisements on Consumer Purchase Intention of Dairy Milk Powder (With Special Reference to Colombo District) <i>S.G.Nanayakkara and C.J.P.Kulathilaka</i>	212
A Study on the Factors Influence to Advertisement Avoidance in Social Media (with Special Reference to Female Professionals in Colombo District) <i>K.D.M. Priyadarshani, C.J.P. Kulathilaka</i>	213
Factors effecting job Satisfaction of the Private Bank Workforce in Gampaha District, Sri Lanka <i>A. Irosh, P.A.B.H Amarathunga and S. Pathirathna</i>	214
Likeable Attributes Of Beauty Product TV Advertisements Impact on Female Consumer Purchase Intention (With Special Reference to Kandy Area) <i>K.P.N.S. Parakramage and H.M.W.M. Herath</i>	215
Impact of Employees' Engagement in Sport Activities on Job Performance in Sri Lankan Business Organizations <i>W.L.R.I.A. Liyanaarachchi, J. Sutha and T.G.A.H.C. Amarawansha</i>	216
Intellectual Capital Disclosure: A Study of Australia and Sri Lanka <i>P. Pratheepkanth</i>	217
The Influence of Visual Merchandising on Consumer Buying Behaviour (With Special Reference to Stationery Sector in Colombo District) <i>W.H. Maduwanthi and C.J.P. Kulathilaka</i>	218
Consumers' Moral Response to the Company Response in a Product Harm Crisis: A Role of Gender <i>G.C. Samarakweera</i>	219

Influence of Tea Packing Design towards Consumer Buying Behavior <i>S.C. Senevirathne, R.A.P.I.S. Dharmadasa and A.M.C. Amarakoon</i>	220
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Environmental Studies

Oral

Assessing the Suitability of Groundwater for Drinking Purpose in Paddanichupuliyankulam, Veppankulam and Nelukkulam in Vavuniya Divisional Secretariat Division <i>K. V. M. Reva and N. P. Premachandra</i>	223
Effects of Rainfall on Plant Survival in Restored and Unrestored Pine Stands in Lower Hanthana, Sri Lanka <i>S.M.M. Lakmali, J. Jayawardhane, A.M.T.A. Gunaratne and L.S. Nawarathna</i>	224
Development of Electrochemical Method to Remove Nitrogenous Compounds from Prawn Industry Wastewater <i>K. Kirujika, S. Kreshaanth, C. A. Gunathilake, D. T. Udagedara and A. Manipura</i>	225
Ecosystem Carbon Sequestration of Different Land-uses of the Lowland Wet Zone: A Case Study from Waga Area, Kalutara District, Sri Lanka <i>K.A.J.M. Kuruppuarachchi, B.D. Madurapperuma and G. Seneviratne</i>	226
Investigation of the Effectiveness of Salt Barrage in Jaffna Peninsula (5 th Phase) <i>S. Sinthuparkavi, T. Udagedara and T. Gamachchige</i>	227
Assessment of Ground Water Salinity in Upparu Lagoon Area in Jaffna with Respect to Salt Water Intrusion <i>K. Thananjeyan, M.D.N.D. Perera, S. Wijethunga and S. Saravanan</i>	228
Conversion of Waste Polypropylene into Hydrocarbon Fuel – Analysis of the Effect of Set Temperature on Reaction Time and Liquid Yield <i>E.P. Rohan, B. Sumith and L.K.T. Srima</i>	229

General Characteristics of Wastewater and Effectiveness of Existing Treatment Methods in Hospitals with Special Reference to Uva Province <i>A.M.I.U. Kumara, Sansfica M. Young, T.H.N.G. Amaraweera and Y.M.S.S. Yapa</i>	230
Investigate The Suitability of Gold Fish (<i>Carassius auratus</i>) Effluent as a Nutrient Source in Recirculating Aquaponic Systems <i>A. Ahalya and A. Nanthakumaran</i>	231
Public Perception and Management Implications of Invasive Flora in Vavuniya District, Northern Sri Lanka <i>K. Arjunan and S. Umashuthan</i>	232
Comparative Life Cycle Analysis of Environmental Impact from Micro and Small Scale Cassava Chip Production Using Raw Cassava Roots <i>M.M.F. Minna, M.A.D. Somendrika and I. Wickramasinghe</i>	233
Efficiency Comparison of Three Types of Constructed Wetlands for Treating Reverse Osmosis Rejects <i>P. G. K. B. Ranathunga and N. P. Premachandra</i>	234
Socio-economic Risk Assessment of Soil Erosion Integrating GIS to Universal Soil Loss Equation; A Case Study from Nillambe Catchment, Kandy <i>E.N.C. Perera and D.T. Jayawardana</i>	235
A Comparative Study on Water Vapour Permeability of Surface Treated Paperboards with Keratin and Gammalu (<i>Pterocarpus marsupium</i>) Latex <i>H. M. I. A. Uduwerella, M. K. Ranasinghe and A. R. P. C. C. J. Amarasinghe</i>	236
Integrated Wastewater Treatment Using Water Hyacinth (<i>Eichhornia crassipes</i>) and Blue Swimming Crab (<i>Portunus pelagicus</i>) Shell Waste <i>U.S. Samarasinghe, G.G.N. Thushari, A.P. Abegunawardana, N.P.P Liyanage and H.M.J.C. Pitawala</i>	237

A Study on Toxicity Effect of Mancozeb Fungicide Residual on Zebrafish (<i>Danio rerio</i>) Embryo <i>W.C. Hiroshini, N.P.P. Liyanage, S.C. Jayamanne and D.P.N. De Silva</i>	238
Genetic Variation of Growth and Reproductive Parameters of <i>Jatropha curcas</i> in a Progeny Trial at Anapallama (IM2) in Sri Lanka <i>R.M.J.C. Rathnayake, K.M.A. Bandara and W.G.C. Wekumbura</i>	239
Removal of Excessive F ⁻ , Mg ²⁺ and Ca ²⁺ in Groundwater by Electrolysis <i>Jayawardena N.K.R.N, Amarasooriya A.A.G.D. and Weragoda S.K.</i>	240
Use of Laterite Soil as a Filter Material to Remove Copper from Aqueous Solution <i>S.Y. Mahagodage, D.T. Udagedara and D.T. Jayawardana</i>	241
Identifying Leachate Plumes Using Geophysical Methods: A Case Study from Open Municipal Solid Waste Dumpsite in Badulla <i>K.K.V. Dulmini, S.A. Samaranayake, S.N. De Silva, D.T. Udagedara, H.M.D.A.H. Bandara and K.V.G.S. Perera</i>	242
Identification of Near Surface Water Flow Path in Kanniya Hot Water Spring <i>Chathuranga H.D.N., Subasinghe N.D., Premachandra N.P., De Silva S.N., Samaranayake S.A. and Bandara H.M.D.A.H.</i>	243
Analysis of Slope Stability on Road Cut Slopes; a Case Study at BadullaBibile Road and a Cost-Effective Proposal for Future Road Cut Slope Studies <i>M.N.M. Rifkhan, P. Jayasinghe and W.A.P. Christopher</i>	244
Hardness Removal Using Graphite-based Nano Materials <i>K.A.M. Kularathne, R. Weerasooriya, A.R.Kumarasinghe and A.N.B. Attanayake</i>	245
Rhizosphere Microbial Activity of <i>Crotalaria retusa</i> L. Grown in Soil Contaminated with Used Lubricating Oil <i>S.S. Walakulu Gamage, K. Masakorala, M.T. Brown and S.M.K. Widana Gamage</i>	246

Assessment of the Plant Growth Performances of Vertical Green Walls Developed with Different Plant Types in a Tropical Climate <i>Perera T.A.N.T., Halwatura R.U., Jayasinghe G.Y. and Rupasinghe H.T.</i>	247
Seedling Composition and Relative Growth in Dieback-affected Tropical Montane Cloud Forest in Horton Plains National Park, Sri Lanka <i>Tithira Lakkana, Sisira Ediriweera, Anoma Perera and Mark Ashton</i>	248
Effect of Some Selected Plant Species in Ameliorating Indoor CO_2 Concentration <i>K.A.A.D. Madumali, R. Senaratne, G. Seneviratne, C. Lekamge and D.S.A. Wijesundara</i>	249
Baseline Survey of Sediments from Galle Harbor Basin <i>Jayasekara M. A. D. D., Asanthi H. B. and Kumara P. B. T. P.</i>	250
Quantitative Assessment of Microplastics in Surface Water of West Coast - off Colombo, Sri Lanka <i>A.M.G.A.D. Athawuda, H.B. Jayasiri, S.C. Jayamanne, W.R.W.M.A.P Weerakoon, K.P.G K.P. Guruge and G.G.N. Thushari</i>	251
Analyzing Seasonal Variation of Water Quality Parameters of Kelani River <i>N.P.K. Ranathissa, J.K.H. Sampath, A.N.B. Attanayake and H.A.K. Amarakoon</i>	252
Study on the Treating Ability of Palmyrah Seed Shell Based Activated Charcoal in Newly Designed Domestic Water Filter <i>R. Tharsan, N.S. Withanage, G. Abhiram and J. Mary</i>	253
Use of Spectral Signature Characteristics to Differentiate Mangrove Species <i>Wijesinghe L.V., Fonseka H.P.U., Marasinghe B.S. and Mohamed Rila A.R.</i>	254
Poster	

Spatial and Temporal Variation of Temperature Trends in Last Century of Sri Lanka <i>U.S. Meegahakotuwa and K.W.G. Rekha Nianthi</i>	255
Increased Reactive Oxygen Species Induced by Toxic Heavy Metals as an Initiator of CKDu <i>S.W.A.M. Upamalika and C.T. Wannige</i>	256
Physico-Chemical and Bacteriological Quality of Reverse Osmosis Water in Vavuniya District <i>N. Anoja</i>	257
Avifauna at Warathenna-Hakkinda Declared Environmental Protection Area (EPA) in Kandy, Sri Lanka <i>K.G.D.D. Thilakarathne, P.H.T. Lakkana, G.N. Hirimuthugoda and N.P.S. Kumburegama</i>	258
Spatial and Temporal Variation of Flood Affected People in Ratnapura District <i>H.M.I.E. Bandara, U.S. Meegahakotuwa and K.W.G. Rekha Nilanthi</i>	259
Environmental Risk Assessment of Water Basin in Capital City Area of Sri Lanka <i>H. M. P. C. K. Herath and R. Sanjeevan</i>	260
Thermal Ecology of an Endemic Sri Lankan Kangaroo Lizard (<i>Otocryptis wiegmanni</i>) under Wild and Captive Conditions <i>P.H.T. Lakkana, K.G.D.D. Thilakarathne, J.K.H. Sampath and M. Meegaskumbura</i>	261
Evaluation of Rain Drop Project Introduced for Chronic Kidney Disease Uncertain Etiology (CKDu) Patients in Ginnoruwa, Mahiyanganaya <i>N.C. Elladeniya, K.P.S. Madhushan, N. Nanayakkara, D.T.D.J. Abeysekara and K.W.G. Rekha Nianthi</i>	262
Rainfall Variations in Kandy District of Sri Lanka <i>U.S. Meegahakotuwa and K.W.G. Rekha Nianthi</i>	263

Study on Utility of <i>Crassostrea madrasensis</i> Oyster Shells for Water Quality Improvement: An Alternative for Wastewater Treatment <i>R.P. Senadeera, G.G.N. Thushari and A.P. Abeygunawardena . . .</i>	264
Geophysical Techniques and Geochemical Analysis for Identification of Potable Groundwater – A Case study from Morawewa Area <i>S. Arangajanan, S.N. De Silva, A.N.B. Attanayake and S.A. Samaranayake</i>	265
Assessment of Groundwater Contamination at Jaffna Municipal Council Solid Waste Dumping Site <i>V. Vysshnavi, W. M. D. S. K. Weerakoon and A.N.B. Attanayake .</i>	266
Geochemical Characteristics of Geothermal and Non-geothermal Water at Wahawa Field in Sri Lanka <i>M.M. Sajath, D.T. Udagedara and S.A. Samaranayaka</i>	267
Diurnal Behavioral Patterns and Substrate Use of Endemic Endangered Frog <i>Fejervarya greenii</i> in Horton Plains National Park (HPNP) <i>M.C. Prabhath, E.G.D.P. Jayasekara and W.A.D. Mahaupatha . .</i>	268
Fabrication of Supersand for Water Purification <i>R.S. Thennakoon, R. Weerasooriya, A.R.Kumarasinghe, A.N.B. Attanayake and H.M.T.S.Ritigala</i>	269
Relations of Municipal Solid Waste Generation and Composition to Socio-Economic Factors of Households <i>T. Abiramy and R. Thivyatharsan</i>	270
Optimization of Pre-Treatment Process of Iron Removal from Groundwater <i>M.D.R.M. Manathunge, S.K. Weragoda, W.M.D.S.K. Weerakoon and W.B.M.L.I. Weerasekara</i>	271
Identification of Perception and Adaptation to Climatic Change by the Tea (<i>camellia sinensis</i>) Small-holders in Rathnapura District <i>N. M. Weerasinghe, A. P. I. S. Dharmadasa, N. S. Withanage and A. Senaratne</i>	272

Degradation of Cellulose and Pectin in Organic Wastes by Selected Fungal Strains <i>H.M.C.R.K. Hennayake and I.D. Singhalage</i>	273
Development of Micro-Propagation Protocol for <i>Aponogeton dassanayakei</i> <i>H.D.B.K. Hettiarachchi, A.C.W.W.M.C.L.K. Coswatte, M.M.D.J. Senaratne, S.A. Krishnarajah and P.E. Kaliyadasa</i>	274
Germination Characteristics of Rhizomes of <i>Panicum maximum</i> in Coconut Plantations of Sri Lanka <i>A.M. Augustin, S.H.S. Senarathne, K.G. Premathilake and H.M.S.K. Herath</i>	275
Environmental Valuation of Dunhinda Falls <i>T.I. Manawadu and R.A.P.I.S. Dharmadasa</i>	276
Food Science and Technology	
Oral	
Identification of Possible Microbial Contamination Points and Sources in Commercial Tea Blending Process Factory in Kelaniya <i>T.R Liyanawickrmasinghe, E.K.G.P.U Dharmarathna, K.P.M Kahandage and E.D.N.S. Abeyrathne</i>	279
Variation of Antioxidant Activity of Traditional Rice Due to Gamma Irradiation <i>M.P.U. Kumara and E.M.R.K.B. Edirisinghe</i>	280
Evaluation of Anti-Bacterial Activity of Hydrolyzed Ovomucin Using Fish Pattie Produced from Tilapia (<i>Oreochromis mossambicus</i>) <i>A.L.Y.H Aruppala and E.D.N.S. Abeyrathne</i>	281
Antioxidant Property of Peptides Derived from Ovalbumin Using Protease Enzyme under Different Temperature and pH Conditions <i>M.A.A. Madushani, A.L.Y.H. Aruppala and E.D.N.S. Abeyrathne</i>	282

Comparison of Lipid Profile of Smoked Catla (<i>Catla Catla</i>) Made Under Different Combustion Conditions <i>A.H.T.N.D. Sumanathilaka, E.D.N.S. Abeyrathne and A.G.A.W. Alakolanga</i>	283
Utilization of Lycopene from Tomato (<i>Lycopersicon esculentum L.</i>) Peel as Natural Antioxidant and Colorant in Stirred Yoghurt <i>W.K. Meegahawaththa, D.C. Mudannayake and I.D. Singhalage</i>	284
Development of Reduced Fat, Inulin Incorporated Prebiotic Butter <i>M.P.I. Priyadarshani and D.C. Mudannayake</i>	285
Development of Garlic (<i>Allium sativum L.</i>) Incorporated Synbiotic Butter <i>J.M.N.H. Premerathne and D.C. Mudannayake</i>	286
Characterization of Potentially Industrial, Important Lactic Acid Bacteria (LAB) Isolated From Goat Milk <i>D.L.D.A.S. Premasiri, D.U. Rajawardana and D.C. Mudannayake</i>	287
Development and Assessment of Sensory, Physicochemical and Phytochemical Properties of a Soursop (<i>Annona muricata L.</i>) Jam <i>K.M.D.N. Rodrigo, C.R. Gunawardhana, P.W. Jeewanthi and W.A.J.P. Wijesinghe</i>	288
Evaluation of Combined Antimicrobial activity of Leaf Extracts of <i>Psidium guajava</i> and <i>Moringa oleifera</i> against <i>Staphylococcus aureus</i> <i>D.M.C.P. Daundasekara and M.M.S.N. Premetilake</i>	289
Effect of Starter Culture and Type of Milk on Textural and Functional Properties of Mozzarella Cheese <i>W.M.N.N. Walisinghe, D.C. Mudannayake, G.Y.G.S. Yatinuwara and M.W.C.D. Palliyeguru</i>	290
Application of Crude Extract of Gelatin from Tilapia (<i>Oreochromis mossambicus</i>) Skin as an Edible Coat for Tomatoes (<i>Solanum lycopersicum</i> var. <i>padma</i>) <i>H.P.M. Lakchani, M.K. Ranasinghe, E.D.N.S. Abeyrathne and U.D.P. Manjula</i>	291

Physico-chemical Characterization of Cookies Enriched with Sugarcane Bagasse Fibers <i>M.P.G. Vijerathna, Isuru Wijesekara, Indira Wickramasinghe, S.M.T.A. Maralanda and M.A. Jayasinghe</i>	292
Progressive Freeze Concentration of Fruit Juices and Yield Improvement by Partial Ice Melting <i>S. DineshKumar, M.P.G. Vanniarachchi and J.A.E.C. Jayawardena</i>	293
Effect of Gamma Irradiation on Histamine Content of Yellowfin Tuna (<i>Thunnus albacares</i>) Fish Muscle <i>I.H.W. Surendra, E.M.R.K.B. Edirisinghe and R.M.N.P. Rathnayake</i>	294
Development and Quality Evaluation of Ready to Drink Fruit Flavored Whey Beverage <i>K.H.I. Gimhani and A.L.J.C. Liyanage</i>	295
Effect of Storage Conditions to Minimize Contaminants before Packaging of Ceylon Cinnamon Quills (<i>Cinnamomum zelianicum Blume</i>) <i>N.D.G.A. Chinthaka, G.G. Jayasinghe, H.A.S.L. Jayasingha and G. Abhiram</i>	296
Effect of Cow Milk and Goat Milk on Growth and Survival of <i>Bifidobacterium animalis</i> in Presence of Bee Honey <i>S.K. Balasuriya and D.C. Mudannayake</i>	297
Impact of Seed Moisture Content on Yield, Antioxidant Activity and Free Fatty Acid Content of Sesame Oil <i>O.C. Abeysekara and R. Shanthini</i>	298
Effect of Coagulation Temperature on Yield, Chemical, Sensory and Textural Properties of Buffalo Milk Paneer <i>T. Dishiwarthani, D.C. Mudannayake, U.L.P. Mangalika and J.M.D.R. Jayawardana</i>	299
Effect of Dehydration Temperature on Quality of Virgin Coconut Oil <i>R.A. Nipunika, H.P.D.T. Hewapathirana, W.A.J.P. Wijesinghe and S.M.I.P.G. Bandara</i>	300
Poster	

A Study to Enhance the Shelf Life and Postharvest Quality of Tomato (<i>Solanum lycopersicum L.</i>) using Aloe Vera Herbal Coating <i>T. Mahendran and G. Hariharan</i>	301
Development and Quality Assessment of Cereal based Complementary Food Enriched with Germinated Green Gram and Carrot Flour <i>M. R. Roshana and T. Mahendran</i>	302
Study on Preparation of Composite Vegetable Squash of Tomato and Pumpkin <i>K .Premakumar, M.V.R.G Lakmali and S.M.A.C.U Senarathne</i> . .	303
Evaluation of Physiochemical Changes in Un-Boiled Eggs Stored at Different Temperatures <i>G.R.S.R. Eregama, A.L.Y.H. Aruppala, H.M.J. Pitawala and E.D.N.S. Abeyrathne</i>	304
Determination of the Organoleptic Properties of Hydrolyzed Ovalbumin Incorporated Dry Cured Ham <i>D.P.M.K. Gunasekara, A.L.Y.H. Aruppala and E.D.N.S. Abeyrathne</i>	305
Development of a Fruit Nectar Using Locally Available Willard Mango Variety. <i>S.G. Kothalawala and J.M.J.K. Jayasinghe</i>	306
Identification of the critical control points of a newly established commercial Spray Dried Milk Factory <i>L.R. Rajapaksha, A.L.Y.H. Aruppala and E.D.N.S. Abeyrathne</i>	307
Identification and Characterization of Acetic Acid Bacteria Isolated from Sri Lanka <i>M.A.A. Buddhika, P.A.B.N. Perumpuli and M.N. Kaumal</i>	308
Development of a Value Added Canned Fish Product Using Rough Trigger Fish (<i>Canthidermis maculatus</i>) <i>J.W.P.C. Jeewanthi, A.S. Mahaliyana, K.E. Udayathilaka and E.D.N.S. Abeyrathne</i>	309

Effect of Induced Ripening Agents on Physicochemical Properties of Ambul Banana (<i>Musa acuminata</i> , AAB)	310
<i>S.D.T. Maduwanthi and R.A.U.J. Marapana</i>	
Formulation of a Natural Flavor Enhancer Based on Glutamic Acid and Study of Sensory Properties	311
<i>K.N. Wijayasekara and J. Wansapala</i>	
Evaluation of Antioxidant Properties and Total Phenol Content of Bark Exudates of <i>Lannea Coromandelica</i> & <i>Mangifera Indica</i> and Its Application as a Functional Fruit Coating	312
<i>V.G.G. Chandrajith and R.A.U.J. Marapana</i>	
Effect of Stage of Maturity on Physicochemical Properties of Jackfruit (<i>Artocarpus heterophyllus</i> Lam.) Flesh	313
<i>R.A.S.N. Ranasinghe and R.A.U.J. Marapana</i>	
Physicochemical Characteristics of Peanut Butter Fruit (<i>Bunchosia armenica</i>) And Possible Application in Food Industry	314
<i>G.A.D.V. Karunasena, S.B. Nawarathne and V.G.G. Chandrajith</i>	
Assessment of Sensory Acceptability of Beetroot (<i>Beta vulgaris</i>) incorporated Buttermilk Wine during Storage	315
<i>W.M.M.H Thilakarathne, M.K Ranasinghe, B.M.P Priyadarshani and R.M.T Madushanka</i>	
Assessment of Physio-Chemical and Sensory Properties of a Value Added Buttermilk Based Beverage Incorporated with Finger millet (<i>Eleusine coracana</i>)	316
<i>B.M.P. Priyadarshani, M.K. Ranasinghe, W.M.M.H. Thilakarathne and R.M.T Madushanka</i>	
Assessment of Sensory Acceptability of Diyamiththa (<i>Cissampelos pareira</i>) Leaves Extract Incorporated Lacto-vegetarian Set Yoghurt during Storage	317
<i>R.M.T Madushanka, M.K Ranasinghe, H.A.S.L Jayasinghe, W.M.M.H Thilakarathne and B.M.P Priyadarshani</i>	

Antimicrobial Activity of Turmeric (<i>Curcuma longa</i>) Against <i>Salmonella Spp</i> and <i>E. coli Spp</i> <i>D.L.L. Lakmina, M.K. Ranasinghe, E.D.N.S. Abeyrathne and D.K.D.D. Jayasena</i>	318
Determination of Composition and Curcumin analysis of Turmeric Grown in Sri Lanka and India <i>R.C.N. Thilakarathna, G.D.M.P. Madhusankha and S.B. Nawarathna</i> 319	
Enhancing Sesame Oil Quality by Heat Treatment <i>S.M. Kuruppuarachchi and R. Shanthini</i> 320	
Biochemical Analysis of Underutilized Seaweed <i>Ulva lactuca</i> from Matara, Sri Lanka and Its Application in the Development of a Nutribar <i>R.M.A.C. Udayangani, Isuru Wijesekara and Indira Wickramasinghe</i> 321	
Comparative Analysis of Physicochemical and Sensory Attributes of Mature and Immature Tumid Venus Clam (<i>Gastrarium tumidum</i>) in Different Locations of Jaffna Lagoon, Sri Lanka <i>S. Jeyaamuthan, S.A. Kumar, J.M.D.R. Jayawardana, G.G.N. Thushari and D.K.D.D. Jayasena</i> 322	
Formation of Edible Casings from Hydrolyzed Ovalbumin <i>R.M.T.S. Rathnayake, M.K. Ranasinghe, E.D.N.S. Abeyrathne and C. Boraluwa</i> 323	
Effect of Maturity Level on Quality and Yield of Virgin Coconut Oil (VCO) and White Coconut Oil (WCO) <i>D.P.N.L. Dasanayaka, E. Samaranayaka, W.A.J.P. Wijesinghe and S.M.I.P.G. Bandara</i> 324	
Influence of Milk Fat and Added Sugar Content on Texture Profile of Set Yoghurts <i>P.G.I. Dias, R.M.U.S.K. Rathnayaka and J.W.A. Sajiwanie</i> 325	
Hospitality, Tourism and Event Management	
Oral	

Determinants of Tourism Industry Attractiveness: Evidence from Tourism and Hospitality Undergraduates of Public Universities in Sri Lanka <i>P.D.N.A.B. Jayarathna and K.M.M.C.B. Kulathunga</i>	328
Impact of Destination Attributes on Tourists' Purchase Intention towards Shopping Products in Colombo District <i>H.V.R.U.M. Gunawardhana and K.M.M.C.B. Kulathunga</i>	329
Analysis of Organizational and Environmental Benefits from Sustainable Waste Management Practices in Hotels (with special reference to Kandy District, Sri Lanka) <i>W.A.D.S. Wijesinghe, A.K.A. Damunupola and P.I.N. Fernando</i>	330
Planning Eco-friendly Wedding Events (with special reference to event organizers in Colombo district) <i>S.L. Nilushika, D.A.K. Damunupola and J. Sutha</i>	331
Potentials of Developing Sri Lanka as an International Wedding Tourism Destination (study based on Colombo and Negambo Areas) <i>J.A.I. Udayakantha and P.I.N. Fernando</i>	332
Modeling Residents' Support for Mega Events: A Partial Least Square Path Model Based on Perceived Event Impacts and Quality of Life <i>Ruhan Ranasinghe and Dhananjaya Nawarathna</i>	333
A Study of Factors Affecting the Business Success of Tourism Related Small and Medium Enterprises in Sri Lanka (with special reference to Central province) <i>M.A.M. Raazim, A.M.D.B. Nawarathna and Y.M.C. Gunaratne</i>	334
Why Sri Lankans Eat at International Fast Food Outlets? Motivations and Demographics <i>E.W. Biyiri, D.M.C. Dassanayake and S.N.S. Dahanayake</i>	335
Impact of Beach Tourism on the Host Community: Evidence from Arugam Bay Beach in Sri Lanka <i>K.Koushiga, A.K.A. Damunupola and J. Sutha</i>	336

Perceived Destination Loyalty of International Millennial Tourists: Evidence from Eco-Tourists in Sri Lanka <i>R.A.A.K. Ranaweera, H.A.A. Dilhani1 and P.I.N. Fernando</i>	337
The Role of Business Events' Brand Personality on Participants' Event Loyalty in Sri Lanka <i>W. Y. M. Perera, S. F. Fasana and J. Sutha</i>	338
Role of Destination Attributes in Developing Religious Tourism in Anuradhapura; Perspective of Chinese Tourists <i>U.G.O. Sammani and T.M.P.S.I. Tennakoon</i>	339
Effect of Authentic Atmospherics in Ethnic Restaurants on Consumer Emotions and Revisit Intension (special reference to Sri Lankan, Chinese & Indian restaurants in Colombo district) <i>D.G.M.H.C. Gamlath, A.C.I.D. Karunaratne and J. Sutha</i>	340
Study the Impact of Destination Attributes on International Tourist Satisfaction in Uva Province as a Tourist Destination <i>H.A.I. Srilal and P. I. N. Fernando</i>	341
Determinants of Street Food Consumption in Colombo City, Sri Lanka; Perspective of Foreign Tourists <i>M.D.C.M. Perera, A.M.D.B. Nawarathne and K.M.M.C.B. Kulatunga</i>	342
Socio-Economic Determinants of Wildlife Tourism Affecting on Tourism Service Suppliers- Special Reference to Ruhuna Yala National Park and Horton Plains National Park <i>K.L.P.M. Perera and P.I.N. Fernando</i>	343
The Impacts of Entertainment Events on Host Community with Special Reference to Hikkaduwa <i>V.S. Liyanage, A.K.A. Damunupola and J. Sutha</i>	344
Socio-Economic and the Environmental Impacts of Developing a Hydropower Plant in Kithulgala Adventure Tour Site (with special reference to adventure activity operators) <i>M.P.M. V.R. Samaranayaka, A.K.A. Damunupola and P.H.T. Kumara</i>	345

Community Based Tourism and Poverty Alleviation in Sri Lanka: With Special Reference to Monaragala District <i>E.A.S.I. Samarasekara and P.H.T. Kumara</i>	346
A Study on Labour Turnover Intention of Millennial Employees in Hotel Industry; With Special Reference to Five Star Hotels in Sri Lanka <i>Gammampila, A.C.I.D. Karunaratne and Y.M.C. Gunarathne . . .</i>	347
Impact of Marketing Mix Factors in Tourists' Decision Making of Revisiting Sri Lanka (with special reference to beach tourism in southern province) <i>A.A. Idroos, A.K.A. Damunupola and P.I.N. Fernando</i>	348
Impact of Destination Attributes to Develop Rural Tourism in Medadumbara Divisional Secretary's Division; Perspective of Foreign Tourists <i>U.G.M. Karunathilaka and K.M.M.C.B. Kulathunga</i>	349
A Comparative Study on the Influence of Promotional Mix Factors on Domestic Tourists' Destination Choice: Evidence from Dambulla & Sigiriya UNESCO World Heritage Sites <i>W.G. Kasthuri and C.J.P. Kulathilake</i>	350
Impact of Web Quality on Customer Satisfaction and Purchase Intention (special reference to Sri Lankan travel agents) <i>S.D.D.P.S. Dissanayake, A.C.I.D. Karunaratne and P.I.N. Fernando</i>	351
Analysis of the Effect of the Working Environment to the Job Satisfaction of the Air Hostesses (with special reference to Sri Lankan Airlines) <i>W.G.N.S.C.D. Wijerathna and H.M.W.M. Herath</i>	352
Impact of Eco Tourism Practices on Customer Satisfaction (with special reference to hotels in Uva province) <i>D.C.A.A. Chathuranga, A.C.I.D. Karunaratne and K.M.M.C.B. Kulathunga</i>	353
Poster	

Exploring Tourism Risk at the Destinations at Jaffna Peninsula with Special Reference to Keerimalai Ritual Beach site. <i>Ilangkeeran Bithushan, Kidnarasa Kabilan, Kalimuththu Shanmuganathan and Mahalingam Ramanan</i>	354
Travel Motivations of Beach Tourists: Push and Pull Approach from Trincomalee <i>U.M.Ahsan, A.K.A.Damunupola and Y.M.C. Gunaratne</i>	355
A Comparative Study on Tourists' Satisfaction with Attributes of Cultural Heritage Sites (with special reference to select Ancient Heritage of Sigiriya and Golden Temple of Dambulla) <i>M.H.F. Hasna and T.M.P.S.I. Tennakoon</i>	356
Identifying Barriers in Commencing Own Business: Evidence from Hospitality and Tourism Graduates in Sri Lanka <i>H.K.K. Milinda, S.F. Fazana and P. I. N. Fernando</i>	357
The Study on Impact of Service Quality on Guest Loyalty in Hotel Industry: (with special reference to five star hotels in Kandy district) <i>M.M.G.K. Marasinghe, A.C.I.D. Karunarathne and J. Sutha</i>	358
Examining Key Areas of Tourists' Complains: Case of Freelance Tour Guides <i>N.W.T Dilshan and G.C.N. Boteju</i>	359
Stepping Boom to Doom Tourism? A Special Focus on Elephant Seeing in Sri Lanka <i>W.G.S.R. Wijesundara</i>	360
Developing Tea Ourism Niche Market in Sri Lanka: Stakeholders' Perspective <i>P.I.N. Fernando and K,W.S.N. Kumari</i>	361
 Humanities and Social Science	
 Oral	

Effectiveness of E-Learning on Interest in Carbon footprint and Environmental Awareness among School Students in Kurunegala District <i>S. Pathirathna, P.A.B.H. Amarathunga and A. Irosh</i>	364
The Uses of Blogs as an E-learning Tool in Sri Lankan Higher Education <i>S.A.M.Fawaz</i>	365
Factors Affecting on the Lack of Online Education Practices among Undergraduates of Social Sciences and Humanities <i>V.U.I.K. Gunasinghe and G.S.P. Gunarathne</i>	366
Language Testing in Second National Language Development among Sri Lankans: An Initial Review <i>M. Rubavathanan</i>	367
Perception of the Students on Obtaining the Assistance of ESL/EFL Websites to Learn English; a Study with Special Reference to the Second Year Undergraduates of Uva Wellassa University <i>D.M.R.S Dissanayake</i>	368
Analysis of the Contemporary Situation of Illicit Alcohol Consumption in Sri Lanka <i>G.N.D. Guruge, S.M. Young and S.K. Kithalawaarachchi</i>	369
Public Perception on the Aranayake land Slide: Post-Disaster and Pre-Disaster <i>K.G.S.P.D Alwis</i>	370
Organizational Challenges in Managing Schools: Experiences of Government Schools in Sri Lanka <i>C. Kasturiarachchi and T.T.K. Kasturiarachchi</i>	371
A Study of Identifying the Common Causes for Dementia <i>Chandrika R.</i>	372
Emotional Intelligence in Buddhism <i>H.R.N. Peiris</i>	373

The Impact of Micro Financial and Non-Financial Services on the Productivity Growth of the Microenterprises in Sri Lanka <i>S.U.Badullahewage and D.P.Withanage</i>	374
Trial and Error Learning in Influence in Fashion: Clothing Attitudes of the Kings of the Kandyan Kingdom of Sri Lanka <i>G.M. Ranathunga</i>	375
Impact of Technology on Children Growth and Development <i>H.M.Rafeena and C.M.M.Mansoor</i>	376
Ragging and Its Impact on Learning English as a Second Language; a Qualitative Study with Special Focus to the Faculty of Humanities and Social Sciences, University of Ruhuna <i>S. Chandradasa and D. Jayawardena</i>	377
Perceptions towards New Restrictions on Polythene Usage in Sri Lanka - Case Study in Colombo City <i>A.M.I.U. Kumara, P. Drechsel, S. Fernando and W.G.A.N. Jayathilake</i>	378
Fashion Identity; a Self in Context and Visual Expression <i>P.V.M Karunaratne</i>	379
The Impact of Television Food Advertisements on Children, with Special Reference to the Plantation Community in Badulla District <i>H.M.W.M. Herath</i>	380
Correlation between Sri Lankan University Students' Self -Esteem and their English Speaking Skills <i>H.M.W.M. Herath and J.M.P.V.K. Jayasundara</i>	381
Mindfulness, Perception and Wisdom <i>H.M.M. Herath</i>	382
An Archeological and Religious Study of Sagama Rajamaha Vihara and Sagama Rock Inscription <i>H.M.M. Herath</i>	383
Poster	

Difference Among [i][ga], [eun][neun] and [eul][leul] Grammar Particles in Korean Language <i>E.D.P Edirisinghe and M.A.P.S Marasinghe</i>	384
Farmers' Perception on Transition towards Organic Paddy Cultivation: A Case Study in Matara District. <i>H.M.P.M. Dayarathne, N.I.K. Nanayakkara, A.M. W. W.N.D.B. Abeysekara and A.L. Sandika</i>	385
Impact of Pursuing Certificate in English for Junior Executives on Enhancement of Communication through English Language <i>J.M.P.V.K. Jayasundara and H.M.W.M. Herath1</i>	386
 Materials and Mineral Sciences	
Oral	
Uranium Extraction from Seawater around Sri Lanka using Amidoxime Modified Nano and Mesoporous Silica <i>Chamila Gunathilake</i>	389
Depositional History of Sediments in Eastern Lagoons of Sri Lanka: Sedimentological and Mineralogical Evidences <i>M.M.T.I Megasooriya, A.M.N.M. Adikaram, H.P.T.S Hewathilake</i>	390
Kaolin - based Filter Material to Remove Textile Dyes in Water <i>H.T.R. Imalka and D.D.C. Wanniarachchi</i>	391
Silica from Rice Husk as an Alternative to Commercially Available Silica Fillers in Tyre Compounding <i>T. Kirushanthi, H.M.J.C. Pitawala, D.Edirisinghe, D.R.Ratnaweera and T.N.B. Etampawala</i>	392
Ceramic Waste-Based Natural Rubber Composites: An Exciting Way for Improving Mechanical Properties <i>Y.G. Kondrage, H.M.J.C. Pitawala, K. Thangavel, D. Edirisinghe and T.N.B. Etampawala</i>	393

Synthesis of Expanded Graphite using Sri Lankan Vein Graphite via Ultrasonication <i>M.M.K.R.N.D. Senavirathne, J.N. Kanagaratnam, T.H.N.G. Amaraweera and A. Wijayasinghe</i>	394
Antibacterial Activity of Silver Deposited Vein Graphite against Waterborne Pathogenic <i>Escherichia coli</i> <i>K.K.A.D. Kumar, T.H.N.G. Amaraweera, M.M.S.N. Premetilake and H.W.M.A.C. Wijayasinghe</i>	395
Confirmation of Newly Discovered Area in Eppawala Phosphate Deposit Using Geological, Geochemical and Geophysical Methods <i>M.M.T.D.M. Kumari, N.D. Subasinghe, A.N.B. Attanayake and S.A. Samaranayake</i>	396
Purification of Low Grade Quartz Bearing River Sand <i>C.N. Kalubowila, Y. Garthiga, T.H.N.G. Amaraweera and A. Wijayasinghe</i>	397
Synthesis and Characterization of Ionic Liquid Based Gel Polymer Electrolyte for Rechargeable Batteries <i>S.M.K.M Gunadasa, A.M.I.E Gunathilaka and H.M.J.C. Pitawala</i>	398
Cellulose Whiskers Extracted from Banana Pseudo-Stem as Reinforcing Filler for Natural Rubber Tyre Treads Using Latex Intercalation Method <i>T.A.R. W.M.M.C.G. Bandara, T.N.B Etampawala, Sarath Kularathne, H.G.I.M. Wijesinghe and A.M.W.K. Senevirathna</i>	399
Application of Solar Desalination Technology to Provide Safe Drinking Water for Water-scarce Areas in Jaffna Peninsula <i>S.Kunaseelan and S.Saravanan</i>	400
Silica Extracted from Rice Husk Ash as an Effective Reinforcing Filler for Natural Rubber Composites <i>K.C. Samaraaweera, H.G.I.M. Wijesinghe, T.N.B. Etampawala, D.G. Edirisinghe and A.M.W.K. Senevirathna</i>	401

Effect of Ethepron Stimulation on Physico-Mechanical Properties of Carbon Black Filled Natural Rubber Vulcanizates <i>E.N.N. Nanayakkara, A.P. Attanayake, H.G.I.M. Wijesinghe and A.M.W.K. Senevirathna</i>	402
Fabrication of Smart Umbrella Canopy with Super Hydrophobic Property <i>U.G.M. Ekanayake, N. Rathuwadu and M.M.M.G.P.G. Manthilaka</i>	403
Carbon Fiber Networked Nano Carbon Black as a Novel Conductive Filler to Enhance the Thermal Conductivity of Natural Rubber Composites <i>J.M.A.R.B. Jayasinghe, R. T. De Silva, K.M.N. de Silva, W.R.M De Silva and M.M.M.G.P.G. Mantilaka</i>	404
Highly Adsorptive Filter Based On Iron Oxide Nanoparticles for Dye Removal from Aqueous Solutions <i>D.M.S.N. Dissanayake, G. T. D. Chandrakumara, M.M.M.G.P.G. Mantilaka, T.C. Palihawadana, K.M. N. de Silva, H.M.T.G.A. Pitawala, R.T. De Silva and G.A.J. Amaratunga</i>	405
Garnet rich mineral sand based filter media for Removal of fresh water algae <i>K.A.J.W Siriwardhana, T.H.N.G Amaraweera and M.M.S.N. Premathilake</i>	406
Synthesis of Feldspar Nanoparticles by Top Down Approach <i>Anoja Senthilnathan, D.M.S.N. Dissanayake, T.C.Palihawadana, Ruchira N. Wijesena, Nadeeka D. Tissera and M.M.M.G.P.G. Mantilaka</i>	407
Nano-Porous Iron Yttrium Oxide Particles Synthesis as Value Addition to Sri Lankan Garnet Sand <i>D.M.S.N. Dissanayake, Anoja Senthilnathan, G. T. D. Chandrakumara and M.M.M.G.P.G. Mantilaka</i>	408
Poster	
Optimization and Structural Analysis of a Gel Polymer Electrolyte Based on Polyacrylonitrile to be used for Na Batteries <i>K.S. Perera and K.P. Vidanapathirana</i>	409

Feasibility of using industrial waste in Sri Lanka to develop composite construction material: A Review <i>Chiranjaya Y.A.S.U</i>	410
Possibility of Using Remote Sensing Techniques as a Tool in Exploration of Marble Deposits in Sri Lanka <i>P.G.S.C. Amarasiri, R.G.C. Jaliya and E.P.S.K. Ediriweera</i>	411
Fabrication of Solid State Dye Sensitized Solar Cell Using Red Sandalwood as Natural Sensitizer <i>P.L.D.R. Liyanage, T.N.B. Etampawala and P.M. Sirimanne</i>	412
Development of Heat Insulating Paint Using Rice Husks and Kaolin <i>S. S. Induruwage and D. D. C. Wanniarachchi</i>	413
Ascertain an Optimum Temperature and Soaking Time to Enhance the Colour of “ <i>Maangu</i> ” Tourmaline <i>I.L.C.S. Wickramarathna, R.G.C. Jaliya, S. Illangasinghe, S. Diyabalanage and P. Francis</i>	414
Recycling of Cathode Ray Tube Glasses and Utilizing the Waste Glasses in the Roof Tile Industry of Sri Lanka <i>M.N Jayasinghe, H.M.J.C Pitawala, K.J.R.S Fernando, A.G.T.R Amiyangoda and E.M.T.D.S.B Ehalamalpe</i>	415
Increasing the Purity of Graphite Samples Taken from the Under Flow of the Froth Flotation Process Using a Gravity Separation Method <i>G.V.B. Ulukkulama, R.C.G. Jaliya and L.P.S. Rohitha</i>	416
Removal of Iron Impurity from Vein Quartz by Acid Leaching <i>A.G.N.C.S. Wijerathne, R.G.C. Jaliya and L.P.S. Rohitha</i>	417
Optimization of Mixing Parameters using Mooney Viscosity of Top & Bottom Profiles in Off-the-Road Rubber Track Compounds <i>U.D.D. Bhagya Malshani, S. Gunawardena, H.G.I.M. Wijesinghe and P.E. Kaliyadasa</i>	418

Effect of Technically Specified Rubber (TSR) Variations on Rheological Properties of Soft Compound of Solid Tires <i>D.A.W.Y. De Silva, P.K. Wickrama Arachchi, S.R.W.M.C.J.K. Ranawana and G. Abhiram</i>	419
Development of a pH Responsive Ceramic Material <i>Chathuranga Mahanama and D.D.C. Wanniarachchi</i>	420
Use of Coir Fibre Waste as an Effective Raw Material for Fibre Boards Reinforced with Natural Rubber Latex Compounds and PhenolFormaldehyde Resin <i>W.L.A.M. Liyanage, H.M.S.K. Herath, H.G.I.M. Wijesinghe and C.R.C. Perera</i>	421
 Mechanical Engineering and Mechatronics	
Oral	
RFID Based Smart Personal Baggage System <i>P. Kasun and S.M. Vidanagamachchi</i>	424
Autonomous Baby Care System <i>B. Pushpakanthan and V. Hiroshaan</i>	425
Development of a monitoring device for fermentation stage of black tea manufacturing <i>T. Thevathayarajh and D.D.C. Wanniarachchi</i>	426
Obstacle Avoidance System For A Quadrotor UAV Using Over Head Mounted Camera, Based On Image Processing Technique <i>R.D. Prabhashitha and H.A.N.B. Amarasiri</i>	427
Object Sorting System Using Affordable Robotic Manipulator <i>A.M.C. De Silva, C. Amarasinghe and H.A.N.B. Amarasiri</i>	428
Vision Based Guiding System for AGV Using Robot Operating Systems <i>P.K.S. Asanga, A.R.P.C.C.J. Amarasinghe and S. Ranasinghe</i>	429

Computerized Motor Spare Parts Identifier <i>R.A.D.R.K. Mark and M.L. Wickrama</i>	430
Finite Element Analysis of Tyre-Rim with Different Nave Thicknesses <i>Akila Fernando and Dimuthu Darshana</i>	431
Autonomous Guided Vehicle for the local market <i>H.A.D. Tharaka and A.R.P.C.C.J. Amarasinghe</i>	432
Unique Object Following Robot <i>K. Juvaraj and U.M.N. Jayawickrema</i>	433
A portable gas sensing Device Based on Imageprocessing <i>I.U.Bamunukula and D.D.C Wanniarachchi</i>	434
Haptic Teleoperated Steering System for Unmanned Ground Vehicles <i>D.N.B. Wijekoon and W.A. Rasika Nandana</i>	435
GSM, GPS and Facial Recognition Based Vehicle Security System <i>G.G.S. Udara, B.C. Liyanapathirana and K.W.S.N. Kumari</i>	436
An innovative Fixing Solution for holding Complex Shaped Components <i>B.M.S.C.B. Balasuriya, H.W.P. Bhanuka, H.R.L. Sampath, A. L. Kulasekera and N. D. Jayaweera</i>	437
A Controller for Assistive Devices using Eye Movement and Electroencephalography <i>T. Abienash and W.A. Rasika Nandana</i>	438
Poster	
Development of Specific National Energy Benchmark Model for Sri Lankan Apparel Industries <i>W.A.J. Anurangi and K.B. Wijesekara</i>	439
Pneumatic Rotary Turret Feeder <i>R.H.A.G. Nandasiri, K.W.S.N. Kumari and B.J. Watawana</i>	440

Raw material stored location Identification in the Garment Factory using RFID Technology <i>R.S.M.D.M. Chandrasekara and K.S.S.N. Kumari</i>	441
Eye Blink Detection by Image Processing to Prevent Vehicle Accidents <i>K.S.H. Nimanthi and H.A.N.B. Amarasiri</i>	442
Portable Charger Powered by Piezo-electric Crystal Vibration <i>M. W. M. N. Weerakoon and A.R.P.C.C.J. Amarasinghe</i>	443
Solving Poisson's equation with Dirichlet boundary condition using Henstock-Kurzweil integral <i>M.K.A.J. Maldeniya, N.C. Ganegoda, S.K. Boralugoda, K.K.W.A.S. Kumara and K. de Silva</i>	444
Study the Effect of Far Infrared-Withering on Black Tea Manufacturing <i>N. Piratheepan, G. Abhiram and S.R.W.M.C.J.K. Ranawana</i>	445
Automatic Sun Tracking Solar Panel <i>U.A.D.N. Anuradha and K.W.S. Chathuranga</i>	446
An Automated Reconfigurable Supporting Structure for Aeronautical Applications <i>N. Vitharana, S. Nishanthan, A. L. Kulasekera and N.D. Jayaweera</i>	447

Animal and Crop Production Technology

- Plant Breeding and Varietal Improvement
- Crop Production and improvement
- Crop Protection/Pest and Diseases
- Plantation Crops
- Organic Agriculture/Green Technology
- Animal Nutrition and Feed Production
- Animal Health, Welfare and Farm Bio-security
- Organic and Alternative Livestock Production
- Rural development, Organization and Economic of Livestock Production
- Animal Production and Impact on Environmental Sustainability
- Current Issues in Animal Production

The Effect of Wood Apple Bark Extract (*Limonia acidissima*) on Internal and Sensory Attributes of Chicken Eggs Stored under Room Temperature

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Eggs are one of the highly nutritious, low-cost food consumed. Storage under ambient temperature is known to reduce the internal qualities. Wood apple bark extract (*Limonia acidissima*) is a waxy substance which is available naturally. Coating materials are used to improve the shelf life of eggs. So the objective was to increase the shelf life and preserve sensory qualities of egg using wood apple bark extract as a coating material on eggs. A total of 312 medium sized white eggs from 61-weeks old Hy-line white were purchased from a commercial layer farm. Eggs were individually weighed and arranged under completely randomized design into three different coating treatments as wood apple extract (WA), mineral oil (MO) and non-coated (NC). Each parameters were measured by using 03 replicates. The eggs were stored under room temperature (27 ± 2 °C) for 06 weeks. Weight losses, internal quality parameters such as Haugh unit, albumen and yolk pH values, and microbial analysis for *Salmonella* of eggs were measured weekly for 06 weeks. Sensory attributes of eggs were measured using 30 untrained panellists (age 23-27). Fourier-transform infrared spectroscopy (FTIR) analysis was done to analyse the structural changes. Weight losses were minimum in MO coated eggs than others ($p < 0.05$). Haugh unit decreased significantly ($p < 0.05$) in NC but in others it was more than 50% till the 04th week. In all treatments, egg albumen and yolk pH increased during the storage ($p > 0.05$). However, coated eggs reduced the grade from AA to A within 03 weeks. All coated eggs were negative for *Salmonella* test during the tested period. Colour of the egg yolk did not change due to the coating material. Sensory attributes confirmed that no sensory changes in all treated eggs up to the 03rd week of storage. FTIR analysis confirmed that the Amide-A and Amide-1 bonds of the coated eggs did not change with the time. The present study confirmed that WA is another good replacer for the MO in commercial scale.

Keywords: Haugh unit, Mineral Oil, *Salmonella*, Sensory properties, Wood apple.

Evaluation of Test Cross Combinations to Identify the Potential Restorers and Maintainers for Hybrid Rice Production in Sri Lanka

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Experiment was conducted to identify the new restorer and maintainers for hybrid rice programme at Rice Research and Development Institute Batalagoda in *Maha* 2016/17 and *Yala* 2017 seasons. Hundred and forty seven crosses were produced by using 29 CMS lines crossing with 58 elite inbred lines in *Maha* 2016/17. All F₁ hybrid progenies and respective male parents were planted in a test cross nursery in *Yala* 2017. Other agronomical practices were conducted according to the recommendations of the Department of Agriculture, Sri Lanka. Pollen sterility and fertility of F₁ hybrids were observed via light microscope after staining them with I-KI solution. Fifty six pollen fertile F₁ crosses were identified having >81% pollen fertility and thirty one male parents of such crosses were selected as restorers. Meanwhile four pollen sterile F₁ combinations were identified and they showed >98.6% pollen sterility (IR58025A / RES 256, IR78359A / RES 256, IR78364A / RES 256, BG CMS7A/RES 256). The pollen parent of such hybrid combinations were selected as maintainer (RES 256) and it was advanced to back cross breeding programme in order to develop new CMS lines.

Keywords: Restorers, Hybrid rice, Pollen sterility

Priming with Nitric Oxide Donor Sodium Nitroprusside Enhances Germination and Storage Life of Recalcitrant Rubber (*Hevea brasiliensis*) Seeds

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Rubber (*Hevea brasiliensis*) seeds lose their viability within a few days after falling from the tree. Use of old seeds has resulted in low germination percentage and extended germination time in commercial rubber nurseries. Nitric oxide (NO) is a signaling molecule involved in biological processes from seed germination up to senescence. The present study explored the effect of NO donor sodium nitroprusside (SNP), as a chemical priming agent, on germination and storage life of rubber seeds and subsequent growth of seedlings. Fresh rubber seeds were soaked in SNP solutions at different concentrations viz., 50, 100 and 150 µM for 24 hours and were sown in a germination bed after storing at different time intervals viz., 0, 7, 14, 21 and 28 days, respectively. 140 seeds were used for each treatment at each storage time interval. No germination was recorded after 28 days of storage irrespective of priming treatments. At zero day of storage, there was no significant difference in germination percentage. However, after the 7th day of storage, a significantly ($p \leq 0.05$) higher germination percentage was recorded with SNP at 50 µM (80.7% and 99.2% after 7 and 14 days of sowing respectively) as compared to control (60% and 75.7% after 7 and 14 days of sowing respectively). At the 14th day and 21st day of storage, a significantly ($p \leq 0.05$) higher germination percentage was recorded with SNP at 50 and 100 µM when compared to control and mock treatment (hydropriming) after 21 days of sowing. There was no significant difference in growth attributes viz, stem diameter, shoot height, number of leaves, leaf area, internodal length, chlorophyll content, dry weight of roots and shoots of seedlings raised from seeds imposed with different treatments after two months from planting. Therefore, NO treatment at 50 and 100 µM concentrations could effectively be utilized to improve the germination and short-term storage life of rubber seeds.

Keywords: Germination, Nitric Oxide, Rubber, Sodium Nitroprusside

Evaluation of Physiochemical Changes in Raw Chicken Eggs Stored at Room Temperature

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Chicken eggs are widely used in the world, due to perishability which undergoes deterioration with the time. This affects with egg processing industry and to economic losses. In this study, physiochemical changes of raw chicken eggs (RCE) stored at room temperature (28-31 °C) were determined. A total of 60 medium sized white shelled RCE obtained from 61-wk old Hyline White hens were analyzed for weight loss (%), yolk color, Haugh unit, USDA grade, pH of egg yolk and egg white and Fourier transform infrared (FTIR) spectrums at 0, 1, 4, 8, 12, 16, 20, 24, and 29 days Microbial analysis for *Salmonella* was checked at 0 and 29 days of storage. Weight loss (%) and pH of egg white and yolk increased whereas Haugh unit and USDA grade decreased at 29th day. Yolk color significantly increased ($p < 0.05$) from 12 to 14 and weight loss (%) increased ($p < 0.05$) from 0 to 6.27 with the storage time. However, Haugh unit showed a significant decrease ($p < 0.05$) from 85.13 to 40.33 and USDA grade significantly decreased ($p < 0.05$) from AA grade to B grade during 29 days of storage. Albumin pH and yolk pH significantly increased ($p < 0.05$) from 8.81 to 9.59 and from 5.77 to 6.43, respectively. *Salmonella* was not observed in RCE during storage at room temperature. FTIR spectrums indicated changes occurred in bonds of Amide A (3304 cm⁻¹), Amide I (1637 cm⁻¹), Amide II (1547 cm⁻¹), Amide III (1238 cm⁻¹), Amide IV (594 cm⁻¹), Asymmetric CH₃ Stretching (2925 cm⁻¹) and Symmetric CH₂ Stretching (3304 cm⁻¹). Moreover, secondary structural changes were detected in protein in RCE during the storage. In conclusion, RCE showed significant physiochemical changes in weight loss, Haugh unit, albumin pH, yolk pH and chemical structures during the storage period upto 29 days at room temperature.

Keywords: FTIR, Haugh unit, pH, Yolk color, USDA grade.

Effectiveness of the Approach Grafting Over the Other Vegetative Propagation Methods of Nutmeg (*Myristica fragrans* Houtt.)

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Nutmeg (*Myristica fragrans* Houtt.) is unique among spice plants as it produces two distinct spices, nutmeg and mace. Nutmeg is the seed kernel inside the fruit and mace is the covering (aril) on the kernel. It is dioecious plant and sexual propagation by seedlings yields 50% male seedlings, which are unproductive. There is no reliable method to determine the sex of the sexually propagated nutmeg plant until flowering and it takes 6-7 years. Even though, the solution is vegetative propagation, the available techniques take long time and less in success. This experiment was conducted with the objective of testing the effectiveness of approach grafting over the current vegetative propagation methods of nutmeg in local context. Different other methods of vegetative propagation namely cleft grafting, soil layering, air layering and stem cutting were attempted. Randomized Complete Block Design was used for six treatments and each treatment contains three replicates. Data were subjected to Analysis of Variances, t-test and GLM procedure using SAS 9.0 statistical package at 5% level of significance. Averages were compared with the Duncan's Multiple Range Test. After three months period, the reported mean successful percentages for cleft grafting, soil layering, air layering, stem cuttings, approach grafting with plagiotropic shoots and approach grafting with orthotropic shoots were 24.81%, 0%, 17.13%, 0%, 75% and 87.37% respectively. A significant difference was observed between the mean successful percentages of approach grafting against other vegetative propagation methods ($P < 0.05$). But, there was no significant difference between the mean successful percentages of approach grafting with plagiotropic shoots and approach grafting with orthotropic shoots ($P > 0.05$). There was a higher potential for the success of approach grafting of nutmeg when compared to other vegetative propagation methods for the production of planting materials. Mass propagation through approach grafting with plagiotropic shoots and orthotropic shoots can be recommended for the production of female plants. Field testing of approach grafted plants with the cleft grafted and air layered plants could also be proposed.

Keywords: Approach grafting, Orthotropic shoots, Plagiotropic shoots, Propagation

DNA Based Analysis for Distribution of *Meloidogyne* Species in Selected Crop Plants in Different Geographical Locations in Sri Lanka

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Meloidogyne species are highly destructive endoparasitic nematodes with a wide host range. Molecular identification of the *Meloidogyne* species that infect crop plants was performed in this study using *Meloidogyne* infected 28 root samples collected from four different crops in five different geographical locations in Sri Lanka during May to July in 2017; Passara (6.934909, 81.152698) tomato, Thanamalwila (6.439755, 81.133397) chili, Pallekele (7.280104, 80.702034) capsicum, Vellankulam (9.186089, 80.126481) chili, Kaluwanachikudy (7.529373, 81.794609) chili and Kaluwanachikudy (7.529373, 81.794609) okra. Polymerase chain reactions were carried out in these samples with MF/MR primer pairs, C2F3/1108 primer pairs and 194/195 primer pairs. Genus specific universal primers MF/MR amplified, 500 bp fragment of ribosomal DNA of Passara tomato, Thanamalwila chili, Pallekele capsicum, Vellankulam chili and Kaluwanachikudy chili samples representing the presence of genus *Meloidogyne*. Primer pair C2F3/1108 amplified, 705 bp fragment of mitochondrial DNA of Thanamalwila chili, Pallekele capsicum, Vellankulam chili and Kaluwanachikudy chili samples representing the presence of *Meloidogyne enterolobii*. Primer pair 194/195 amplified, 700 bp fragment of ribosomal DNA of Passara tomato and Kaluwanachikudy chili samples representing the presence of *Meloidogyne hapla*. A mixed population of *M. enterolobii* and *M. hapla* was resulted in Kaluwanachikudy chili. Kaluwanachikudy okra did not produce any band with any primer pair amplifications revealing that it had unknown species. This study confirms the expansion of the distribution of *M. enterolobii* and *M. hapla* in Sri Lanka in recent years. *M. enterolobii* was present in all the chili/capsicum samples tested and this is the first report of its availability in infested chili/capsicum plants in Sri Lanka.

Keywords: *M. enterolobii*, *M. hapla*, DNA based assays.

Effect of Major Socio-Economic Factors on Dairy Cattle Milk Production in Maho Veterinary Region in Kurunegala District

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Livestock plays a socially and economically significant role in Sri Lankan agriculture providing multi-functional outputs and supplementing family incomes for livelihood security. Therefore, the present study was conducted to identify the effect of major socio-economic factors and constraints on dairy cattle milk production in Maho veterinary region in Kurunegala district. Three hundred and fifty (350) farmers from Maho veterinary region were selected using stratified sampling. Socio- economic and production data were collected using a pre-tested structured questionnaire. Data were subjected to descriptive analysis and multiple linear regressions using Minitab 17 statistical software. Results of the descriptive analysis revealed that majority engaged in dairy cattle farming as a major source of income (58.29%). Of the total farmers, 78.29% practiced semi-intensive rearing while Jersey and Sahiwal were reported as the dominant breeds (38%) within the region. Average daily milk production was $6.20 \text{ L cow}^{-1} \text{ day}^{-1}$. Results of the regression analysis highlighted relationships between breed type, breeding technique, feeding method, concentration type, level of education of the farmer and experience in dairy farming with the daily milk production ($P < 0.05$). Fitted regression model well predicted the daily milk production ($R^2 = 94\%$). It disclosed that breed type, breeding technique, feeding method, concentration type, level of education of the farmer and experience determine the dairy cattle milk production. However, lack of high yielding cross breeds, less success in artificial insemination (AI), low quality pasture and seasonality in pasture production and poor milk collection network were reported as the major constraints. The key findings of this study might promote improving the factors affecting the milk production in Maho veterinary region.

Keywords: constraints, dairy cattle, milk production, regression analysis, socio economic.

Foliar Application of Seaweed Liquid Extracts on Growth Performance of *Glycine max* (L.)

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Seaweeds are found in coastal areas of Sri Lanka. Usage of synthetic fertilizer and pesticide cause vast array of health hazards and environmental problems. Seaweed extracts are one of the alternatives to these problems. In this regard, the first experiment was conducted to find out the seaweeds availability in the coastal Pasikudah area. Six different species were identified and their physio-chemical properties were investigated. Those were *Sargassum crassifolium*, *Turbinaria turbinata*, *Halimeda opuntia*, *Salvinia molesta*, *Oldenlandia corymbosa*. Among six species two most abundantly available species of *Sargassum crassifolium* and *Turbinaria turbinata* were selected for second experiment using soybean varieties namely Pb-1 and MISB 01. Pot experiment was conducted in the Crop Farm, Eastern University to find out the effect of seaweed extracts on growth performance of two soybean varieties. The experiment was arranged in a Factorial Complete Randomized Design with six treatments and eight replicates. Seaweed extract 20% was applied to soybean varieties at weekly interval until harvest and their performance were recorded. Both foliar seaweed extract applications had significant ($p<0.05$) effect on tested parameters of two soybean varieties. Foliar application of *S. crassifolium* and *T. turbinata* extracts increased chlorophyll content (10.29, 10.55 SPAD Units), number of flowers (133.89%, 87.08%), effective nodules (165.2%, 65.2%) and shoot biomass (107.7%, 50.9%), respectively in MISB 01. Also in Pb-1 increased chlorophyll content (18.2, 17.49 SPAD Units), number of flowers (104.25%, 29.78%), effective nodules (115.54%, 42.01%), shoot biomass (93.52%, 59.11%). Among two seaweed varieties, *S. crassifolium* provided highest performance on number of flowers, effective nodules and biomass of both soybean varieties. It could be concluded in this experiment that *S. crassifolium* seaweed liquid extract can be used to increase the growth performance of both soybean varieties.

Keywords: Seaweed, *Sargassum sp.*, seaweed extract, Soybean

Effect of Coloured Cellophane Shading on Seed Germination, Plant Growth and Fruit Quality Characteristics of Tomato (*Solanum lycopersicum* L.)

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In urban agriculture there are trends to grow crops under different colour shading. Colour of light differently affect on plant growth and biochemical properties of plant. The present study was conducted to evaluate the effect of coloured shading on seed germination, plant growth, fruit quality and fruit yield of tomato (*Solanum lycopersicum* L.). Yellow, red, green, blue coloured cellophane and transparent cellophane (control) were used in the experiment. To evaluate quality of fruits two experiments were conducted in a polythene house with Complete Randomized Design; (1) whole fruit covered by coloured cellophane and (2) whole plant covered by coloured cellophane. The coloured cellophane shading differently affected on seed germination, growth, fruit quality and yield of tomato. The highest seed germination was observed in yellow colour (93.47%) and the lowest at green (73.25%) at day 6th of germination. At one month after transplanting highest and lowest plant height (24.5 cm, 13.5 cm) and number of leaves (8, 7) were found in yellow and green, respectively. The highest leaf area (20.07 cm²) and plant fresh weight (4.83 g) were found in control; whereas, the lowest was found in green (4.34 cm², 0.74 g, respectively). The highest fruit weight (35.13 g) and length (3.97 cm) were found in the fruits covered by green cellophane; whereas, the lowest (24.74 g, 3.20 cm) in the blue (Experiment 01). The highest Brix value was found in red and the lowest from yellow. Ascorbic acid content was highest in yellow colour (90 mg/100ml) but lowest in green colour (30 mg/100ml). In the experiment 2, blue cellophane recorded the highest fruit weight (51.10 g), and size; whereas, the control recorded the lowest. Brix value was higher in control and the lowest in blue colour. Fruit peel thickness was higher in red (0.65 cm) and lowest in blue (0.51 cm). The highest Ascorbic acid content was recorded in yellow colour (121.25 mg), whereas the lowest in blue (57.5 mg). Finally, it can be concluded that yellow colour is the most effective on accelerating seed germination and control treatment is better for vegetative growth of the plant. To have high ascorbic acid content whole plant should be covered with yellow cellophane, but when it consider yield, blue cellophane is the best.

Keywords: Colour cellophane, Fruit quality, Seed germination, Tomato, Vegetative growth.

**Evaluation of the Relationship between SPAD Reading and Biochemical Profile of Fresh Leaves of Selected Tea Cultivars
*(Camellia sinensis (L.) O. Kuntze)***

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Biochemicals in fresh tea leaves affect to the quality of made tea and are difficult to evaluate by traditional chemical extraction methods. Therefore, this study was conducted to investigate a simple method to evaluate foliar biochemicals using SPAD reading of three widely grown tea cultivars (*Camellia sinensis (L.) O. Kuntze*), viz: TRI 2025, TRI 3035 and TRI 4046 in the Uva region. Fresh leaf samples of different developmental stages were randomly collected from Wewasse and Glen Alpine estates, Badulla. Leaves were placed in an ice box immediately after detaching from the bush and transported to Agricultural Chemistry laboratory of Uva Wellassa University. Study was conducted as two experiments during the period from July to December 2017. Average of five SPAD readings on each side of the midrib per leaf were taken to produce a single SPAD reading for each leaf. Leaves of each cultivar were categorized into seven samples according to the SPAD reading (i.e. SPAD 20, 30, 40, 50, 60, 70 and 80). Chlorophyll a, b and carotenoids were extracted and quantified in the first experiment while total polyphenols, reducing sugars and proteins were extracted and quantified in the second experiment. The relationship between chemical components and SPAD reading was estimated using regression analysis and Pearson Correlation coefficient. In the first experiment, the highest positive correlation (0.999) was recorded in between SPAD reading and total chlorophylls of cultivar TRI 3035. In the experiment 02, the polyphenols, reducing sugars and proteins of all cultivars were shown a strong, negative, non-linear relationship with SPAD reading ($R^2 > 0.90$). The results revealed that the SPAD meter readings can be used to assess the relative chlorophyll content and approximate concentrations of the selected biochemicals in fresh tea leaves simply and non-destructively. Thus, the findings will be useful in the decision making of harvest time and quality control in tea sector.

Keywords: Biochemicals, Correlation, SPAD reading, Tea cultivars

Effect of Different Irrigation Levels on Flower Initiation and Some Yield Attributes of Black Pepper (*Piper nigrum* L.)

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Black pepper (*Piper nigrum* L.) popularly known as “king of spices” is one of the earliest spices known to man and is the largest commodity in the international spice trade. Pepper is cultivated over an area of 32,800 ha. of Sri Lanka, mostly in Matale, Kandy, Kegalle, Kurunegala and Nuwara Eliya districts. Water scarcity in Dry Zone and some parts of Intermediate Zone has limited the expansion of cultivation and moisture stress may cause variation in yield attributes in black pepper. Identification of optimum irrigation level to get higher yield in black pepper is vital as such information is limited. Therefore, a pot experiment was conducted under protected environmental conditions to find out the variation of yield parameters of black pepper under different irrigation levels. Three irrigation levels (8, 4, 2 L plant⁻¹) were applied weekly to the selected 3 year old black pepper vines of MB-12 variety. There were 3 replicates, grown in 38.7 L pots containing a potting mixture of Reddish Brown Latosolic soil and Compost at 2:1 ratio. Different yield parameters were recorded. Mean values of yield attributes such as number of spikes per plant (81), spike length (11.76 cm), filling percentage (88.9%), number of berries per spike (87.4), fresh weight of berries of 10 spikes (128.1 g) and dry weight of berries of 10 spikes (37.9 g) were significantly higher in black pepper vines with the irrigation level of 8 L plant⁻¹ compared to other two treatments. It was also observed that the yield attributes progressively decreased with decreasing level of irrigation in the study. Therefore, an irrigation treatment closer to field capacity (8 L plant⁻¹) is more suitable to get a higher yield in black pepper and further studies are suggested at field level before making recommendations.

Keywords: Black pepper, Moisture stress, Yield attributes

Comparison of DNA Isolation and Dominant and Co-dominant Molecular Markers to Reveal the Genetic Sex of *Gallus domesticus* (Domestic Chickens)

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The whole blood of chickens contains nucleated erythrocytes and thrombocytes which yield high amount of DNA thus cause many troubles during DNA extractions. Optimization of DNA extraction from avian blood is important to yield high quality DNA and is vital for the success of all downstream applications. Determination of genetic sex of chickens is an important aspect in the avian research as well as in layer industry. Among the various methods of sex determination, Polymerase Chain Reaction (PCR) based methods are considered as most accurate and inexpensive. PCR methods have been developed based on the amplification of sex chromosome linked dominant and co-dominant loci in the chicken genome to distinguish between sexes. Success of this PCR based genetic sexing depends on the optimization of the PCR conditions and the reliability and reproducibility of molecular markers. Therefore this study was aimed at investigating the optimum conditions of DNA isolation from chicken blood and to compare the reproducibility of one co-dominant and two dominant sex markers to be validated as a tool for sex determination in avian research. Six different extraction procedures including manual and solution based commercial purification kit were evaluated. Efficacy of procedures was assessed with different combinations of initial blood, lysis buffer, and protein denaturant in related to the DNA yield and purity. Three primer sets namely CHD1, HUR 0423 and HUR 0424 were evaluated for the genetic sexing of chicken by polymerase chain reaction. The study results showed that an initial volume of 10 µL blood yields a significantly high DNA with high purity. Dominant marker HUR0424 showed to be a reliable marker system for the genetic sexing of domestic chickens over co-dominant markers.

Keywords: Dominant markers, Co-dominant markers, *Gallus domesticus*, Genetic sexing, Protocol optimization

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Effect of Storage Conditions on Seed Dormancy and Vigor of Newly Developed Rice Varieties

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Inappropriate storage conditions and seed dormancy affect the seed quality resulting poor germination and loss of vigor. A study was conducted to identify the effect of storage conditions on seed vigor and dormancy of newly developed rice varieties. The experiment was laid down in a split plot design with four replicates. Harvested seeds of 24 varieties were dried and stored at two storage conditions *viz.* cold storage ($18\text{-}20^{\circ}\text{C}$) and ambient ($30\text{-}32^{\circ}\text{C}$) separately. The duration for dormancy of each variety was considered as the period from harvest till germination reached up to 85% and determined using the germination test at one week interval. Seed vigor was investigated by electrical conductivity test and cold test. There was an interaction between storage condition and variety ($P \leq 0.05$) for dormancy period. There was a significant effect of storage condition for seed vigor and dormancy. No significant differences ($P \geq 0.05$) in vigor index between two storage conditions were observed. Varietal variation was observed for dormancy, conductivity and vigor index. Bw12-574, Rathusuduru and Ld11-7-3-1 showed longer dormancy periods under cold (90-100 days) and ambient (48-83 days) storage. At13-3048, At373, Bg15-520 and Ld12-6-22-1 showed shorter dormancy periods under cold and ambient storage (32-62 and 20-27 days, respectively). Bw272-6b, Rathusuduru and Ld12-6-22-1 showed less vigor due to high conductivity values ($0.08\text{-}0.24 \text{ dS m}^{-1}$) and Bw272-6b, Rathusuduru and Bw14-509 showed less vigor due to lower vigor indexes (18.5-22.2). At13-1543, At13-3791, WAS4-2-3 were considered as high vigor varieties due to lower conductivity value ($0.05\text{-}0.12 \text{ dS m}^{-1}$) and higher vigor indexes (27.2-25.5). Since cold storage increases dormancy period it can be recommended for rice seeds with shorter dormancy period to store them longer without breaking the dormancy. Results of this study revealed the importance of manipulating storage conditions to enhance seed vigor and lengthen the dormancy period.

Keywords: Dormancy, Rice, Storage, Variety, Vigor

Yield Response of Cowpea (*Vigna unguiculata* L. Walp) to Different Soil Compaction Levels

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Soil compaction is recognized as one of the major forms of soil degradation. Soil compaction may increase soil potency and thereby can affect on crop production. Under this context, a pot experiment was conducted to see the effect of soil compaction on yield attributes of cowpea (cv. Wijaya) in sandy regosol at the Crop Farm, Eastern University, Sri Lanka. The experiment was arranged in a Completely Randomized Design (CRD) with three replicates. Soil compaction at different bulk density levels (1.60, 1.80, and 2.00 g cm⁻³) was tested and 1.33 g cm⁻³ was used as the control. All other agronomic practices were followed as per the recommendation of the Department of Agriculture. The measurements were taken at the harvesting stage 60 days after sowing (DAS) of cowpea. The results revealed, the yield parameters such as number of pods, pod length, average number of seeds per pod, and average pod yield per plant of cowpea were significantly ($p < 0.05$) reduced by the higher level of soil compaction compared to the control. The highest performance reduction of above parameters was recorded at the compaction level of 2.00 g cm⁻³ followed by 1.80 g cm⁻³. Most of the above parameters in the crop treated with the compaction level of 1.60 g cm⁻³ were comparable with control. Therefore, it can be concluded that soil compaction level greater than 1.60 g cm⁻³ significantly reduces the yield attributes of cowpea.

Keywords: Bulk density, Cowpea, Soil compaction, Yield attributes

Application of Gamma Irradiation as a Quarantine Treatment to Control Fruit Fly (*Bactrocera dorsalis*) Prevailing on Export Potential Mango Fruits in Sri Lanka

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Fruit flies cause considerably serious damage to mango fruits by reducing quality and nutritional suffering. Among all the quarantine treatments, irradiation is unique as it is the only treatment used which does not cause acute mortality; instead, insects are prevented from maturing or are sterilized. Currently there are no any approved irradiation quarantine treatment doses for eggs of *Bactrocera dorsalis*. The objective this study was to determine the effective irradiation dose to control eggs of *B. dorsalis*. Export quality Tom EJC mango fruits which were artificially inoculated with *B.dorsalis* eggs were treated with 100 Gy, 200 Gy and 250 Gy Gamma radiation. The experiment was carried out in Complete Randomized Design with four treatments and a control with three replicates. Each replicate included three fruits where approximately 50 eggs were introduced to each fruit. After exposing to gamma irradiation, there was no any adult emergence but some of eggs were developed into larvae and pupae. No significant difference was observed in titratable acidity, brix, colour, moisture content, pH, texture and water activity of irradiated fruits compared to untreated fruits. Therefore, selected three gamma radiation dosages can be declared suitable for reducing the development of *B. dorsalis* eggs and it does not cause any quality defects to the fruit.

Keywords: *Bactrocera dorsalis*, Gamma Irradiation, Mango, Quarantine

Effect of Selected Plant Aqueous Extracts on Controlling of Brown Plant Hopper (*Nilaparvatalugens*), Paddy Bug (*Leptocorisaooratorius*) And Rice Leaf Folder (*Cnaphalocrocismedinalis*)

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Cnaphalocrocismedinalis, *Nilaparvatalugens* and *Leptocorisaooratorius* are major insect pests in rice which cause a considerable loss of annual rice yield. Synthetic pesticides are widely used to manage pest attacks in rice cultivations in Sri Lanka. Compared to the synthetic pesticides, plant based extracts are usually safer to the environment and humans. This study was conducted to test the bio-efficacy of four selected plant extracts viz *Azadirachtaindica* (Neem), *Annonamuricata* (Anona), *Calotropis gigantean* (Wara) and *Lantana camara* (Gadapana) against *Cnaphalocrocismedinalis*, *Nilaparvatalugens* and *Leptocorisaooratorius* and to compare the insecticidal activity of the commonly used synthetic pesticide with plant extracts against the above-mentioned pests. Aqueous extractions of these plant species were made in three concentrations. i.e. 10 g/100 ml, 50 g/100 ml and 100 g/100 ml. Tested synthetic pesticides against *Cnaphalocrocismedinalis*, *Nilaparvatalugens* and *Leptocorisaooratorius* were Tebufenozone (20 ml/10 l), Thiamethoxam (5 g/16 l) and Carbosulfan (560 ml/ac) respectively. The experiment was laid out in Complete Randomized Design with fourteen treatments including a control with three replicates for each pest. Ten second instar larvae of *Cnaphalocrocismedinalis*, fifteen adult of *Nilaparvatalugens* and thirty adult of *Leptocorisaooratorius* were taken as experimental units. Bioassay methodology was used. Mortality percentage at 96 hours after application of each extract was recorded. It was concluded that in controlling of *Cnaphalocrocismedinalis*, *Nilaparvatalugens* and *Leptocorisaooratorius*, the most efficient plant extracts were *Annonamuricata* (50 g/100 ml), *Azadirachtaindica* (50 g/100 ml) and *Calotropis gigantean* (10 g/100 ml) respectively.

Keywords: Rice pests, synthetic pesticides, plant extracts

Comparison of Two different Commercially Available Vitamin-Mineral Premixes in Broiler Diets on Growth Performance and Meat Quality of Broiler Chicken

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This study was conducted to determine the effectiveness of two different vitamin-mineral premixes on performance, meat quality and meat composition of broiler chicken. A total of ninety ($n = 90$) day-old male broiler chicks were randomly assigned into three dietary treatments. Each treatment comprised three replicates and ten broiler chicks were included in each replicate. Broilers were allocated to one of the three diets and fed for 42 days in a completely randomized design. The dietary treatments included two different premixes as T₁ (Basal diet + Vitamin-Mineral premix 1) and T₂ (Basal diet + Vitamin-Mineral premix 2) and the control group (T₀) fed with the basal diet only. The highest ($p < 0.05$) daily body weight gain (56 gbird⁻¹day⁻¹) and the lowest ($p < 0.05$) feed conversion ratio (1.68) of broiler birds were recorded from the birds fed T₁ diet. The highest (34%) and the lowest cook loss (33%) ($P < 0.05$) were recorded from T₂ and T₁ treatments, respectively. The highest ($p < 0.05$) manganese concentration (0.065 mg/L) and the crude protein percentage (26%) of chicken breast meat were recorded from the birds fed T₁ diet and the lowest manganese concentration (0.0213 mg/L) was recorded from the birds fed control diet. The highest (9%) and the lowest (4%) ash percentages ($P < 0.05$) were recorded from T₂ and T₁ treatments, respectively. The pH, color, water holding capacity and texture of broiler breast meat were not affected ($p > 0.05$) by dietary treatments. In conclusion, the supplemental dietary vitamin-mineral premix 1 has made beneficial effects on performance and meat composition of broiler chicken than the dietary vitamin-mineral premix 2.

Keywords: Broiler chicken, feed conversion ratio, meat composition, weight gain

Effect of Different Levels of a Commercially Available Acidifier on Growth Performance, Meat Quality and *Escherichia coli* Count in the Ileum of Broiler Chicken

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The study reported herein was conducted to investigate the effect of different levels of an acidifier on performance, meat quality, E. coli count in the ileum and the organ weights of broilers. A total of 120-day-old male broiler chicks were randomly assigned into four treatments. Each treatment comprised three replicates of 10 birds each. Broiler chicks were randomly assigned into three acidifier levels (0.5, 1.0 and 1.5 ml/3L) as T₁, T₂, T₃ treatments, respectively. The control group (T₀) treated with normal water only. Broilers were fed with a basal diet for 42 days in a completely randomized design. The highest ($p < 0.05$) daily body weight gain (67 g) and the lowest ($p < 0.05$) feed conversion ratio (FCR) (1.48) were recorded from T₂ treatment. The lowest ($p < 0.05$) E. coli count ($7.314 \log \text{cfu g}^{-1}$) in the ileal digesta content was recorded from T₃ treatment. The lowest ($p < 0.05$) cook loss (31%) was recorded from the control group. The lowest ($p < 0.05$) lightness (65.7) and the highest ($p < 0.05$) redness (10.08) of broiler breast meat were recorded from T₂ treatment. The highest ($p < 0.05$) relative weight of the proventriculus (0.39%) was recorded from T₀ treatment. The highest ($p < 0.05$) relative weights of the duodenum (0.4%) and the caeca (0.3%) were recorded from T₀ treatment and the lowest relative weights of the duodenum (0.22%) and the ceca (0.19%) were recorded from T₂ treatment. The highest ($p < 0.05$) relative weights of the heart (0.67%) and the pancreas (0.27%) were recorded from T₀ treatment and the lowest relative weights of the heart (0.42%) and the pancreas (0.09%) were observed from T₂ treatment. In conclusion, supplementation of an acidifier in 1ml/3L concentration has better effects on performance, E. coli count of the ileum and organ weights of broiler chicken.

Keywords: Acidifier, Feed conversion ratio, Relative weight, Weight gain

Effect of Polybag Size on Growth and Physiological Attributes of Rubber (*Hevea brasiliensis*) Seedlings

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The annual requirement of budded rubber plants [*Hevea brasiliensis* (Willd. Ex A. Juss.) Mull. Arg.] has increased. Currently, finding top soil for filling polybags has become an issue in raising rubber plants. Therefore, it is essential to find ways to minimize the amount of soil usage. The present study examined the effect of the size of polybag on growth attributes of rubber seedlings for an eight-week period. The experiments were conducted in the government rubber nurseries at Egaloya (Wet Zone, LW) and Monaragala (Intermediate Zone, IL). Six bag sizes with reduced volume (3" x 15", 4" x 15", 5" x 15", 4" x 13", 5" x 13" and 6" x 13") as compared to the standard size (6" x 15"-control) were used for LW whereas five bag sizes (6" x 15", 6" x 16", 6" x 17", 7" x 16" and 7" x 17") as compared to control (7" x 18") were used for IL. Germinated seeds were transplanted into each polybag filled with top soil and arranged in a nursery according to a randomized complete block design (RCBD). There were 60 replicate plants for each treatment. Growth and physiological attributes of seedling viz., stem height (cm), stem diameter(mm), number of leaves, chlorophyll content (SPAD value), leaf area (cm²), stomatal conductance (g_s), tap root length (cm), tap root dry weight (g), total root dry weight (g) and shoot dry weight (g) were recorded after 8 weeks from transplanting. There was no significant ($P > 0.05$) difference in growth and physiological attributes of seedlings raised in reduced sizes of polybags when compared to those raised in the standard sized polybags in both agro-climatic zones during the experimental period. Therefore, there is a potential to use reduced sizes of polybags to raise rootstocks of rubber while reducing the amount of soil usage.

Keywords: Growth, Intermediate Zone, Polybag size, Rubber seedlings, Wet Zone

Effect of Deep Litter and Slatted Floor Systems on Broiler Breeder Performance of, Hatchability, Fertility and Exterior Quality of Eggs

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An experiment was conducted to compare the effect of deep litter and slatted floor systems on broiler breeder performance, hatchability, fertility and exterior quality of eggs. A total of 23100 female and 2100 male commercial broiler breeders (Cobb 500) were randomly assigned in to two different treatments and housed under two different rearing systems (deep litter and slatted floor) from 26 to 34 weeks of age. Each treatment replicated three times. Data were recorded daily and analyzed using Analysis of Variance (ANOVA) in Complete Randomized Block Design (RCBD) and means were separated using Tukey's means of comparison. The highest ($P < 0.05$) female body weight (3.6 kg), number of damaged eggs (143) and number of destroyed eggs (99) were recorded from 2/3rd of slatted floor system. The highest ($P < 0.05$) daily egg production (2846), male body weight (4.1 kg), and number of floor eggs (40), number of doubled yolk eggs (270), number of misshaped eggs (12) were recorded from deep litter system. Female and male mortality percentage, egg weight, number of tiny eggs, fertility and hatchability percentages were not affected by floor systems ($P > 0.05$). The results concluded that birds reared on deep litter system were exhibited better broiler breeder performance as compared to slatted floor system during 26 to 34 weeks.

Keywords: Bird performance, Deep litter, Egg quality, Hatchability, Slatted floor

Status of Natural Parasitism of Rice Yellow Stem Borer, *Scirpophaga incertulas* in Bathalagoda Region, Sri Lanka

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The Rice yellow stem borer, *Scirpophaga incertulas* is one of the major insect pests of rice crop in Sri Lanka. This study was conducted to determine the status of natural parasitism of Rice yellow stem borer, *Scirpophaga incertulas* prevailing at pesticide treated and untreated conditions. Egg masses and infested plants with white head symptoms were collected from the experimental sites, reared and kept until the emergence of larvae, pest adult or parasitoids. Parasitized egg masses and parasitized infested plants were counted and emerged parasitoids were identified with the aid of taxonomic key. Weather parameters were subjected to correlation analysis to check whether there is a relationship of the level of parasitization. *Tetrustichus schoenobii* was the recorded egg parasitoid. *Poecilotraphera taeniata*, *Tetrustichus oyyari*, *Tropobraconschoenobil*, and *Cotesia flavipes* were recorded as pupae/larvae parasitoids. Significantly high rate of egg and pupae/larvae parasitization was observed in pesticide untreated fields than the pesticide treated fields. Rainfall, maximum temperature, minimum temperature, humidity morning and evening, and sunshine hours did not show any correlation with parasitization during the *Yala* season of 2017. The egg and pupae/larvae parasitization of yellow stem borer occurred in *Yala* season 2017 in Bathalagoda region.

Keywords: Rice yellow stem borer, Parasitization, Parasitoids

Effect of Phytase Supplementation on Growth Performance, Bone Mineralization, and Fecal Phosphorus Excretion in broilers fed Phosphorus Deficient Diet

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Corn-soybean based broiler diets are rich in phytic acid (Py). The presence of Py is known to lower the phosphorus (P) availability in animal feed. As a result, P is released to the environment with birds' excreta. Microbial phytase (MP) supplementation in broiler diets enhance the P availability. This study was conducted to investigate the effect of MP (Natuphos® E) extracted from *Aspergillus* on growth performance, bone mineralization and P excretion of broilers. A total of 810 day-old (Indian River) male chicks were randomly allotted in to 3 dietary treatments; (1) control group (CON) fed with P sufficient diet without MP, (2) P deficient diet with 0.01% MP and (3) P deficient diet with 0.02% MP in a completely randomized design. Diets were formulated based on nutrition specifications for Indian River. Each dietary group consisted of six replicates. On day 35, final body weights were measured and excreta were collected. Tibia bone samples were collected and analyzed. Broilers fed a diet with 0.02% MP showed the highest daily weight gain (54.22 g), daily feed intake (86.43 g) and 0.01% showed highest feed conversion efficiency (1.51) compared to the CON ($p < 0.05$). Broilers fed a diet with MP showed the highest (0.01%-4.91%; 0.02%-4.39%) tibia P level compared to the CON (3.55%) ($p < 0.05$). Fecal P excretion was lower in broilers fed a diet with MP compared with CON (72.44%) ($p < 0.05$). The lowest (14.09%) P excretion was observed in broilers fed the diet with 0.02% MP compared to those fed a diet with 0.01% MP (38.22%) ($p < 0.05$). Tibia P level showed a strong negative correlation ($r = 0.829$; $p < 0.01$) with P excretion. In conclusion, broilers fed a diet with MP enhanced the P retention that supported the growth performance, and tibia bone development. The results of this study suggested that the supplementation of 0.02% MP in P deficient broiler diets could replace Dicalcium phosphate usage for improved growth performance and P retention of broilers.

Keywords: Dicalcium phosphorus, Fecal phosphorus, Microbial phytase, Phosphorus excretion, Tibia phosphorous

Evaluation of Different Methods of Reducing Night Temperature in Seed Potato (*Solanum tuberosum L.*) Production in Simplified Nutrient Film Technique

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Potato is a starchy, tuberous crop belongs to the family *Solanaceae*. Although potato is the 4th largest food crop and the staple food in some countries, potato is commercially grown only in Nuwara-Eliya, Badulla, Jaffna and Puttalam districts in Sri Lanka. However, Seed potato is mainly produced in Nuwara-Eliya due to favourable weather conditions in this area especially low night temperature. Seed potato production in Bandarawela is relatively low because of the high temperature compared to Nuwara-Eliya. Tuberization is promoted under low night temperatures. Because of that high night temperature in Bandarawela may reduce tuberization. Thus, reducing night temperature by different methods may help to increase the seed potato production. The current study was conducted under controlled environmental conditions using Simplified Nutrient Film Technique (SNFT) to identify the best method to reduce night temperature for seed potato production in Bandarawela. Five night temperature controlling methods (T1-Control, T2-Mini exhaust fans in bins, T3-Fan pad method combined with mini exhaust fans in bins, T4-Fan pad, T5-Nutrient cooling) with three replicates were installed and plant performances were measured once a week. Key yield determining parameter, number of tubers (25) was significantly higher in SNFT with T3 compared to other treatments (T1-13, T2-12, T4-19, T5-14). Mean values of plant height (cm), stem height (cm), number of stolons, root volume (cm³) and stolon volume (cm³) were significantly higher in T3 (126.8, 102.6, 15, 14.3, 10.3, respectively) compared to control (105.9, 76.7, 10, 12.4, 6.4, respectively). Moreover, T3 reduced the night temperature by approximately 1-2 °C. Therefore, fan pad method combined with mini exhaust fans in bins method is the most suitable method to reduce night temperature for seed potato production in Bandarawela region.

Keywords: Night temperature control, Plant performance, Seed potato, Simplified Nutrient Film Technique

Evaluating the Effect of Selected Synthetic Chemicals on the Growth of *Pseudomonas spp.* in Nitrile Latex

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Glove industry isconsiderable among the industries operating in Sri Lanka because of its significant contribution to the national economy. The presence of microorganisms in latex makes a severe impact on the properties of final product and, on human health. Specially, the *Pseudomonas spp.* pathogenic on human reported to produce a problematic bacterial slime layer on latex dipping tanks, in nitrile latex based disposable glove industry. This study was conducted to select a suitable synthetic antimicrobial chemical compounds to produce good quality glove products at low cost and withless impacts on human health. *Pseudomonas spp.*bacteria were isolated on selective culture medium, and identity of the bacterium wasconfirmedusing gram staining, methyl red reduction, H₂S and the catalase tests. The effectiveness of changing process parameters such as pH level and temperature according to company standards and selected synthetic antimicrobial compounds namely; acticide biocide and proxel gel biocide were evaluated. The effect of changing process parameters and selected synthetic chemical compounds on tensile properties of the nitrile latex gloves were statistically tested,using one-way ANOVA. Accordingly, a significant reduction of bacterial growth on nitrile latex with decreased tensile properties on gloves was found after adjusting pH level of latex dipping tank into 10.5 using KOH and NH₃. Further, the treatment with biocides wasidentified as the best bacterial control method and it was found that the acticide biocide was better than proxel gel biocide. Treatment with acticide biocide in the medium did not result in a significantdamage on the tensile properties of nitrile latex gloves. Therefore, acticide biocide can be applied for minimizing the growth of *Pseudomona sspp.* in nitrile latex glove production at low cost and with high bio security.

Keywords: Biocides, Gloves, Nitrile Latex, *Pseudomonas spp.*

Effect of Organic and Conventional Management of Tea [*Camellia Sinensis* (L.)O. Kuntze] Cultivation on Soil Productivity and Crop Response of Tea on the Fifth Pruning Cycle

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In organic tea cultivation, poor productivity is a major problem despite its all other benefits. This study attempted to assess long term impacts of field grown tea at the fifth pruning cycle under organic and conventional management in the long term TRIORCON trial established at Tea Research Institute, Talawakelle. Organic management treatments included tea waste, neem oil cake and compost and the conventional system was under TRI recommendations on agro inputs. Selected crop and soil indicators were studied. In parallel, beans grown on relevant soils under glass house conditions were used as indicator plants to elucidate short term effects. Data analysis was undertaken using SAS statistical package by analysis of covariance. Results revealed that chemical parameters of organically treated soils differed significantly ($P < 0.05$) from those of the conventionally treated soil. Soil pH was within the suitable range in the four treatments. Soil organic carbon contents in organic (Compost) and conventional systems were 3.69 and 2.60%, respectively. Total N content (%) was 0.40 and 0.26 under organic (Compost) and conventional systems, respectively. Soil exchangeable K shown in organically treated soil (Tea waste) was 116.25 ppm. The highest soil available P was determined in the conventionally treated soil, 53.75 ppm. The highest biological richness was exhibited as $66.42 \text{ CFU mg}^{-1}$ in the organically treated soils (Tea waste) whereas the lowest richness ($30.25 \text{ CFU mg}^{-1}$) was observed in the conventionally treated soil. The overall yield drop in this organically treated cultivation system was 25% lesser than that of the conventionally treated tea. Shoot length and shoot: root ratio of beans was not significantly ($P > 0.05$) different. Proper crop and soil fertility management with organic systems is expected to maintain the organic system to be healthy and also to ensure premium price for the product while demonstrating environment and social benefits.

Keywords: Conventional soil management, Crop parameters, Organic agriculture, Soil chemical properties, Yield of tea

Analysis of Pesticide Residues in Fruits and Vegetables exported to the European Union and determining the effect of Chlorine Treatment on Diazinon Residues

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Presence of pesticide residues in agricultural commodities can cause acute and chronic toxicities on humans. The objective of this study was to develop a monitoring programme to regulate the pesticide usage of farmers and to determine the effect of chlorine treatment on diazinon residues of tomato and bean samples. Two surveys were conducted to identify the malpractices of the farmers and exporters who cultivate and process the commodities, which are exported to the EU. A total of 98 samples of fresh fruits and vegetables were analysed for the presence of 66 active ingredients of pesticides. The quick easy cheap effective rugged and safe multi-residue extraction method was followed, using gas chromatography mass spectrometry. There were no malpractices were identified at farmer level while three malpractices were identified at exporter level. Analytical results revealed that only 26% of the samples were positive for pesticide residues. Pesticide residues above the European Union Maximum Residue Limit (MRL) were detected in 65% of samples among the contaminated. Multiple residues (2-3) were present in 11% of contaminated samples. Eleven pesticides were detected, of which 7 were insecticides, 4 were fungicides and no weedicides. Mostly detected active ingredients were profenophos and etofenphox, both of which were insecticides and carbendezim, a fungicide. The chlorine treatment had a significant effect on reduction of Diazinon residues in tomato ($p = 0.024$) and bean ($p = 0.005$) samples. The results confirmed the presence of pesticide residues in fruits and vegetables exported to the EU. Chlorine treatment at 150 ppm dosage could effectively reduce the residues of diazinon in tomato and beans.

Keywords: Pesticides, Residues, Chlorine, Maximum Residue Limit, Pesticide Contamination

Selection of Elite Hybrids of Rice Based on Combining Ability and Heterosis

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The general combining ability (GCA) of the parents and specific combining ability (SCA) and standard heterosis, mid parent heterosis and heterobeltiosis of the hybrids of rice were analyzed in an experiment involving 16 F₁ hybrids and their parents (Cytoplasmic male sterile lines CMS91, CMS117, CMS73, CMS25) and restorer lines, (Res156, Res160, Res316 and Res290). All the crosses and parents were evaluated along with three standard check rice varieties, BG403, BG357 and BG304. The observations were recorded on 11 morphological and agronomic traits including, productive tillers per hill, 1000 grain weight, number of filled grains per panicle, plant height, panicle length, days to 50% flowering, flag leaf length, flag leaf width, root dry weight, root volume and yield per hill. The crosses were categorized as three months, 3.5 months and four months hybrid lines, based on 50% flowering data. The study revealed significant differences among the parents for most of the characters except yield per hill, productive tillers per panicle, filled grains per panicle, root volume per hill and root dry weight. CMS73, CMS25 and Res160 exhibited positive significant GCA values for thousand grain weight, flag leaf length and flag leaf width, respectively. SN290 exhibited a significant negative GCA value for plant height. None of the parents or hybrids showed significant GCA or SCA effects in the desired direction for all the traits studied. Evaluation of the overall performance of hybrids obtained for standard heterosis, heterobeltiosis and specific combining ability, with respect to yield related traits revealed, CMS91 x Res316, CMS117 x Res160, CMS117 x Res316, CMS73 x Res160, CMS73 x Res316, CMS25 x Res160 and CMS25 x Res156 to be elite hybrids. CMS73 and CMS117 and CMS25 were identified as good testers and Res160 and Res316 were found to be better performing lines or restorers.

Keywords: GCA, SCA, Combining ability, Heterosis, Hybrid rice

Field Evaluation of Different Coffee Cultivars (*Coffea sp.*) Against Infestation of Coffee Berry Borer (*Hypothenemus hampei* Ferrari)

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One of the major constraints to coffee production throughout the world is the damage caused by the Coffee Berry Borer (CBB), *Hypothenemus hampei* (Ferrari). The first report of the occurrence of CBB appears to be that of 1935 in Rathnapura district in Sri Lanka. It is now prevalent in all areas, at varying degree of damage to both Arabica and Robusta coffee. Damage on coffee berries bribs in heavy losses on economical production of coffee in developing countries, including Sri Lanka. The objective of this study was to identify the infestation level of CBB in six selected coffee cultivars and to assess the CBB populations in coffee fields. Six selected coffee cultivars were, Catimour, S4711, HDT of Arabica species and IMY, CCI, BS5 of Robusta species. The experiment was laid out in randomized complete block design, with six treatments and three blocks. Damage severity was recorded on fifty-four tagged coffee plants. Ten branches were selected for a coffee plant where each branches contained more than fifty berries. Data were collected on the same berry cluster, during three months at weekly intervals. Starting from zero damaged berries, diameter of coffee berry was measured by using a Vernier Calliper (0.1mm). Ninety coffee berries were randomly selected from each of Arabica and Robusta for measurements. The data were recorded continuously during the three months at weekly intervals. The results showed that there were significant CBB damage differences among the coffee cultivars. Among the selected cultivars BS₅ was the least damage by CBB and HDT was the most susceptible cultivar and S4711 was also found to be susceptible but to a lesser extent. Berry Borer population is high in Arabica field than in Robusta field. When the diameter of the coffee berry increase, the level of infestation of CBB also increases.

Keywords: Coffee Berry Borer, Infestation, *Hypothenemus hampei* Ferrari

Development of Fumigation Protocol for Liquid Phosphine for the Control of Rice Weevil (*Sitophilus oryzae*) in Stored Milled Rice

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An experiment was designed to develop a fumigation protocol for liquid phosphine (2% phosphine and 98% liquid carbon dioxide) to control rice weevil (*Sitophilus oryzae*) in stored milled rice and thereby to increase the food safety at the quarantine service in Sri Lanka. The experiment was laid out in a Complete Randomized Design with eight concentration levels of liquid phosphine; 10, 20, 35, 50, 100, 150, 200, and 250 g (equivalent to 140, 280, 490, 700, 1400, 2100, 2800, and 3500 ppm, respectively) with a control treatment. All treatments were replicated three times. Each concentration level was tested under two time regimes (24 and 36 hrs.) and 50 same-aged adults were introduced to glass vials with 50 g of milled rice in each. Similarly, other life stages viz. pupae, larvae and egg infested rice, each weighing 50 g, were introduced separately to vials for fumigation. Mortality of *S. oryzae* was recorded soon after the fumigation as well as 1, 4, 7, 14, 21, 28 and 35 d after fumigation. In the eight treatments, except for the control treatment, 100% mortality was recorded in the adult stage, in both time regimes. After 14 d of treatment, all tested concentration levels against pupae of *S. oryzae* showed mean newly emerged adult numbers of 0.67, 0.67 and 0.33 ($P < 0.0001$) at 140, 280 and 490 ppm, respectively, for the 24 hrs. time regime and 0.33, 0.33 and 0.67 ($P = 0.053$) at 140, 280 and 490 ppm, respectively, for the 36 hrs. time regime. After 28 d, 24 hrs. treatment of liquid phosphine concentrations against the eggs of *S. oryzae* recorded a mean newly emerged adult number of 0.67 ($P = 0.003$) at 280 ppm whereas the 36 hrs. treatment of liquid phosphine yielded adult numbers of 0.33 and 0.33 ($P = 0.322$) at 140 and 280 ppm, respectively. The lowest concentration and the lowest fumigation time to achieve 100% mortality of all stages of *S. oryzae* was 700 ppm with 24 hrs. of fumigation time. Therefore, the concentration level of 700 ppm with 24 hrs. of fumigation time can be declared suitable for achieving 100% mortality of *S. oryzae*, as per the present findings.

Keywords: Fumigation, Liquid Phosphine, *Sitophilus oryzae*, Rice

Assessment of Avocado as a Potential Alternative Host Plant for *Colletotrichumgloeosporioides* Causing Nutmeg Leaf Fall Disease

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Nutmeg (*Myristicafragrans*) is an important Export Agricultural Crop grown in Sri Lanka. It is mainly distributed in Kandy and Matale Districts. Nutmeg Leaf Fall Disease (NLFD) was reported as an economically important disease in 2004 and *Colletotrichumgloeosporioides* was identified as the causal organism of the disease. Avocado, mix cropped with nutmeg in Kandyan home gardens reported some diseases with the same causal organism as that causing NLFD. Therefore, the study was conducted to assess the potential of avocado being an alternative host to the causal organism of NLFD and to upgrade the existing Integrated Disease Management practices of NLFD. The cross infection potential by *C.gloeosporioides* isolated from nutmeg leaves and avocado fruits were tested through cross inoculation between healthy avocado fruits and healthy nutmeg seedlings. Pathogenicity was quantified calculating Percent Disease Index (PDI) and Virulence Index (VI). The results revealed that there is a possible disease causing ability of both crops by each isolated strains of *C.gloeosporioides* in both ways. The calculated PDI values were 15% and 55% and VI values were 20.2% and 25.8% for nutmeg and avocado, respectively. Thus, avocado plant was identified as a potential alternative host for the causal organism of NLFD. Therefore, the field sanitation of avocado plants must be recommended as an additional measure, where nutmeg and avocado are grown together to avoid spreading of NLFD as a long term disease management strategy.

Keywords: Nutmeg Leaf Fall Disease, *Colletotrichumgloeosporioides*, Alternative host, Cross inoculation

Effect of Propagator Height on Growth and Survival Rate of Black Pepper (*Piper nigrum L.*) at Nursery Stage

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Black Pepper (*Piper nigrum L.*) is a spice belongs to family Piperaceae and known as the “King” of spices. Propagation through stem cuttings is the common practice. Before field planting, stem cuttings should be kept about 1.5 months inside the propagators and another two months under hardening process at the nursery stage. There is a need to identify the proper height of propagator which gives the highest growth and survival rate. Objective of the study was to increase the growth rate of pepper cuttings to produce field-ready plants within a short period of time by changing the propagator height. The experiment was conducted at the Central Research Station, Matale, Sri Lanka, during August to November 2017 and six different propagator heights (30, 40, 50, 60, 70, and 80 cm) were used as the treatments with 3 replications. Growth parameters such as number of leaves, shoot length, root length, number of roots and root volume and survival percentage were analyzed using ANOVA technique. Propagator with 50 cm height produced plants with significantly highest performance with respective to the above growth parameters except number of leaves compared to 60 cm propagator (current practice). Survival percentages in 50 cm and 60 cm propagators are 99.3% and 98.6% and root volumes were 0.85 cm³ and 0.73 cm³, respectively. Therefore, propagator with 50 cm height can be recommended to propagate pepper cuttings within shorter period of time in place of 60 cm propagator.

Keywords: Black pepper, Growth, Propagator height, Stem cuttings, Survival percentage

Comparison of High Performing Seedlings and Vegetatively Propagated Tea Cultivars in Selected Tea Estates in Badulla.

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Prolonged drought is a major problem that prevails in Badulla. There are well adapted seedling teas in estates which also gives a higher yield like TRI recommended cultivars. This study was conducted for comparison of morphological characters of high performing seedling teas and extensively used vegetatively propagated tea cultivars in selected tea estates of Badulla. Three estates were selected based on the climatic conditions and the recommendation by the Balangoda Plantations PLC. Fifteen morphological characters were considered for the cluster analysis such as number of pluckable shoots, shoot weight, banji shoots, internodal length, leaf angle and pose, leaf length, leaf width, young leaf pubescence, leaf waxiness, greenness, waviness of leaf lamina, leaf blade attitude, pigmentation of leaf petiole and stomatal density. Measurements were taken from five seedling teas as S1, S2, S3, S4 and S5 and three recommended vegetatively propagated cultivars from each estate. Mean comparison was conducted for the characters which were significantly different. Selected teas were clustered separately without overlapping and showed each as a specific genotype. S2 seedling clustered with TRI 3015 and showed the highest mean value for considered characters in Uryestate. S3 seedling showed the highest mean values but none of the TRI recommended cultivars were clustered with S3 in Thelbedda estate. In Spring Valley mean values of S5 was the highest and clustered with CY9. Therefore S2 from Ury, S3 from Thelbedda and S5 from Spring Valley can be recommended as potential mother bushes to obtain cuttings for nurseries.

Keywords: Morphological characterization, Seedling teas, Vegetatively propagated cultivars, Mother bushes

Investigating the Association between Vesicular Arbuscular Mycorrhiza (VAM) and *Commelina benghalensis*

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A study was conducted to investigate the presence of an association between the Vesicular Arbuscular Mycorrhiza (VAM) and *Commelina benghalensis*. The effect of *C. benghalensis* as a weed was also studied as a specific objective. A pot experiment was carried out using single nodal stem cuttings of *C. benghalensis* and chili plants applied in 4 treatments, i.e. 3 stem cuttings + 2 chili plants (Treatment 1), 6 stem cuttings + 2 chili plants (Treatment 2), 6 stem cuttings alone (Treatment 3) and 2 chili plants alone (Treatment 4). Experiment was carried in a Completely Randomized Design with 10 replicates. As an indicator plant, chili seeds were sown after 3 days of planting weed cuttings and thinned out upto two plants per pot. Growth measurements of chili (height) and *C. benghalensis* (creeper length) were measured at fortnight intervals. After 10 weeks of planting cuttings, fresh and dry weights of chili and weed were measured, soil nutrient analysis for Carbon, Nitrogen and Phosphorus for each treatment was done, soil VAM spore counts were taken and root colonization percentages of VAM were calculated from each treatment. Root colonization percentages and the spore counts gave no any significant difference among treatments having *C. benghalensis*. Root colonization percentage by VAM ranged from 50-55% at 10 weeks after planting and the soil VAM spore count ranged 170-185 per 100 g of soil. Soil phosphorous level was significantly higher in pots with *C. benghalensis* due to Phosphorous solubilization. Therefore, the limiting factors for plant growth seemed to be some other nutrients or factors, rather than Phosphorus. Longest creeper length, creeper fresh and dry weight were observed in treatment 3 and significantly lower in treatment 2. Height, and fresh and dry weight of chili were significantly lower in treatment 2 and treatment 3 compared to treatment 4. The study concluded that there is an association between VAM and *C. benghalensis* and although there is a competition between the weed and the crop there are some favorable effects particularly due to Phosphorus solubilization.

Keywords: Vesicular Arbuscular Mycorrhiza (VAM), *Commelina benghalensis*, Soil spore count, Root colonization

Effects of Moisture Stress on Selected Biochemical Parameters and Yield of Three Tomato (*Solanum lycopersicum* Mill.) Cultivars during the Flowering Stage

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There is a need to utilize water efficiently and effectively because water availability is scarce in the Dry Zone of Sri Lanka. Tomato is grown in the Batticaloa district to a limited extent. The yield is low because growth of tomato is highly affected by moisture and heat stresses especially during the *Yala* season. This experiment was conducted in a farmer's field near to the Eastern University of Sri Lanka at Batticaloa district. Investigations were carried out to determine the effect of moisture stress on selected biochemical parameters of three tomato cultivars viz. 'Roma', 'Thilina' and 'KC1' during the flowering stage and to find out the most suitable tomato cultivar which resists to drought without much yield reduction. This experiment was laid out in the Two Factor Factorial Randomized Complete Block Design with six treatments and four replications. Moisture stress was imposed for a period of six days for the treated plants during the flowering stage. The control plants were irrigated daily to the Field Capacity. Free proline and lycopene contents were significantly higher and chlorophyll content was significantly lower in the stressed than that of control treatments. The 'KC1' tomato cultivar showed the highest amount of free proline (0.56 mg cm^{-2}) and lycopene (73.6 mg g^{-1}) contents and lowest amount of chlorophyll (0.28 mg g^{-1}) content than Roma (0.54 mg g^{-1}) and Thilina (0.37 mg g^{-1}) cultivars. Moisture stress significantly ($p<0.05$) reduced the yield of 'KC1', 'Roma' and 'Thilina' tomato cultivars. The highest yield (5252 kg ha^{-1}) was obtained in the 'KC1' with low (14%) yield reduction and the lowest yield (4080 kg ha^{-1}) was found in 'Thilina' with high (31%) yield reduction under moisture stress. From these results it could be stated that 'KC1' was able to resist drought better than the rest of the tomato cultivars and produced the yield well under this condition. Hence, 'KC1' tomato cultivar could be suggested for tomato growers in the drought prone areas in Batticaloa District.

Keywords: Free proline, Lycopene, Moisture stress, Tomato, Yield

Assessment of Environmental Impact of Selected Herbicides Used in Rice Farming in Sri Lanka

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Environmental hazard of pesticides are estimated using Environmental Impact Quotient (EIQ) method. Commonly used 12 herbicides were selected for the assessment of EIQ in order to know what the eco-friendly herbicides to be used. EIQ values were calculated for one hectare using EIQ calculator which is available online at http://www.nysipm.cornell.edu/EIQ_Calc. Among the selected herbicides, *Propanil* 360 g/l EC showed the highest field use EIQ of 41.2 having the biggest impact. *Ethoxysulfuron* 15% WG had the lowest field use EIQ of 0.1 with the lowest impact. Ecological impact of MCPA 600g/l SL, MCPA 400g/l SL and Glyphosate 360g/l SL was also higher in comparison to other herbicides. *Azim sulfuron* 50% WG, *Bispyribac sodium* 100g/l, *Bispyribac sodium* 20% WP, *Penoxulam* 240g/l ISC, *Cyhalofop-butyl* 100g/l, *Fenoxyprop-p-ethyl* 75g/l EW, *Ethoxysulfuron* 15% WG and *Carfentrazone-ethyl* 240g/l EC have shown lower field use EIQ and therefore they were more environmental friendly herbicides.

Keywords: Ecological Impact Quotient

Effects of Selected Growth Regulators and Botanical Extracts on the Growth and Flowering of Anthurium (*Anthurium andeanum* L.)

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Anthurium is a popular tropical cut flower in Sri Lanka and mainly cultivated for the export market. There are many factors affecting growth and flowering of Anthurium. Growth regulators have significant effect on growth and flowering of cut flowers such as Anthurium. An experiment was conducted under a shade house to determine the effects of different growth regulators and botanical extracts on the growth and flowering of Anthurium in the Crop Farm, Eastern University, Sri Lanka. Five treatments namely, T1: Control, T2: Ethylene (480g L⁻¹), T3: Gibberellic Acid (100mg L⁻¹), T4: Fruit tonic (5%) and T5: Seaweed (*Sargassum crussifolium* L.) extract (20%) were used. The experiment was arranged in a Completely Randomized Design with five replications. Recommended agronomic practices were followed uniformly for all treatments. Foliar application of growth regulators and botanicals were carried out in two weeks interval during flowering stage. Number of leaves and number of flowers per plant were measured at two weeks interval. Leaf area and plant biomass were measured at the end of the experiment. Analysis of Variance was performed to determine significant difference among treatments ($p < 0.05$). Results revealed that seaweed extract applied showed significantly ($p < 0.05$) higher values in the measured parameters than the other treatments. It could be due to the presence of macro and micro nutrients and the growth promoting substances in the *Sargassum crussifolium* L. seaweed extract. Seaweed extract could also act as a bio stimulant on Anthurium plants and increase growth and flowering. From the findings, it could be concluded that, application of Seaweed (*Sargassum crussifolium* L.) extract (20%) can be used to increase the growth and flowering in Anthurium.

Keywords: Biomass, Bio stimulant, Growth regulators, Leaf area, Seaweed extract

Induction of Mycorrhizal Associations in *Piper nigrum* L.

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Black pepper (*Piper nigrum* L.) is used as a spice and the demand for organic spices is increasing. In organic farming, arbuscular mycorrhizal (AM) fungi are used as biofertilizers. Hence, the feasibility of inducing micorrhizal associations in pepper was investigated. Four inoculum levels of native *Glomus* sp. were tested in pot experiments to find out the effective spore density for inoculation. Inoculum levels were prepared by incorporating different numbers of viable (brown colored) spores per 800g pot: 400 spores(T1), 800(T2), 1200(T3) and 1600(T4). Completely randomized design was used with five replicates. Destructive sampling was done at 12th, 20th and 28th weeks post inoculation. The measurements taken were: plant height, shoot dry weight, root dry weight, number of leaves, and stem diameter at the collar region. Fungal colonization was observed in cleared roots under the microscope. Final AM spore density of soil was quantified. Data were statistically analyzed. All four treatments were successful in infecting pepper roots. The brown spore density was significantly different at 20th and 28th week of post inoculation. The mean number of spores was high in T2, 42.4 at 20th week and 41.2 at 28th week post inoculation. The brown spore densities of T2 and T3 increased with time while T1 and T4 showed a decrease. The shoot and root dry weights were significantly different ($p < 0.05$) at the first and second destructive sampling. The mean plant height was the highest in T2 at 12th, 20th and 28th weeks recording the heights being 36.42 cm, 60.76 cm and 95.9 cm, respectively. Shoot dry weight was high in T2: 2.45 g, 3.27 g and 5.72 g at 12th, 20th and 28th weeks, respectively. Root dry weight was high in T4, 0.22 g at 12th, T2 and T4 0.27 g at 20th and T1 0.57 g at 28th weeks. Accordingly the pot which incorporated 800 spores was found to be the most effective. Hence, the spore density influences for better colonization and simultaneous improvement in growth parameters.

Keywords: *Glomus* sp., Spore, Density, Pepper

Pesticide-Related Risks Associated with the Crop Management Practices Performed by Small-Scale Tomato Growers in Mid Country, Sri Lanka

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Improper use of pesticides and pesticide residues pose a great threat to food safety and environmental health. Thus, the present study was conducted to assess the pesticide-related risks associated with tomato, a crop which is exposed to heavy usage of pesticides. The study was conducted using small-scale tomato farmers in Marassana, Sri Lanka. A detailed questionnaire based farmer survey was carried out using thirty farmers to evaluate the current pesticide handling practices adopted by them. Further, using three selected farmer fields in the study area, analysis of pesticide residue levels in tomato samples, collected at the time of harvesting according to our instructions, was done by Gas Chromatography-Mass Spectrometry and Gas Chromatography-Electron Capture Detection techniques. Findings of the present study revealed the presence of Chlorothalonil (0.066 mg kg^{-1}), Profenofos (0.024 mg kg^{-1}) and Phenthroate (0.096 mg kg^{-1}) in the collected tomato samples. According to CODEX guidelines Maximum Residue Limits (MRL) for Chlorothalonil, Profenofos and Phenthroate are 5 mg kg^{-1} , 10 mg kg^{-1} and 7 mg kg^{-1} respectively. Based on CODEX limits, in all the cases, detected pesticide residue levels were below the maximum residue limits (MRL). Moreover, the survey revealed that majority of the farmers in the study area do not practice the recommended pre-harvesting interval, do not dispose empty pesticide containers and do not follow protective measures during the application of pesticides according to safety recommendations. Even though, the detected pesticide residue levels in the selected farmer fields were below the MRL levels it indicates the potential risk of accumulation of pesticide residues in tomatoes and the results of the farmer survey indicate the potential risks associated with improper pesticide handling practices. Therefore, the present study emphasizes the importance of shifting to eco-friendly agricultural practices to ensure food safety and sustainability.

Keywords: Pesticides, Tomatoes, Chlorothalonil

Determination of Differences in Heat Tolerance of Exotic Coconut (*Cocos nucifera L.*) Cultivars by *In vitro* Pollen Germination

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Different germplasm accessions available at Coconut Research Institute of Sri Lanka have been used for developing new crosses with favorable characteristics such as high yielding potential and resistance to abiotic stresses. Some crosses which were developed using exotic pollens have been evaluated using some physiological traits yet some important flower characteristics have not been assessed. As nut is the main economically important component of coconut, it is essential to evaluate the reproductive performance of such new hybrids. Successful fruit set in coconut depends on several reproductive processes. These processes heavily depend on environmental conditions. Along with the phenomenon of global warming, it is imperative to identify the potential of new exotic hybrids which can withstand high temperatures. The pollen germination response was quantified in order to determine the differences in heat tolerance and to determine cardinal temperatures of four exotic coconut cultivars by *in vitro* pollen germination. Newly developed exotic hybrids namely TBGD, TRIT, TTMRD and TTAGT planted in the Middeniya Research Center were used. Pollens were collected from six palms from each hybrid. Pollen germination percentage was recorded after incubation for 20 hours in artificial growth media under different temperatures range from 22 °C to 40 °C. Quadratic model best described the response of pollen germination to temperature. All hybrids reached maximum pollen germination mostly in the range of 26 °C – 32 °C. The monthly mean cardinal temperatures over hybrids ranged from 18.52-23.09 °C, 22.08-32.73 °C, 36.91-56.42 °C for TBGD, 16.92-21.71 °C, 22.15-31.80 °C, 40.44-43.62 °C for TRIT, 8.89-21.53 °C, 28.71-31.84 °C, 40.36-48.53 °C for TTAGT and 18.11-21.54 °C, 29.43-32.44 °C, 39.99-43.91°C for TTMRD. It is evident from the results that all exotic hybrids have a wider temperature adaptability than most of the commercially grown cultivars in Sri Lanka.

Keywords: Cardinal temperatures, Exotic hybrids, Heat stress

Effects of Different Population Densities on the Growth and Yield of Maize (*Zea mays L.*) var. ‘Bhadra’ in the Batticaloa District of Sri Lanka

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An experiment was carried out to determine the effects of different population densities on the growth and yield of maize (*Zea mays L.*) var. ‘Bhadra’ in the Batticaloa district of Sri Lanka during the period of June to September, 2017. The experiment was arranged in a randomized complete block design with three replications. Plant population densities were defined as treatments *viz.* 111,111 plants ha^{-1} (T1), 83,333 plants ha^{-1} (T2), 55,555 plants ha^{-1} (T3), 41,666 plants ha^{-1} (T4), and 33,333 plants ha^{-1} (T5). In this experiment, T3 was the control treatment as per recommendation of Department of Agriculture, Sri Lanka. Agronomic practices were followed uniformly for all treatments as recommended by the Department of Agriculture, Sri Lanka. Growth parameters *viz.* plant height, leaf area, plant biomass were measured at monthly interval and yield parameters were measured at the end of the experiment. Analysis of Variance was performed to determine significant difference among treatments ($p < 0.05$). Results revealed that plant height, leaf area, plant biomass and thousand seeds weight of the maize var. ‘Bhadra’ were significantly higher in 41,666 plants ha^{-1} (T4) compared with T3. It could be the optimum plant population for maize cultivation in Batticaloa district. Plants grown at this population density would have received optimum amount of resources. Therefore, growth and yield of maize var. ‘Bhadra’ was higher at this treatment. The lowest population density (33,333 plants ha^{-1}) and the highest population density (111,111 plants ha^{-1}) reduced the growth and yield of maize var ‘Bhadra’. From this experiment, it could be stated that the optimum population densities of maize var. ‘Bhadra’ was 41,666 plants ha^{-1} for the cultivation in the Batticaloa district of Sri Lanka.

Keywords: Optimum population, Maize population density, Growth parameters of maize, Thousand seeds weight

Identification of Factors Affecting Milk Production of Dairy Cattle at Galenbindunuwewa Veterinary Region in Anuradhapura District

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Dairy cattle farming is a key sector in livestock subsector which plays a crucial role as a source of income and a source of nutrients to the Sri Lankan community .This study was carried out to investigate the present status of milk production and to identify the main factors affecting daily milk production at Galenbindunuwewa veterinary region in Anuradhapura District. Total of 300 dairy farmers were selected using Stratified and Simple Random sampling techniques. Milk production and socio-economic data were collected using a pre-tested structured questionnaire covering 41 Gramaniladari divisions in this region. Data were analyzed for descriptive analysis followed by Regression Analysis model using Minitab 17 statistical software. Results of the study revealed that the dairy cattle farming is operated as the major income source of this area (69.4%). With average wean age of 3.14 months, Jersey Sahiwal cross breed was the major breed (28.5%) accounts for 14.8 L/herd average daily milk production. The best fitted multiple linear regression model predicted that of the value of 74.66% daily milk production suggesting that the number of milking cows in the herd, type of breeds, supply forage type, amount of night feeding supply, amount of mineral supplement, roughages feeding methods, concentrate feeding frequency per day, amount of concentrate supply, concentrate type, feed and water availability in cattle shed significantly ($P < 0.05$) affect the daily milk production. However, lack of housing facilities, poor quality feeds and water, less success in artificial insemination (AI) were reported as key constraints which need to be properly focused in future to increase milk production in Galenbindunuwewa veterinary region in Anuradhapura District.

Keywords: cattle farming, constraints, milk production, regression analysis

Effect of Graded Shade Levels on the Growth and Quality of *Polyscias guilfoylei* ‘variegata’ in the Batticaloa District of Sri Lanka

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Identification of optimum shade level is essential for the cultivation of ornamental foliage plants. A shade house experiment was carried out to assess the effects of graded shade levels on the growth and quality of *Polyscias guilfoylei* ‘variegata’, in the Batticaloa district during the period of July to November 2017. The experimental location was crop farm, Eastern University, Sri Lanka. The experiment was arranged in a completely randomized design with twenty replications. Graded level of shades were defined as treatments *viz.* open field (T1), 50% (T2), 60% (T3), 70% (T4) and 80% (T5) of shade levels. Shade houses were constructed using commercial nylon nets of different shade levels. Rooted and uniform cuttings were used as planting materials. Agronomic practices were followed uniformly for all treatments. Plant height, leaf area, number of leaves and plant biomass were measured at monthly interval and quality of cuttings was assessed at the end of experiment as per the criteria given by Conover and Poole (1986). Analysis of Variance was performed to determine significant difference among treatments ($p < 0.05$). Plants provided with 70% shade level showed significantly ($p < 0.05$) better performance in measured growth parameters. In quality assessment also, plants grown at 70% shade level (T4) received significantly highest score. From this study it could be concluded that, 70% shade level is suitable for the export oriented cultivation of *Polyscias guilfoylei* ‘variegata’ in the Batticaloa district as the growth and quality of the plants was higher.

Keywords: Biomass, Leaf area, Quality assessment, Shade level

Effects of Different Levels of Dietary Vitamin Premix (ENHALOR) in Diets on Growth Performance and Meat Quality of Broiler Chicken

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Poultry industry is a well-established livestock industry in Sri Lanka. The profitability of the industry depends on growth performance and meat quality of broilers and various feed additives are used in the industry. This research was conducted to determine the effect of different level of dietary vitamin premix (ENHALOR) on growth performance and meat quality of broiler chicken. Three hundred sixty-day old (Cobb 500) male broiler chicks were randomly assigned to four dietary treatments and each treatment comprised with 09 replicates. The dietary treatments included 4 concentrations of vitamin premix. The control group (T_0) of birds received 350 g, 350 g, 300 g ton⁻¹ of premix for booster, starter and finisher diets, respectively. The other experimental birds of three treatments were treated with vitamin premix such as T_1 (330 g, 280 g, 250 g ton⁻¹), T_2 (280 g, 250 g, 200 g ton⁻¹) and T_3 (250 g, 200 g, 180 g ton⁻¹) in booster, starter and finisher diets respectively. Average body weight and feed intake were recorded during the experimental period. At the end of day 40 birds were slaughtered and organ weight, carcass weight, meat quality parameters were measured. The highest ($p < 0.05$) daily weight gain (23 g bird⁻¹ day⁻¹), (70 g bird⁻¹ day⁻¹), (73 g bird⁻¹ day⁻¹) and the lowest ($p < 0.05$) feed conversion ratio (1.75, 1.5 and 2.06) of broilers were recorded by T_2 treatment in booster, starter and finisher phase respectively. The highest ($p < 0.05$) pH (6.67) of broiler breast meat was recorded from T_0 and the lowest (6.53) pH of broiler breast meat was recorded from T_1 . In conclusion, the dietary supplementation of vitamin premix (ENHALOR) for broiler booster (280 g ton⁻¹), starter (250 g ton⁻¹) and finisher (200 g ton⁻¹) diets has better effects on performance of broiler chicken.

Keywords: Feed conversion ratio, pH, Vitamin premix

Evaluation of the Quality of Cinnamon Quills (*Cinnamomum zeylanicum* Blume) after Primary Processing in Matara District: A Case Study

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Ceylon cinnamon is an indigenous spice crop to Sri Lanka and the main export product is cinnamon quills. Maintenance the quality of cinnamon quills is a challenge as it is exposed to a wide range of contaminations during post-harvest practices. Cinnamon growers, processors and dealers not much concern about the maintenance of hygienic conditions. Therefore, this case study was conducted to evaluate the quality and major contaminations of cinnamon quills handled by different parties, *viz.*, growers (T1), collectors (T2) and exporters (T3) present in Matara district. Three different parties and the control (T4) which prepared in the cinnamon research center were served as four treatments. Samples were collected proportionate to the population of each party and physical, chemical and biological properties of collected quills were compared with the control. Data analysis was done using Minitab 17 Statistical package using analysis of covariance. Moisture % of quills collected from growers (21.8%) statistically significant ($P < 0.05$) compared to quills handled by collectors and exporters. Oil content present in quills of control (1%) statistically on par with other three treatments. Sulphur was the major chemical contaminant present on cinnamon quills and it was significantly highest in exporter level as 20 ppm ($P < 0.05$). Quills collected from growers and collectors exhibited statistically same values for acid insoluble ash % (2.26 and 2.92, respectively), water activity (a_w) (0.83 and 0.84, respectively) and bark colour while the collectors maintained significantly different insoluble ash % and a_w collated to control and exporters ($P < 0.05$). Insects are the biological contaminants present in cinnamon quills and it was significantly highest in grower and collector levels, 75 and 68 per 100 g of quills, respectively. The results revealed that the attention paid by growers and collectors on possible contaminants and quality aspects of cinnamon quills in a poor stage.

Keywords: Cinnamon quills, Contaminants, Grower, Matara district, Quality

Use of Lried Caged Layer Litter for Replacing Molasses in Total Mixed Rations (TMR) for Dairy Cattle

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This study was carried out to investigate the use of dried caged layer litter in replacing the expensive molasses in total mixed ration (TMR) for dairy cattle. Litters samples from layers at different age groups (14, 17, 33, 37, 59, 72 weeks) were selected and were analyzed for proximate composition. Litter from 14 weeks old layers showed the best proximate composition (dry matter 79.56%, crude fiber 30.86%, and crude protein 0.709%). Selected dried caged layer litter samples were tested for *Salmonella* and *E coli* using XLD and EMB selective media, respectively and results were negative for both. Further selected litter was heat treated (105 °C till 2 hrs.) and control (*Pennisetum purpureum* 40 kg, Molasses 2 kg, concentrate 3 kg, mineral supplement 50 g), treatment one (control + 1 kg of both litter and molasses) and treatment two (control + 2 kg of litter) were prepared. Nine Jersey cross milking cows in second lactation (BW 437 ± 19.4 kg) were randomly assigned to three groups and formulated TMR was fed (45 kg cow⁻¹ day⁻¹). During experiment period, adlibitum supply of water was given and no medication was practiced. After one week of acclimatization period, daily milk production and feed intake were measured individually up to two weeks duration and results revealed that no significant difference in average daily milk production and the feed intake (p value > 0.05). Results suggested that the dried caged layer litter could be successfully incorporated to the dairy cattle diet replacing molasses however further studies are required regarding improving aroma and subsequently the palatability of the dried caged layer litter which might affect to significantly higher daily milk production.

Keywords: cattle feed, caged layer litter, molasses, Total Mix Ration (TMR)

Evaluation of Refused Tea as an Alternative Medium for Coir Dust in Potting Mixtures using Hot Pepper (*Capsicum chinense* Jacq)

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Coir dust is a by-product of coconut industry and used as a potting mixture. It is scarcely available in local market due to its high demand. Conversely, refused tea is a waste of tea industry and a threat to the environment due to its accumulation. The objective of present study was to evaluate refused tea as an alternative medium for coir dust in potting mixtures using hot pepper (*Capsicum chinense* Jacq). A study under polytunnel conditions was carried out at Regional Agriculture Research and Development Centre, Makandura, Sri Lanka. Complete Randomized Design was adapted assigning six treatments according to the volume basis: T1 [soil], T2 [Soil + Compost, 1:1], T3 [Soil + Compost + Coir dust, 1:1:1], T4 [Soil + Compost + Coir dust + Refused tea, 1:1:1/2:1/2], T5 [Soil + Compost + Refused tea, 1:1:1], T6 [Soil + Compost + Refused tea, 1:1:2] with four replicates. Soil moisture content, bulk density (g cm⁻³), pH, electrical conductivity, organic C, exchangeable K, available P and total N were determined. Number of days for the first and 100% flowering, height and canopy width at the first and 100% flowering, number of primary branches, plant fresh and dry weight, root: shoot ratio and root length were also recorded. Yield parameters were recorded every week: number of pods per plant and mean weight per pod (g pod⁻¹). All tested refused tea media showed similar physico-chemical properties to the commercially available coir dust growth media. Out of the growth parameters T5 formed significantly higher root length and plant height compared to T3 ($P < 0.05$). With respect to the mean pod weight T3, T4 and T5 showed no significant difference ($P > 0.05$). The findings indicate that there was no significant ($P > 0.05$) difference between the both coir dust and refused tea media, it emphasizes soils mixed with refused tea result better plant performance. Hence; refused tea can be used as an alternative media for coir dust in potting mixtures in hot pepper cultivation.

Keywords: Refused tea, Coir dust, *Capsicum chinense* Jacq, Growing media parameters, Plant growth parameters

Survey on Consumer Behavior and Egg Quality Parameters in Badulla District among the Consumers Age between 15-44 years

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Eggs are highly nutritious and perishable food with low price. Quality standards in eggs and egg products are highly concerned in the world. Objective of this research was to assess the consumer behavior and awareness of egg quality among the people age of 15-44 years in Badulla district. Samples were taken using fluid survey web based software. 385 respondents from 15 Divisional Secretaries divisions in Badulla district were interviewed by pre tested questionnaire according to SLS 959:1992. Respondents were categorized in to urban, rural and estate sectors. Hence 72.2% individuals were Buddhist, 20% Hindus, 4.2% Islam. Education level was distributed as; 25.2% Below O/L, 33.2% O/L Qualified, 36.1% A/L Qualified, 4.9% Graduates and 0.5% Post-graduates. 93.8% individuals prefer Chicken eggs while 6.0% prefer quail eggs. 62.9% prefer brown shell eggs and 19.7% prefer white shell eggs. But 17.4% consumers in all age category groups not concerned in color. Majority of the consumers purchase 5-10 eggs per week (50.6%) and only 11.9% purchase 0-5 eggs. Mainstream of the consumers who have purchasing power belong to age category between 24-35 years. 68.1% purchased eggs from retail shops while 11.7%, 11.2% and 9.1% from farms, local houses and super markets, respectively. 30.1% individuals consumed four eggs per week while 27.3% consume three eggs per week and 21% consume five eggs per week per person. 86.8% had some basic knowledge on external defects and 81.1% had knowledge on internal defects. 13.2% and 18.9% of consumers had no consciousness regarding internal and external defects, respectively. Urban consumers were more aware on quality than others ($p < 0.05$). 16.4% consumers use appearance of eggs to identify the level of spoilage while 28.1% shaking, 37.4% by dipping in water and 6.5% by weight loss. Most preferred egg yolk color among the consumers was No 08. In conclusion, consumers in urban area were more concerned on quality standards than the other consumers but identification on defects were high in estate people.

Keywords: Education Level, External Defects, DS divisions, Internal Defects, Purchase eggs

Analysis of Chemical Composition and Oil Yield of *Cymbopogon nardus* and *Cymbopogon winterianus* in Thanamalwila Area

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Citronella (*Cymbopogon nardus* and *Cymbopogon winterianus*) plant is a perennial crop which is used to extract citronella oil as a commercial product. Citronella is cultivated in Southern coastal area of Sri Lanka, mostly in Matara and Hambantota districts. Citronella cultivation is recently started in Thanamalwila area. Variety, climatic and soil condition can affect the yield and chemical composition of citronella oil. Objective of this study was to analyze and compare the oil yield and chemical composition of two species cultivated in Thanamalwila area to select the best species for oil extraction. Steam distillation technique was used to extract the citronella oil and gas chromatography-mass spectrometry (GC-MS) was followed to analyze the chemical composition. It was found significantly ($P < 0.05$) higher percentages of Citronellol (7.14%), Citronellal (9.02%) and Geraniol (16.01%) in *Cymbopogon nardus* than in *Cymbopogon winterianus* in which the respective values were 4.68%, 4.81% and 6.3%. There were no significant differences between two species with respect to their Camphene, Limonene and Borneol contents. The oil yield of *Cymbopogon nardus* was significantly ($P < 0.05$) higher than that of *Cymbopogon winterianus*. Therefore, as far as the oil yield and chemical composition of oil are concerned, *Cymbopogon nardus* is the best variety to cultivate in Thanamalwila area.

Keywords: Citronella, *Cymbopogon nardus*, *Cymbopogon winterianus*, Thanamalwila

Detection of Fungal Contaminations in Export Coir Consignments

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Coir or coconut fibre is a natural hard fibre extracted from the husk of the coconut. Coir is a good source for harboring and growth of fungi due to the high moisture content and the nutrients, it can support the growth of pathogens harmful to men, animals and plants. Export market is looking for coir products with minimum contaminants which is important to control the crop infections and maintain the human health. In the present study attempt was made to identify the fungal species present as contaminants in the export coir consignments which threatens the bio security of importing countries. Fungi in coir samples were isolated by inoculating the PDA plates with direct culture method and dilution series method under the aseptic conditions. Nine fungal species were isolated after 72 hours of incubation period. Isolated fungi were sub cultured separately to obtain the pure cultures which is important in the process of identification. Fungal and spore morphology was examined under the inverted compound microscope (Labomed TCM 400) for the identification of fungal species. *Mucor* sp., *Aspergillus* sp., *Fusarium* sp., *Colletotrichum* sp., *Geotrichum* sp., *Paradoxa* sp., *Rhizopus* sp., *Trichoderma* sp., and *Penicillium* sp., were found after the investigation of 8 samples of different coir exporting companies in Sri Lanka. *Aspergillus* sp. and *Mucor* sp. were the most abundant fungal species among the companies while *Paradoxa* sp., *Fusarium* sp. and *Trichoderma* sp. were recorded only in samples from 3 companies.

Keywords: Coir, Fungi, Aseptic, Bio security, Contaminants

Effect of Vitamin E and Selenium Supplementation on Hatchability, Fertility and Performance of Broiler Breeders

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The present study was conducted to determine the effect of vitamin E and selenium supplementation on the hatchability, fertility and performance of broiler breeders. A total of 42 weeks old 198 Cobb 500 birds were randomly assigned to 18 deep litter pens (10 females and 1 male per pen) and were supplemented for two months of period. Broiler breeders were randomly assigned to three treatments and six replicates. The control group (T_0) received only water. The birds from treatment 1 (T_1) and treatment 2 (T_2) were supplemented with 10 mg L⁻¹ pure vitamin E and 50 mg/1 L Selenium with vitamin E. The lowest ($p < 0.05$) hatchability (77%) was recorded from T_0 treatment and the highest ($p < 0.05$) hatchability (88%) was recorded from T_1 treatment .The lowest ($p < 0.05$) fertility (86%) was recorded from T_0 treatment and highest ($p < 0.05$) fertility (93%) was recorded from T_1 treatment. The lowest ($p < 0.05$) growth performance (87%) was recorded from T_0 treatment and the highest ($p < 0.05$) growth performance (98%) was recorded from T_1 treatment. There were no significant differences of total egg production, weekly average feed conversion ratio and weekly average weight gain of broiler breeders between three dietary treatments ($p > 0.05$). In conclusion the hatchability, fertility and performance of broilers were increased by dietary supplementation on said amount of selenium supplementation (50 mg L⁻¹) than pure vitamin E (10 mg L⁻¹).

Keywords: fertility, hatchability, Performance, Selenium supplementation, Vitamin E

Effect of different levels of Stocking Density and Dietary Sodium Bicarbonate (NaHCO_3) on Performance, Meat Quality and Organ Weights of Broiler Chicken

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This study was conducted to determine the effectiveness of different levels of NaHCO_3 and different stocking densities on performance and meat quality of broiler chicken. A total of 360, 19-day-old broiler chicks were randomly allocated in to 6 experimental units in a 2×3 factorial arrangement of two different stocking densities as D_1 (Standard density: $1.2 \text{ ft}^2 \text{ bird}^{-1}$) and D_2 (High density: $0.85 \text{ ft}^2 \text{ bird}^{-1}$) and three levels of NaHCO_3 (0%, 0.3%, 0.5%). Each treatment consisted with 5 replicates. Data were subjected to factorial analysis using the General Linear Models procedure of two-way ANOVA of statistical analysis system. The highest ($P < 0.05$) daily weight gain of broilers was recorded from D_1 ($59 \text{ g bird}^{-1} \text{ day}^{-1}$), 0.3% NaHCO_3 ($69 \text{ g bird}^{-1} \text{ day}^{-1}$). The highest ($P < 0.05$) average daily feed intake was recorded from D_2 ($112 \text{ g bird}^{-1} \text{ day}^{-1}$), 0.5% NaHCO_3 ($116 \text{ g bird}^{-1} \text{ day}^{-1}$). Favourable ($P < 0.05$) feed conversion ratio was obtained from D_2 (2.31) and 0% NaHCO_3 (3.06). The highest ($P < 0.05$) pH value was recorded from D_1 (5.53) and 0.3% NaHCO_3 (5.51) and lowest ($P > 0.05$) from D_2 (5.35), 0% NaHCO_3 (5.30). Highest ($P < 0.05$) redness of breast meat was recorded from D_1 (12.49), 0.3% NaHCO_3 (12.37). The highest ($P < 0.05$) relative weight of intestine was recorded from 0% NaHCO_3 (4.67). Highest ($P < 0.05$) liver weight was recorded from 0.3% NaHCO_3 (2.60). In conclusion, dietary supplementation of 0.3% NaHCO_3 has better effects on growth performance of broilers regardless of the stocking density.

Keywords: Stocking density, NaHCO_3 , Average daily weight gain, Average feed intake

A Study on Health Management Practices in Free Range Chicken Farming in Batticaloa District

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Free Range Chicken (FRC) farming plays an important role in rural economy. Information on health management in FRC in Sri Lanka is minimum. The study objective was to identify health management practices in FRC farming in Batticaloa district. Data on FRC farming, especially focusing on health management were gathered from randomly selected 120 FRC farmers in 6 veterinary ranges in Batticaloa district using a pre-tested structured questionnaire. Data analysis was conducted by obtaining frequencies of respondents belonging to each category using Minitab 16 software. Majority of farmers were females (53.3%). Most of farmers (74%) reared common village chicken and main rearing purpose was to sell eggs (46.67%). 22.5% of egg production was used for family consumption reflecting the importance of FRC farming in rural farm family nourishment. According to farmers' perception, infectious diseases (70.6%), parasitism (70.8%) and predation (40.8%) were the major constraint in FRC production. Coccidiosis (27%) and fowl pox (26%) were the main diseases reported. Only 31.7% of farmers treat the sick birds either by western (54.55%) or indigenous (45.45%) medicine. Vaccination was not practiced by majority (81.7%) of farmers since they are not aware on vaccination (68.04%). Parasitism was common during April-June (35%) or October-December (35.8%). Ectoparasitism was a common problem and carbaryl, engine or cooking oil and liquid paraffin were externally used to control and plastering the wall of chicken houses was practiced as hygienic practice. Endoparasitism was identified by 38% of farmers. Piperazine citrate was used by farmers without having veterinary advices. Apart from the western medicine, indigenous medicine such as; Aloe sp. (26%), pepper (9%), papaya leaves (4%) and milk (9%) were used to control endoparasites by 48% of farmers. In conclusion; according to farmers' perception, although infectious diseases and parasitism are the main constraints in FRC system, farmers' attention on health management is minimum. Hence, FRC system has potential to expand by improving health management.

Keywords: Diseases, Free range, Parasites, Village chicken

Effect of Eco-friendly Growth Media on Survival Percentage of Tea [*Camellia sinensis*(L.) O. Kuntze] to Mitigate Short Term Drought at Nursery Level

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Tea is generally considered to be a shallow-rooting plant, sensitive to the physical condition of the soil and thus growth media may help effectively mitigate short-term drought conditions. Therefore, this study was conducted to study the effect of growing media on soil properties and survival percentage of tea cultivar TRI 2023 during short term drought period at Tea Research Institute, Ratnapura. Six treatment combinations having three growth media (charcoal, paddy husk and refused tea) and two different application methods (3 inches high growth medium layer applied to the bottom of the pot and growth medium incorporated into the soil) were used in pot experiment under protected house condition. Each treatment was replicated four times and CRD was used. Initially, soil moisture status of all treatments was adjusted to a saturation point and after that irrigation was not done for one month. Water runoff and percolation were inhibited using bottom closed pots and evapotranspiration (ET) was considered as the only method for soil moisture loss. ET (mm) was measured using weight difference method and survival percentage (%) was calculated in all 24 pots weekly for one month. Then the second irrigation was done again to saturation point and the study was continued for another month. The results revealed that, there were significant differences among six treatments for both tested parameters. Further, the lowest percentage weight difference (11.2695%) and the highest survival percentage (89.8%) were observed in charcoal incorporated into soil at 1:2 ratio during the study period. Therefore, charcoal incorporated into soil (1:2) can be effectively used as an eco-friendly growth medium as it increases the water retention facilitating more survival of potted plants of tea cultivar TRI 2023 in nurseries during short term drought period.

Keywords: Evapotranspiration, Growing media, Short-term drought, Survival percentage, TRI 2023

Effect of Rainfall Changes on Tea Yield Using Standardized Precipitation Index in Badulla

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The variations in the rainfall pattern is very essential to understand the drought and wet conditions in tea growing areas. Standardized Precipitation Index (SPI) is provided one of useful tool to understand the drought and wet conditions of selected location/s or country. The objective of this study is to identify the impact of rainfall changes in tea growing estates of Badulla region and evaluate its effects on tea yield. Therefore,rainfall and tea yield data were collected from Ury, Telbedde, Spring Valley estates in Badulla region for the period of 1987 to 2016. Change point analyzer was used to understand the changes in rainfall and yield, Mann-Kendall test was used to identify the trend of these data. The 12-month SPI for January to December showed an increasing trend in Spring Valley estate and it indicated higher chance of occurring wet events; whereas decreasing trend in Telbedde estate showed there is a chance of occurring drought events, while Ury showed no trend. The 5-month SPI which is representing desirable period of tea harvesting (South-West monsoon) from May to September showed a decreasing trend which led to high chance of occurring drought events in Telbedde while other estates have no any trend. Also it showed there was a decline in the annual yield by 10 to 32 kg ha⁻¹ per year in Badulla regionThe results of the study revealed that there is a highrisk of changing rainfall pattern in near futurewhich can affect on yield reduction in Badulla region.

Keywords: Drought, Rainfall, Standardized Precipitation Index (SPI), Tea

Statistical Analysis of Determinants of Black Tea Quality

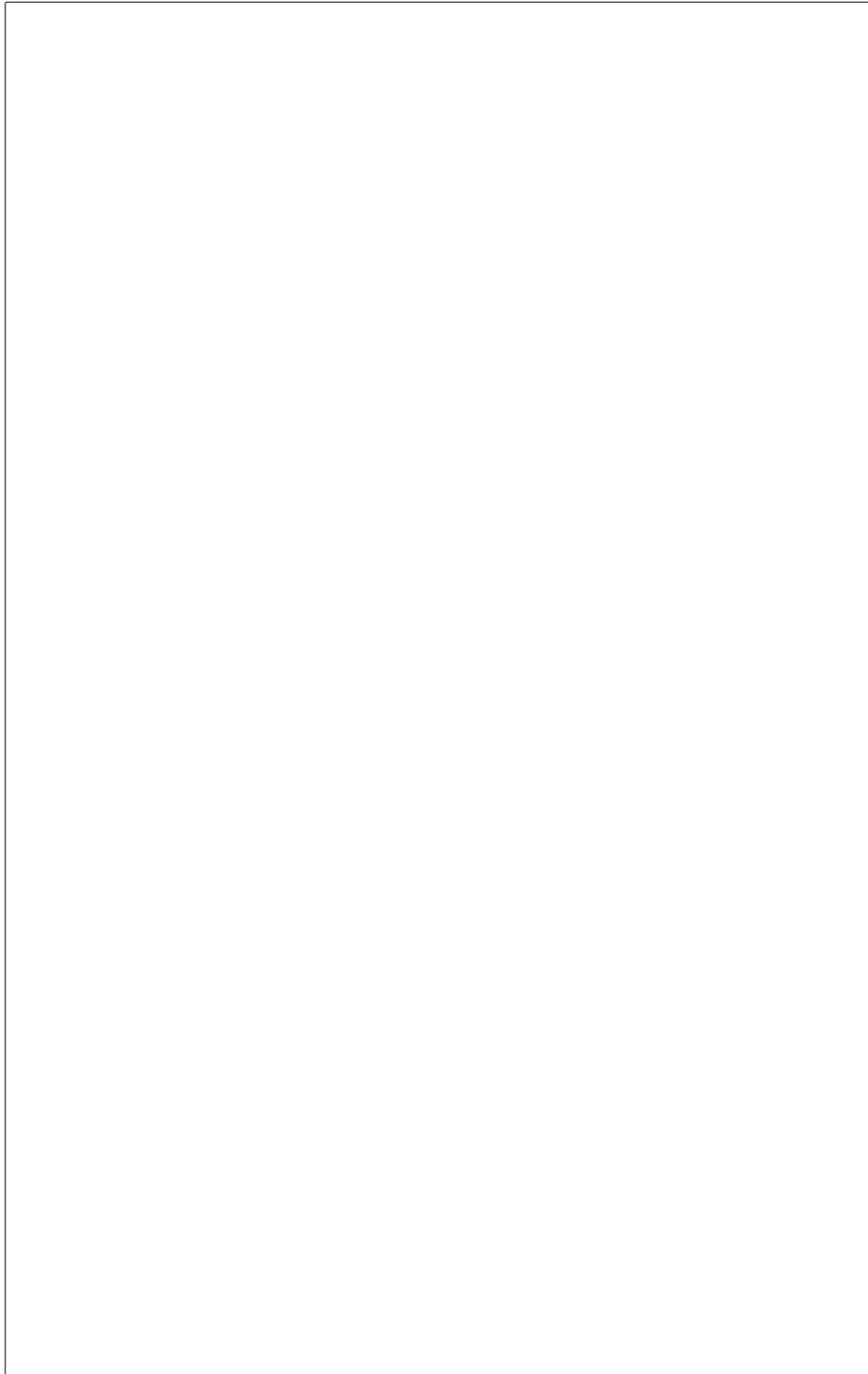
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Tea is the world most popular beverage. It has very good market both locally and internationally. Sri Lankan tea is world renowned for high quality and taste. However, in the recent past, Sri Lanka has lost the top ranking and now in rank third in the world market. Therefore, ensuring the export of quality tea is essential for the regaining the top ranking. In this study, a literature survey was conducted to identify the factors affecting the quality of black tea. Some identified factors are fermentation time, temperature, moisture and humidity content of leaves. These will impact quality parameters such as Theaflavine, Thearubigin, Tea liquor color and brightness. In this paper, a statistical analysis was conducted to identify the extent to which fermentation time and temperature will impact with Theaflavin, Thearubigin, and total color of the tea infusion by using correlation and regression (simple and multiple). An analysis was conducted using 17 reported data where each data point is the average of a triplicate. According to correlation analysis, relationships are available among time, temperature and Theaflavin. When the fermentation time increases, Theaflavin content decreases. When the temperature decreases, Theaflavin content increases. However, the impact of temperature on Theaflavin is not significant as in the observed analysis ($P = 0.966$). A similar study was carried out to find relationship between Thearubigin versus temperature and fermentation time. The results reveal that the thearubigin is not significantly related with temperature ($P = 0.189$) and fermentation time ($P = 0.844$). Tea infusion color is highly related to the time than temperature ($P = 0.098$). It can be concluded that the Theaflavin and tea liquor color is significantly depending on fermentation time, where thearubigin is depending on temperature.

Keywords: Fermentation time, Temperature, Theaflavin, Thearubigin, Regression



Aquaculture and Fisheries

- Commercial Finfish and Shellfish Farming
- Hatchery Techniques and Breeding Management
- Fish Nutrition and Dietary Requirement
- Diseases Management in Aquaculture
- Fish Marketing, Economics and Fisheries Management
- Capture Fisheries
- Culture Enhanced Fisheries Development

Determination of Geographical Variations of Heavy Metals in Swordfish (*Xiphias gladius*) and Yellowfin Tuna (*Thunnus albacares*)

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Bioaccumulation of heavy metals in marine fish has emerged as a serious health concern in consumers and economic burden to fish exporters. Heavy metal concentrations of fish found in Sri Lankan fishery products may cause risks of border rejections and economic losses. However, data are yet to be available in this regard. Present study was conducted to explore geographical variation of heavy metal accumulation in the swordfish (*Xiphias gladius*) and Yellowfin tuna (*Thunnus albacares*). The heavy metal analysis data (Hg, Cd, As, Pb) were collected from two fish export companies in Sri Lanka. Cd, As, Pb metals were not detectable in samples. There were 302 mercury analysis data of swordfish during June to September, 2017 and 33 mercury analysis data of yellowfin tuna during January, 2015 to August, 2017. According to the collected secondary data, particular way points were traced using log sheets. Then using QGIS software, monthly heavy metal variations were mapped against fish species. Results showed that heavy metal analysis data concentrated in main 4 areas between $64^{\circ}00'00.000''E$ - $70^{\circ}00'00.000''E$ & $0^{\circ}00'00.000''N$ - $8^{\circ}00'00.000''N$, $76^{\circ}00'00.000''E$ - $80^{\circ}00'00.000''E$ & $0^{\circ}00'00.000''N$ - $8^{\circ}00'00.000''N$, $88^{\circ}00'00.000''E$ - $92^{\circ}00'00.000''E$ & $14^{\circ}00'00.000''N$ - $18^{\circ}00'00.000''N$ and $82^{\circ}00'00.000''E$ - $90^{\circ}00'00.000''E$ & $6^{\circ}00'00.000''N$ - $14^{\circ}00'00.000''N$. The results revealed that Mercury is the major heavy metal that accumulates in the Swordfish and Yellowfin tuna. According to EU standards, Mercury accumulation is higher in Swordfish that exceed 1ppm standard limit. Accumulation is highest in the fish harvested in the area of $64^{\circ}00'00.000''E$ - $70^{\circ}00'00.000''E$ & $0^{\circ}00'00.000''N$ - $8^{\circ}00'00.000''N$. Accumulating proportion to its harvest was 40.33% that exceeds 1ppm level. The next highest mercury levels were found in the $88^{\circ}00'00.000''E$ - $92^{\circ}00'00.000''E$ & $14^{\circ}00'00.000''N$ - $18^{\circ}00'00.000''N$ and proportion to the total harvest was 10.81% which is greater than 1ppm. In conclusion, the fish caught from these two areas tend to have more Mercury contaminations than those of other areas, suggesting possible predictive modeling applications for heavy metal accumulations in fish.

Keywords: Sword fish, Yellowfin tuna, Heavy metal, Mercury, Mapping

Comparative Analysis of Morphological Characters of Blue Swimming Crab, *Portunus pelagicus* (Linnaeus, 1758) Populations of Western and North-Western Regions in Sri Lanka

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The blue swimming crab, *Portunus pelagicus*, is abundant in indo-west pacific regions and extremely contributes for commercial fishery industry. In Sri Lanka, this species is typically found in Western, Northern, North-Western and North-Eastern Coasts. Morphological studies of *P. pelagicus* are important to identify population clusters and distribution patterns. Hence, this study was conducted to identify morphological variations of blue swimming crabs collected from Puttalam and Kalpitiya areas of the North-Western coastal region and the Negombo area of the Western coastal region. A Total of 240 individuals, 80 from each site were analyzed using twelve morphometric parameters. Standardized morphometric measurements were subjected to Discriminant Function Analysis (DFA) to observe intra-specific variations. According to the results, two discriminant functions were derived with 63.8% and 36.2% of variance for function 1 and 2 respectively, while function 1 was predicted as the strongest component ($P < 0.05$). The length to width ratio of the major cheliped merus (MEL/MEW=0.71) and ratio between carapace width (including 9th anterior-lateral tooth) to carapace length (CW2/CL=0.59) were identified as highly contributing parameters for function 1 and 2 respectively. The overlapped group plots suggested that there was no intra-specific morphological variability among three populations. Based on the results, it can be suggested that all three *P. pelagicus* groups are morphologically similar and consider as one population. The length-weight relationships of crabs in all three sites recorded negative allometric growth ($b < 3$). However, results need to be confirmed using molecular data. Results of the current study provide basic information which could be utilized when constructing management plans on fisheries and conservation for this economically important carb species.

Keywords: Crabs, Morphometry, Population Study, Fisheries Management, Sustainability

Comparison of Blue Swimming Crab, *Portunus pelagicus* (Linnaeus, 1758) populations from Batticaloa and Trincomalee areas in Sri Lanka using Morphometric Parameters

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Western, Northern and Eastern areas of Sri Lanka are famous for blue swimming crab fishery. However, very limited studies have been carried out to identify their population structure. This study investigated the utility of morphological characters to differentiate *Portunus pelagicus* populations of two different areas in eastern province of Sri Lanka. Samples were collected from Batticaloa (n=46) and Trincomalee (n=46) waters throughout its known geographic range. Twelve morphometric characteristics were measured up to nearest 0.01 mm. Discriminant Function Analysis (DFA) was performed to analyze significant intra-specific variations of two populations using standardized morphometric characteristics. The derived single discriminant function was totally accounted for 100% variance (Wilks' Lambda=0.74, P<0.05). The carapace width to carapace length ratio (CW2/CL) was recorded the highest canonical discriminant function coefficient (0.89), thus CW2/CL was selected as the most suitable parameter for the predicted model. The two centroids derived by DFA were 0.59 and (-0.59) respectively for the Trincomalee and Batticaloa, and predict the separation of two groups. According to the plotted graph, minimal overlapping between two groups was observed with possible variation between two populations. Two different allometric coefficients (b) were recorded as 2.92 (closer to isometric growth) and 2.76 (negative allometric growth) for Trincomalee and Batticaloa populations respectively. Hence, the results suggest that there is a possibility of having two *P. pelagicus* stocks in the 2 sites of the eastern part of the island. Changes of prevailing environmental conditions and habitat are the factors that lead to morphological differences of two *P. pelagicus* populations. Finding of this study is important for implementations of site-specific sustainable fishery management programs. Further, population genetic studies are recommended to confirm the results of the present study.

Keywords: Crabs, *Portunus pelagicus*, Morphometric Characteristics, Population differentiation, Fisheries Management, Discriminant Function Analysis

**Effect of Four Formulated Diets on Colour Enhancement of Platy Fish,
(*Xiphophorus maculatus*)**

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Skin colouration is one of the most important factors which determines the commercial value of ornamental fish. Pigmentation in the skin is responsible for different colouration of fish. Pigment enriched feed is a reliable method, because hazardous effect of fish is considerably reduced. Objective of this study was to determine the colour development of platy fish subjected to four different diets. Four formulated diets were prepared using autolyzed ground shrimp head, autolyzed ground crab shell, dried & ground carrot as supplements and control diet without supplement. Twenty-five percent (25%) supplement was used for each diet preparation and other ingredients were common to all formulated diets consisted of the rest of 75% in the diet. Additional 25% of fish meal was used instead of supplement in the control diet. Experiment was conducted using five-day old platy as 30 individuals /tank and each treatment was triplicated. Laboratory conditions were maintained at 26 ± 1 °C of temperature under natural photo periods for 75 days. Fish were fed two times per day until satiation. Photographs were captured in every 2 week interval by a same person with the same camera (Canon EOS 1300D) at a distance of 5.5 cm and 90° of angle at same condition for colour comparison. Pigmentations in the platy fish of each treatment were compared using a Mathematical language function which is called image analysis. Collected data were statistically analyzed using one-way ANOVA at $p<0.05$ of significant level by SPSS 24 software. According to the results, colour intensity of the platy fish fed with the feed containing autolyzed ground shrimp shell were significantly different (0.192 ± 0.005) from the other three diets. All three experimental diets with carotenoid pigments at different levels had enhanced the colour of the fish. Present study reveals that the autolyzed shrimp head supplement is a good candidate in improving the colour of the platy fish.

Keywords: Shrimp waste, Platy fish, Autolysis, Carotenoid, Colour enhancement

Identification of suitable hardening medium for micro-propagated *Lagenandra thwaitesii* species in the Tilapia based aquaponic system

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Lagenandra thwaitesii consider as a threatened endemic ornamental aquatic plant in family Aaraceae. Micro-propagation is a tool for large scale multiplication of these plants. High mortality experienced in transferring of micro-propagated plantlets from the laboratory to the environment is a major limitation in the production of *L. thwaitesii* at commercial scale. Aquaponic system is used for growing of various plants as a new approach to harden micro-propagated aquatic plantlets. This study focused on examining an effective hardening medium for *L. thwaitesii* in an aquaponic system. Six weeks aged uniform samples of in-vitro rooted *L. thwaitesii* plantlets were hardened by 3 different media; coconut husk, clay bricks shards and river gravels. Tilapia fish waste was used as the fertilizer from the aquaponic system, while trickling down to each section with different hardening media. The performance of plantlets in each media were measured using survival and growth parameters (number of leaves, length of roots, shoots and leaves, width of leaves, wet weight of plantlets) during five weeks of hardening period. The collected data were subjected to multivariate analysis at $P < 0.05$ level. According to the results, characteristics of hardening media significantly affect on growth performance of *L. thwaitesii*. Highest average leaf length (24.18 ± 0.582), leaf width (10.58 ± 0.250), root length (87.05 ± 5.15) and wet weight (0.83 ± 0.05) were recorded in clay brick shard medium, while maximum average number of leaves (4.05 ± 0.189) was recorded from gravel medium. The 100% survival rate was obtained in all the hardening media. Bricks play a vital role in cation exchange, which enhances the nutrients availability for plants by increasing the growth rate of plants. Hence, clay bricks shards medium was considered as the best substrate for hardening of *L. thwaitesii* in the Tilapia based aquaponic system. This novel trend in integrated aquaculture system is useful to overcome the practical problems in micro-propagation of *L. thwaitesii* plants, as a valuable asset for ornamental aquatic plant industry.

Keywords: Acclimatization, *Lagenandra thwaitesii*, Aquatic plants, Micro-propagation, Ornamental Aquaculture, Hardening Media

Effect of Methyltestosterone Treated Feed on Growth and Gonadal Histology of Red Blonde Guppy Fish (*Poecilia reticulata*)

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In ornamental guppy fish (*Poecilia reticulata*) industry, male fish has higher demand as they are more colourful and attractive than females. Female guppy could be sex reversed and masculinized by using androgenic hormones. Present study assessed the effect of Methyltestosterone (MT) on growth and gonad differentiation of guppy fish. Three diets used in the study (A, B and C) had similar ingredients in same proportions except in diet A. In diet A, twenty five percent of fish meal was replaced by autolyzed prawn shells. Methyltestosterone was added (100 ppm/ Kg) to diets A & B and diet C was the control of the experiment. Guppy fish ($0.009g \pm 1.66 \times 10^{-4}$) was stocked in glass tanks of size $18'' \times 8'' \times 6''$ at 20 fish /tank. Each treatment was triplicated. Mean body weight of fish in each tank was measured once every two weeks. After 120 days gonads were preserved and histological sections were taken. Highest body weight gain ($0.225g \pm 0.007$), relative growth (44.67 ± 6.53), survival rate ($80.0\% \pm 7.64$) was observed in fish fed with diet C. Mean body weight gain of fish fed with diet C was significantly different ($P=0.04$) from fish fed with diet B indicating that MT exerts negative effect on growth. Male to female ratio in control group was approximately 1:3 and 100% males were observed in fish fed with MT treated feed. Testis of male fish in control group contained spermatozeugmata (SZ) which are regular shaped cysts with clearly distinguished and methodically arranged different stages of spermatogenesis, while masculinized female fish had a different gonadal histology with irregular shaped SZ having stages of spermatogenesis not clearly distinguished and not arranged methodically.

Key words: Methyltestosterone, sex reversal, Masculinization, Guppy

Preliminary Study of the Elasmobranch Fishery in Valaichchenai, Sri Lanka

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Sharks and rays are included within the sub class Elasmobranchii. Indiscriminate fishing techniques have resulted in the progressive depletion of their populations globally. In Sri Lanka, these fisheries are driven by demand for shark fins, mobulid gill plates, their fresh meat and dried fish. This study collected information on shark and ray landings to provide information for sustainable management practices. A questionnaire survey was conducted with 140 fishers and biological parameters (length, weight and maturity data) were collected from 123 shark specimens and 129 ray specimens in Valaichchenai ($7^{\circ}55.58'$, $81^{\circ}31.80'$), in the Eastern Province of Sri Lanka. Results showed a female biased sex ratio for sharks. 11.76% of them were observed to be pregnant. From the male sharks, 16% were immature. For the rays, 40% were immature, comprising of 67% of females of which 3.44% were pregnant. The most abundant species with growth coefficients and condition factors were *Carcharhinus brevipinna* (1.25, 1.09), *Carcharhinus limbatus* (2.80, 0.83), *Carcharhinus amboinensis* (2.36, 1.17), *Mobula japonica* (1.62, 1.47) and *Neotrygon kuhlii* (1.86, 1.98) respectively. All species showed a negative allometric growth, except *Carcharhinus limbatus* and most of the species have shown condition factor greater than one. The questionnaire revealed that fishers were aged between 18 to 68 years (mean= 37.55 ± 11.23) and 64% of fishers stated that their fishing area is as far North as Jaffna, with offshore ranging from 10-700 km. There was no significant difference between attitudes on the awareness of rules and regulations with fishers of varying age groups, but propensity of crossing boundaries showed a significant difference ($p<0.05$) with age group. The results showed that some endangered species such as *Sphyrna lewini* and also vulnerable species such as, *Mobula tarapacana* were being caught and immature males & pregnant females were landed. These results indicate the need of proper implementation of management plans for sustainable utilization of these resources. Thus, conducting awareness programs, declaring restricted areas (nursery grounds) and optimum length at first capture are important for sustainable utilization of fishery resources.

Keywords: Elasmobranch, Growth factor, Condition factor, Maturity, Gill plates

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Determination of the Appropriate *Oryza sativa* (Rice) Straw Fertilizer Loading Level to Enhance Survival Rate of *Catla catla* (Catla) Post Larvae

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Introduction of the Indian major carp species like *Catla catla* (Catla), *Labeo rohita* (Rohu) and *Cirrhinus mrigala* (Mirigal) has been resulted in a significant development in inland fisheries in Sri Lanka. Among these introduced fish species, Catla contributes to freshwater fish production in Sri Lanka significantly. One of the identified problems in Aquaculture Development Center, Udawalawa was lower survival rate of Catla post larvae at nursery stage. Hence this study was conducted to determine appropriate rice straw loading level to enhance survival rate of Catla post larvae reared in nursery tanks of 20 m². The experiment was conducted using a Completely Randomized Design (CRD). A preliminary fertilizing procedure was done to determine a definitive range (75-90 g m⁻² of dried rice straw) to conduct the experiment and the tanks were fertilized at above rates. Body weights and total lengths of post larvae were recorded at stocking and water quality parameters were recorded twice a day in each treatment. Number of survived post larvae in each treatment were recorded with the body weights and total lengths at the end of the rearing period. Recorded data were analyzed using one way ANOVA and Tukey test was used to compare mean values at 5% significance level. Total plankton count, survival rate, length gain and weight gain of post larvae were significantly different ($p<0.05$) among treatments. 80 g m⁻² loading level of rice straw was the best treatment showing highest survival rate (66.62 ± 0.69), greatest length gain (159.08 ± 6.99 cm), maximum weight gain (2,576±176g) and highest mean value of total plankton count (54,910±646). Adequate amounts of planktons and proper water quality parameters act as major reasons for higher survival rate of Catla post larvae. Therefore, the loading rate of 80 g m⁻² was found to be best among treatments for fertilizing Catla nursery tanks with rice straw to enhance survival rate.

Keywords: Rice straw, Catla post larvae, Survival rate, Plankton

Effect of Raw *Spirulina platensis* Supplement on the Growth Performance of Guppy Fish – Red Blonde (*Poecilia reticulata*)

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Aquarium fish industry in Sri Lanka has become a valuable source of foreign exchange recently. Guppy fish (*Poecilia reticulata*) ranks the highest (67%) market of ornamental, fresh water fish export sector in Sri Lanka. *Spirulina platensis* is one of the commercially important micro algae due to its overall nutritional qualities. The study was investigated the effect of dietary supplementation of different percentages of *Spirulina platensis* (5%, 10%, 15%, 20%, and 25%) on growth performance, Feed Conversion Rate and survival rate in guppy and were compared with commercial feed as the control treatment. *Spirulina platensis* were cultured using axenic batch culture method in Zarrouck's medium, under illumination with a photo period of 12 hours light and dark. Glass tanks (0.3 m × 0.15 m × 0.15 m) were used for each treatment with 3 replicates and 21 days old red blond guppy were reared with a stocking density of 10 fish/tank for 30 days. Fish were fed, twice per day at a rate of 10% of body weight for 60 days. Data were collected every 2 weeks interval and analyzed by One Way Analysis Variance (ANOVA). There were significant differences between all the diets in terms of average body weights ($p<0.05$). Average body weight was highest in treatment with 5% raw *Spirulina platensis* incorporated feed (0.45 ± 0.09 g) and lowest in control treatment (0.36 ± 0.13 g). No significant differences were observed in weight gain and Specific Growth Rate (SGR) ($p>0.05$) according to the treatments. There were significant differences of Feed Conversion Ratio (FCR) among all the diets ($p<0.05$), while it was lowest in 5% raw *Spirulina platensis* incorporated feed (1.43 ± 0.06) and highest in the control treatment (2.05 ± 0.09). 100% survival rate was observed in all treatments. The study revealed that 5% raw *Spirulina platensis* dietary supplementation enhances the growth rate in guppy fish.

Keywords: Dietary supplementation, Growth performance, *Poecilia reticulata*, *Spirulina platensis*

Determination of Suitable Breeding Substrate for Redside Barb (*Puntius bimaculatus*) in Captive Conditions

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Redside barb (*Puntius bimaculatus*) is one of the most popular indigenous ornamental fish species, which commonly found in Sri Lanka. This species has been heavily collected from wild for aquarium trade and have a severe influence on the reduction of naturally available stocks. Development of captive breeding and larval rearing techniques are found as an effective strategy to increase commercially available stocks, which will also lead to ensure the sustainable utilization as a valuable resource. Hence, the objective of this study was to determine the suitable substrate for successful breeding of Redside barb in captivity. Three types of breeding conditions; gravels with aquatic plants, sand with aquatic plants, only aquatic plants were provided with stilled water in 60 cm x 30 cm x 30 cm size indoor glass tanks and three replicates for each treatment were used. Mature males with bright red colour stripe on their body and females which released yolked eggs, when slight pressure is applied on their abdominal region were selected as brooders for the experiment. Selected individuals were introduced into each tank at 2:1 male to female ratio. Completely Randomized Design was used as the experimental design and produced fry number was counted. Data were analyzed using one way ANOVA. Spawning was observed in all conditions and fry number varied significantly among three different substrates ($p<0.05$). The highest mean fry number was observed in the substrate of gravel with aquatic plants (195 ± 20) compared to other 2 (fry number in the substrate which contain sand with aquatic plants: 77 ± 39 and only aquatic plants: 33 ± 33). Results of this study revealed that the most suitable breeding substrate for the Redside barb in indoor glass tanks was the substrate with a gravel bottom and aquatic plants.

Keywords: Redside Barb (*Puntius bimaculatus*), Captive breeding, Breeding substrate

Impact of Thermocline Variability on Yellowfin Tuna Catch Rates of Sri Lankan Long-Liners

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Tuna fishery is an important source of income to Sri Lanka, having a greater potential for development. Yellowfin tuna: *Thunnus albacares* is a major species, exported to Japan and EU countries. Vertical migration of fish with changes in temperature is considered as an important parameter to ensure fishing efficiency, thus harvest of yellowfin tuna is associated with the thermocline layer and its seasonal changes. The objective of the present study was to investigate the influence of vertical structure of temperature on catch rates of longline fishery. Temperature-depth recording sensors were used to understand the depth penetration level of hooks and associated temperatures, during the period from July 2012 to February 2014. Based on sensor data and catch records, fishing depth was determined by means of sag caused by slack of the main line in between two buoys. Thermocline variability was analyzed using oceanographic datasets obtained from Copernicus Marine Environmental Monitoring Service. Temperature vertical profiles were extracted from those datasets at each fishing positions and a 5-parameter sigmoid model was used to determine the thermocline properties. Most commonly, 6-9 hooks per basket have been used in longlines, while total number of hooks was 800-1000. Buoy-lines and branch-lines were ranged between 20-30 m and 45-50 m, respectively. Based on the hooks per basket, the depth penetration level closer to buoy-line is ~70 m and ~100 m at the center of a basket. Sagging variability of hooks in a basket have shown a linear relationship ($r^2=0.9992$) with the distance between branch lines starting from buoy-line to the middle of a basket. Catch per unit effort was ranged between 15-70 kg / 1000 hooks. Thermocline depths altered between 100-125 m with variations of corresponding temperatures at 21-23 °C. The developed model is capable of predicting hooking depths, thus the longline configuration can be adjusted with thermocline information for successful fishing operations.

Keywords: Yellowfin tuna, Thermocline, Longline, Temperature–Depth recorders

Identification of Factors affecting to the Blue Swimming Crab (*Portunus pelagicus*) Harvest in Eastern Province, Sri Lanka

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The blue swimming crab; *Portunus pelagicus* is a tropical marine crustacean species, having higher demands in local and global crab market during last few decades. But, there are limited studies on present harvest of blue swimming crab industry in Sri Lanka. Hence this study was conducted to investigate the current status of Blue swimming crab fishery and factors affecting on the daily harvest of Blue swimming crab in the Eastern Province, Sri Lanka. Stratified and Random Sampling techniques were used to select the target and by catch fisheries from Ampara, Batticaloa and Trincomalee districts. Data associated with harvesting methods and practices of Blue swimming crabs were collected from 372 fishermen and 23 sellers using pre tested structured questionnaire. Collected data were statistically analyzed using Minitab 17 software and MS Excel. Multiple Linear Regression model was fitted to determine the main factors affected on the daily Blue swimming crab harvest. Descriptive statistical analysis suggested that majority of the fishermen in the Eastern Province used Gill net (94.7%), while less percentage of fishermen used Cast net (2.9%) and Trap net (2.4%). It was found that, in average 4.5 kg of daily harvest was obtained and average price of blue Swimming crab was Rs 271.69 per kg. Furthermore, results of Regression analysis revealed that there is a significant relationship in daily Blue swimming crab harvest with mesh size, length of net, depth of net and number of net pieces ($p<0.001$). Study concluded that improving these factors would increase the Blue swimming crab harvest in Eastern Province of Sri Lanka and necessary attention needs to be given at policy making in future.

Keywords: Blue swimming crab, Harvest, Eastern province, Regression

Potential use of the skin of *Canthidermis maculata* (Bloch, 1786) as a value added product – A preliminary investigation for a cheaper and greener method

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Trigger fish, *C. maculata* is available in markets as a result of by-catch of tuna fishery industry. It possesses a unique rough skin which is removed while processing the fish. The aim of the current study was to investigate a cheap and easy method to treat the skin of *C. maculata* in order to use as a value added product. Traditionally used solutions for depigmentation and removing scales (i.e. mixture of Na₂S and Ca(OH)₂) was used and was not able to treat *C. maculata* skin. Therefore, this procedure was modified to treat the skin with scales. Depigmentation was carried out using 4% (based on weight of the skin) Na₂S and it was able to create the patchy appearance on the skin samples. Two treatments were conducted to improve the quality of the samples. For treatment I, samples were immersed (1g per 1ml) for 3 days separately in fat liquor agents such as pure coconut oil, castor oil and two prepared fat liquor agents based on coconut and castor oils (oil + H₂SO₄, H₃PO₄ + NaCl + NaOH). As treatment II, samples were immersed in egg yolk (5g per 1ml) for 10 minutes. According to the results, egg yolk was identified as the more appropriate agent, which improves the flexibility of the skin samples within the minimum time duration of 10 minutes compared to others. A colorless varnish layer was applied on treated skin samples to improve the appearance and the water proofing ability. All treated skin samples were kept in the room temperature for six months to observe the changes occurred. It was observed that the skin samples treated with Na₂S and egg yolk were able to maintain its improved quality compared to others. A sample with 50 g weight was produced at the rate of 5/- LKR and it was used to prepare products of wallets, folders, part of shoes etc. Further improvements of samples are suggested using advanced technology. This cheaper and greener method could be used as an additional income source by practicing as a house hold industry.

Keywords: *Canthidermis maculata*, Skin, Texture, Value addition, Na₂S, Egg Yolk

Growth Performance of Black Tiger Shrimp (*Penaeus monodon*) Based on Three Different Brood Stock Collecting Areas Handala, Beruwala and Mulathivu in Sri Lanka

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Seed production of shrimp aquaculture industry in Sri Lanka is totally depends on the wild captured brood stocks. Among the 17 recorded brood stock collecting areas; Handala, Beruwala and Mulativu areas are provided proportionally higher amounts of brood shrimps to the industry. This study was carried out to investigate the differences of the growth performances of the cultured shrimps in accordance to the collecting area of the brood stock to produce post larvae (PL). 15 days old PL pertaining to three different collecting areas including three replicates for each area were stocked in fiberglass tanks (6m^2) with the stocking density of 266m^{-2} . Water quality, feeding and other management practices were maintained almost equally in all culture tanks. Initial PL quality, initial & subsequent average total length and average body weight were measured weekly up to the end of the culture period of 45 days. Survival rates, instantaneous mortality and specific growth rates were calculated. Data were analyzed using one-way ANOVA ($P<0.05$) to determine significant differences of growth parameters. It was revealed that no significant difference ($P>0.05$) of the initial body length and weight of PL stocks collected from three different areas. Though, initial quality parameters of the PL according to the brood stock collection area were not different significantly, lowest PL quality was recorded as 83% from Mulativu area and both Handala and Beruwala were recorded as 94%. After the culture period, highest significant ($P<0.05$) average body weight ($1.04\pm0.08\text{g}$), average body length ($36.8\pm1.23\text{mm}$), highest significant instantaneous mortality rate (5.33 ± 0.66) and lowest survival rate (51.0 ± 9.53) were recorded for the PL produced using brood stock collected from Mulathivu area. There was no significant difference ($P>0.05$) of the specific growth rate of the all cultured shrimps. Overall results indicated that, there was no significant difference between the PL producing from brood stocks collected in three different areas.

Keywords: *Penaeus monodon*, Post larvae quality, Brood stock

Preliminary study of Infectious Spleen and Kidney Necrosis Viral (ISKNV) disease in Asian sea bass (*Lates calcarifer*) using histopathological method in Sri Lanka

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Infectious Spleen and Kidney Necrosis Viral (ISKNV) disease is causing mass mortality in both marine and freshwater fish. Detection of this disease is crucial due to confusing clinical manifestations with many other bacterial and viral diseases. Pathology is one of the old and promising method for confirmatory diagnosis. The present study was carried out to confirm the presence of ISKNV in the cultured marine fish: Asian sea bass by histopathological method. Twenty moribund fish samples of sea bass with the mean weight of 60 ± 20 g were collected from cultured ponds in Trincomalee and Chillaw. Fish were selected based on the clinical signs suspected for ISKNV such as dark coloured fish with apathy, abnormal swimming, loss of appetite, pale gills and petechial hemorrhages in the operculum, mandible, fin base and abdomen. Spleen, Kidney, Liver, Gill and Brain samples were fixed in 10% neutral buffered formalin (NBF) for histopathological analysis. The formalin-fixed tissues were processed routinely, embedded in paraffin wax, cut at 4 μ m, and stained with Hematoxylin and Eosin (H&E). Postmortem finding of the study documented the presence of pale liver, pale gills, splenomegaly and fin rot. Degenerative and necrotic lesions in the kidney (mainly tubular epithelia) were observed in 15 fish (75%). Inflammatory cell (granulocytes, macrophages and lymphocytes) aggregates were observed in 10 fish (50%), while 17 fish (85%) showed degeneration, necrosis and vacuoles in hepatocytes with basophilic intracytoplasmic inclusion bodies. Inflammation of the gills were also observed in 10 fish (50%). This is the first study reporting the presence of ISKNV in the cultured marine fish: Asian Sea bass in Sri Lanka. Further studies are needed to determine the pathogenesis and pathology of ISKNV in different species of fish.

Keywords: Asian Sea Bass, Infectious Spleen and Kidney Necrosis Virus, Histopathology, Hematoxylin and eosin stain

Freshness identification of marketable frigate tuna (*Auxis thazard*) using physical and chemical parameters under market storage conditions

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Identification of freshness of fish in the market is crucial for marine food fish industry in Sri Lanka. Chemical and physical qualities of fish are changed in storage condition and affected on the freshness level in fish muscle. This study was focused to examine chronological changes of physical and chemical parameters of frigate tuna to assess the freshness under the normal storage condition in the marketplace. Fish samples were collected from the commercial catch of Valaichchena harbor and stored under -18°C of freezing condition, which provided the normal market condition according to the findings of questionnaire survey. Five fish samples were kept at room temperature (~25°C) for 6 hrs in each day and pH value, alteration of water holding capacity, fat content, protein level and quality index of general appearance of fish species were tested daily after six hours of period for one week. Reference points of each parameter were suggested based on the pH changes of five replicates as pH act as key indicator on quality deterioration. The quality index of general appearance was ranged at minimum of zero (fresh) - maximum of 20 (spoiled). During the one week of storage period with the condition applied in the marketplace, pH value, water holding capacity, protein and fat content of frigate tuna were reduced significantly ($p<0.05$). Average pH value of frigate tuna was changed significantly at the 4th day (5.69 ± 0.045) ($p<0.05$), hence the 3rd storage day was considered as the reference point of quality deterioration of fish. At the 3rd day, water holding capacity, fat, protein content and quality index of general appearance were 72%, 0.8 %, 20% and 6.2 respectively. Fish appearance was highly changed at the 6th day of the period having 15.6 index value. This study recommends avoiding consumption of frigate tuna after three days in normal market storage condition and web based consumer guide would be useful to identify freshness of fish.

Keywords: Fish Quality, Fish Marketing, Consumer Guide, Quality deterioration, Fish storage

Study of Growth Performance of *Oreochromis niloticus* (Nile Tilapia) Fed by Formulated Diet Incorporated with Phytase Enzyme

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Fish is highly enriched with nutrients and serve as a valuable source of protein. Major constraints faced by inland aquaculture industry of Sri Lanka are higher feed cost and less growth performance of fish. Nile Tilapia (*Oreochromis niloticus*) significantly contributes to the inland aquaculture due to its high adaptability to different environmental conditions and high growth rate. Phytase enzyme incorporated feed increases the release of phosphorus from plant meals and enhance the digestion in fish. Present study was focused to determine the effect of Phytase enzyme incorporated artificial feed on growth performance of Nile Tilapia. Two treatments, Treatment 1 artificial feed with Phytase enzyme and treatment 2 without phytase enzyme were conducted in fiberglass tanks (3.14 m³) with 3 replicates. Artificial feeds were formulated with 39% of protein and 0.2 g kg⁻¹ of Phytase enzyme. Nile Tilapia fingerlings (mean weight 5g±1) were stocked with a stocking density of 5 fish per tank and reared for 10 weeks. They were fed three times per day at 5% of body weight. The live weight and total length of fish were measured within two weeks intervals. The weight gain of treatment 1 (17.25g±4.65) and treatment 2 (15.31g±4.10) were significantly different (p<0.05). Feed Conversion Ratio (FCR) for treatment 1 and 2 were 1.87±0.046 and 2.20±0.241 respectively with no significant difference. There was no significant difference of Specific Growth Rate (SGR) of fish between two treatments. Survival rate of both treatments were 100%. Since Treatment 1 revealed the highest weight gain, Phytase enzyme incorporated feed could be recommended to obtain the high growth performance of Nile tilapia in aquaculture industry.

Keywords: *Oreochromis niloticus*, Phytase Enzyme, Fish feed, Growth performance

Breeding performance of *Pterophyllum scalare* (Angelfish) fed with enriched *Daphnia magna*

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Ornamental fish industry is a popular and profitable trade in the world. The production cost of ornamental fish varies with the cost of fish feed. The objective of the study was to investigate the breeding performance of *Pterophyllum scalare* fed with enriched *Daphnia magna*. The live feed of *Daphnia magna* was enriched with culture media, contained 58% crude protein and artificial feed with 40% crude protein were used to feed *Pterophyllum scalare* brooders (body weight 10g – 27g) as treatment I and II respectively. Square cement tanks with a size of 0.45×0.45 m² were used for each treatment with 4 replicates for 80 days experimental period. Average Temperature, pH, Dissolved Oxygen, and Alkalinity in the two treatments were maintained at 28 °C, 7.4, 6.9 ppm and 560 mg l⁻¹ respectively. Although the brooders spawned in both treatments, the relative fecundity was not significantly different ($P>0.05$). Other breeding performances such as fertilization rate, spawn recovery and spawning period have shown significant differences ($P<0.05$) between Treatment-I and Treatment-II. Comparatively highest fertilization rate (93.19%) and survival rate (70.87%) were observed in the Treatment-I, whereas lowest (fertilization rate: 67.31%) (survival rate: 50.55%) in Treatment-II. Most of the eggs in the Treatment-II remained immature. Highest breeding performance was resulted with enriched *Daphnia magna* when compared to artificial feed in *Pterophyllum scalare*. The results revealed that the nutritional quality of the live feed considerably influenced on the breeding performance of *Pterophyllum scalare*.

Keywords: Enrichment, Brooder fish, Breeding performance, *Pterophyllum scalare*, *Daphnia magna*

Study on impacts of shade and substrates on optimum growth of micro-propagated *Cryptocoryne wendtii*.

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Cryptocoryne wendtii which belongs to the Araceae family play a main role in the ornamental aquatic plant industry of Sri Lanka. Micro-propagation is used as a method for large scale multiplication of this plant. However transferring of micro-propagated plants to the outer environment is challenging and needs best hardening substrate to achieve optimum growth. Therefore, this study was focused to determine the best hardening substrate and shade condition. Eight weeks old 45 plants of in-vitro rooted plants were hardened using three different substrates; coir fiber (A), clay pebbles (B), stone wools (C) and three different shades; without shade (1), 80% shade (2), 60% shade (3) for two months. Five replicates were used under different substrates and shade conditions: A(1,2,3) , B(1,2,3) , C(1,2,3). Growth performances of plants were measured using growth rates; stem length (S), root length (R), number of leaves (L) in all treatments at each substrate and shade. Collected data were subjected to statistical analysis at p<0.05. According to the results, characteristics of substrates and shade (fixed factors) significantly affect on the growth performance of *C.wendtii* (p<0.05). Mean stem length of plants were SA1(10.47cm±.14), SA2(9.78cm±.14), SA3(9.80cm±.14), SB1(9.74cm±.14), SB2(9.72cm±.14), SB3(10.54cm±.14), SC1(10.28cm±.14), SC2(10.10cm ±.14) and SC3(10.33cm±.14) in all the treatments. Mean numbers of leaves are; LA1 (10.5±.16), LA2(9.8±.16), LA3(9.9±.16), LB1(9.7±.16), LB2(9.8±.16), LB3 (10.5±.16), LC1(10.3±.16), LC2(10.1±.16), LC3(10.3±.16) in different treatments, while mean values of root length are recorded as; RA1(3.45cm±.16), RA2 (2.8cm±.16), RA3(2.9cm±.16), RB1(2.7cm±.16), RB2(2.8cm±.16), RB3 (3.5cm±.16), RC1(3.3cm±.16), RC2(3.1cm±.16), RC3(3.2cm±.16). The highest mean values for S, L, R were recorded by stone wool (C) substrate. The results of this study are important to achieve best growth performance of micro-propagated *C.wendtii* plants for ornamental aquatic plant industry.

Keywords: Micro propagation, Hardening, *Cryptocoryne wendtii*, Substrate, Shade

Study on Effects of Substrates for Captive Breeding of Dankolapethiya (*Dawkinsia singhala*)

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Dankolapethiya (*Dawkinsia singhala*) is an endemic freshwater fish in Sri Lanka. This fish species has high ornamental value in export market and their natural stocks are diminishing day by day due to excessive collection by ornamental fish trade, and habitat degradation resulted by anthropogenic activities. Therefore, from the perspectives of the aquarium fish industry and conservation of the endemic fish species, captive breeding of this species is a good remedy. The objective of this study was to identify the ideal substrate under captive breeding environment. Four different substrate conditions created in cement tanks with size of 1.5 m × 0.75 m using coconut coir, sand, gravel and bare bottom and stocked fish at 2:1 male female ratio. Bottoms of the experimental tanks were fully covered with the selected substrates. Each treatment was triplicated. Height of the water column was maintained as 0.20 m. Breeding experiment was started, after 6 weeks of wild caught *Dawkinsia singhala* brooders' acclimatization period. Experimental tanks were observed closely for 7-14 days after commencement of the experiment and 63 individuals of fry were observed in the tanks with sand substrate condition. Out of four different substrates, captive breeding was only successful in experimental tanks with sandy bottom substrate, while spawning of *Dawkinsia singhala* was not successful (0%) in other experimental tanks. The study revealed that *Dawkinsia singhala* can be successfully bred under sand substrate condition in still water. This study will assist researchers to further develop captive breeding techniques for this species.

Keywords: *Dawkinsia singhala*, Endemic fish, Captive breeding, Breeding substrate

Fishery Independent Assessment of the Size on Maturity of the Palk Bay Blue Swimming Crab Fishery (*Portunus pelagicus*) in Jaffna District

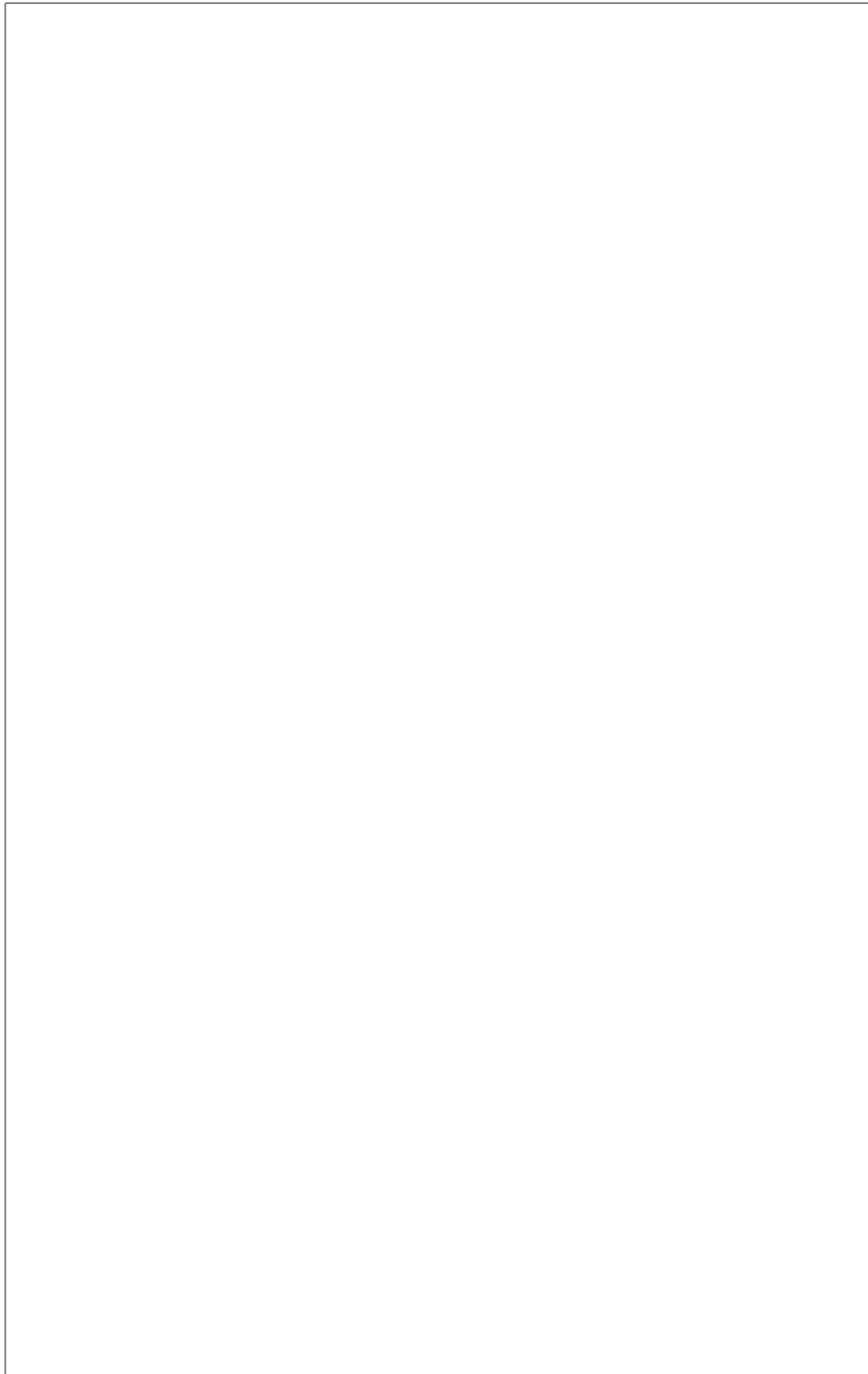
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Blue swimming crab (*Portunus pelagicus*) fishery industry in Sri Lanka has become a valuable source of foreign exchange recently, developed following the end of civil conflict in 2009. Size on maturity is a key life history parameter of exploited populations, used in fishery management practices. The aim of this study was to investigate the size on maturity of *Portunus pelagicus* by using a standardized sampling approach for the Palk Bay fishery. Crab samples were collected from both stake net fishery and crab net fishery during September-November, 2017. *Portunus pelagicus* were sampled from bottom-set crab nets in Mandaitheevu, Thuraiyoor and Chattipulam. *Portunus pelagicus* caught in stake nets were sampled from Kurunagar and Pannai. The maturity for standard sample of female crabs were assessed for a series of length classes ranged at 40 mm-159 mm, to identify the size on maturity for *Portunus pelagicus* in Jaffna District in the Palk Bay fishery. 1,253 of total female crabs were sampled. Carapace width and weight of *Portunus pelagicus* were recorded and Excel solver was used to estimate the size on maturity. The results of size on maturity data collected from crab net fishery dependent data were then compared. The level of maturity and immaturity for crab net were 83% and 17% respectively. 10% and 90% maturity and immaturity level were recorded for stake net fishery. As results revealed, L50 was recorded as 110.41 mm and L95 was 130.87 mm for this stock. According to the results and dependent data analysis, there is an effect in size on maturity of *Portunus pelagicus* by different sampling approaches in Palk Bay Fishery.

Keywords: *Portunus pelagicus*, size on maturity, Sri Lanka



Biotechnology and Bioprocess Technology

- Genetics and Biotechnology
- Natural Products Research
- Natural Products Biosynthesis/Organic Synthesis
- Microbial Processes
- Bioactivity Studies

Antifungal Activity of *Bacillus amyloliquefaciens* Ethyl Acetate Extract and Fractions Against the Fungus *Khuskia oryzae*

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Fungal infections are common among plants and animals which result in economic losses. Finding new antifungal agents from alternative sources may help to solve the above issue. It was observed that, in culture *Bacillus amyloliquefaciens* isolated from a contamination shows antifungal activity against the fungus *Khuskia oryzae*. Therefore, the objective of the current study is to determine the antifungal activity of the crude ethyl acetate extract and the fractions of crude extract of *B. amyloliquefaciens* against the fungus *K. oryzae*. *B. amyloliquefaciens* was grown on Luria-Bertani Agar (LBA), extracted into ethyl acetate after an incubation period of three days and the antifungal activity of the crude extract was tested against *K. oryzae* at 400 µg disc⁻¹ using agar disc diffusion method. Crude extract of 1.5 g was first fractionated by Kupchan solvent-solvent partitioning scheme, sequentially using hexane, methanol/water (9:1); chloroform, methanol/water (6:4) and ethyl acetate, water. Antifungal activity of the three fractions hexane, chloroform and ethyl acetate was determined and the chloroform fraction was active against *K. oryzae*. The active fraction was further purified using Sephadex LH20 size exclusion chromatography using methanol as the eluent. Fractions were combined according to the thin layer chromatography (TLC) profiles and the antifungal activity was tested for the combined fractions (A-F). Flucanazole and methanol was used as the positive and negative controls respectively. Fraction C (32.8 mg) resulted from size exclusion chromatography of the chloroform fraction exhibited 18 mm radius inhibition zone against *K. oryzae* while none of the other fractions showed any activity. Activity of fraction C was similar ($p > 0.05$) to the activity of the positive control. However, TLC profile of the fraction C showed the presence of more than one compound. Thus, further purification of fraction C is necessary in order to isolate the active compound/s which may lead to a potential antifungal agent.

Keywords: *Bacillus amyloliquefaciens*, Antifungal, *Khuskia oryzae*, Fungal infections, Fractionation

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Molecular mapping of leaf rust resistance in C14.16/Aus91433 RIL population

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Leaf rust, caused by *P. triticina* (Pt) is one of the most wide-spread diseases of wheat. This pathogen was introduced into Australia by first migrant settlers. Due to its wide range of adaptation, rapid evolution of *P. triticina* (Pt) pathotypes in Australia has defeated many leaf rust resistance genes. Deployment of genetically diverse sources of resistance in wheat cultivars with the help of tightly linked molecular markers is the most rapid and eco-friendly means of leaf rust control. Seedling-resistant and adult plant leaf rust susceptible cultivar Aus91433 was crossed with the selection C16.14 and the recombinant inbred line population was developed. The C16.14/Aus91433 RIL population was screened with Pt pathotype 104-2,3,6,(7),12 at the seedling stage in greenhouse. Resistant RILs and Aus91433 expressed IT 12C and susceptible RILs and C16.14 exhibited IT 3+. Monogenic segregation for leaf rust response was observed. The resistance locus was temporarily named *LrPak*. Genomic DNA extracted from the resistance RILs and susceptible RILs were processed with high throughput 90K SNP Array-based BSA to detect the chromosomal location of the resistance. The 90K SNP Array identified association of 32 SNPs from chromosome 2B with *LrPak*. These SNPs spanned across 6.0 cM to 27.0 cM interval of the 90K consensus map. Based on the parental polymorphic screening, final linkage map of 17.4 cM showing marker order and position of the gene was drawn. *KASP_80930* and *KASP_51150* flanked *LrPak* 2.1 cM and 2.5 cM proximally and distally, respectively. Identified closely linked molecular markers in this study will be used for marker assisted back crossing of *LrPak* into modern wheat varieties to create diversity for leaf rust resistance.

Keywords: ASR, BSA, Leaf rust, SNP markers

Antibacterial Activities of Endophytic Fungi of *Cyperus iria* Collected from Matale District

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Antibiotic resistance of bacteria has become an ongoing severe human health concern which requires extensive research priority. Endophytic fungi of *Cyperaceae* family plants are considered as a potential source for isolating bioactive compounds. Hence, the objective of the current study was to isolate endophytic fungi of *Cyperus iria* and investigate the antibacterial activities of the crude fungal extracts. Healthy *C. iria* plants were collected from Weragama in Matale district and endophytic fungi were isolated from the surface sterilized roots and aerial parts using five types of media (SYP, YPD, ME, PDA and MEA) enriched with antibiotics. Each pure fungal culture was sub cultured in ten PDA dishes, incubated close to sporulation, extracted into ethyl acetate, filtered and resulting crude extracts were obtained. The crude extracts were tested for antibacterial activity using agar disc diffusion assay against four bacteria, *Staphylococcus aureus* (ATCC 25928), *Bacillus cereus* (ATCC 11718), *Pseudomonas aeruginosa* (ATCC 9027) and *Escherichia coli* (ATCC 35218) at 400 µg disc⁻¹ concentration where Gentamycin (10 µg disc⁻¹) and methanol (10 µl disc⁻¹) were used as the positive and negative controls, respectively. Total 34 morphologically distinct putative endophytic fungi, 23 from aerial parts and 11 from roots, were isolated. Thirteen fungal extracts exhibited antibacterial activity against *S. aureus*, 24 against *B. cereus*, 12 against *P. aeruginosa* and one against *E. coli*. Among all, 29 fungi were active against at least one bacterium tested while five fungi were inactive to all. Activity of three extracts against *B. cereus*, 12 against *P. aeruginosa*, and one against *E. coli* was similar to the activity of the positive control. Fifteen extracts against *B. cereus*, 27 against *P. aeruginosa*, 33 against *E. coli* and 21 against *S. aureus* showed significant ($p < 0.05$) antibacterial activities compared to the negative control. In conclusion, *C. iria* from Matale harbors a lot of endophytic fungi, where several are capable of producing bioactive secondary metabolites with selective antibacterial properties.

Keywords: Bioactive, Antibacterial, Endophytic fungi, *Staphylococcus aureus*, *Pseudomonas aeruginosa*

Acknowledgement: Financial support from the National Science Foundation (NSF), Sri Lanka, Research Grant: RG/2016/EB/03

Control of *Colletotrichum gloeosporioides* L. Caused Anthracnose Using Isolated Yeast Species

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Anthracnose is one of the most widely spread post harvest diseases which is mainly caused by the fungus *Colletotrichum gloeosporioides* L. for a vast variety of fruits around the world. To control this damage various commercialized fungicides are being used. But due to harmful effects of these on consumers, scientists have now turned towards novel bio controlling methods. In this study the antagonistic activity of four types of wild yeasts species were tested against *C. gloeosporioides* as yeast has become one of the promising alternative to chemical fungicides. Four types of yeasts (Y162, Y234, Y342 and Y467) were isolated from surfaces of leaves of *Carica papaya* L (papaya), *Psidium guajava* L (Guava) and *Cocos nucifera* L (Coconut) water and *C. gloeosporioides* was isolated from infected papaya and banana tissues obtained from Badulla area. Yeast isolates were identified using colony, morphological characteristics and *C. gloeosporioides* isolate was also identified using colony, morphological characteristics through slide cultures. Four types of yeast isolates were tested for antagonistic activity against *C. gloeosporioides* using dual culture method. A commercialized fungicide (Fucanazole) was used as the positive control. Antagonistic activity was tested by calculating percentage of inhibition of colony radial growth (PIRG %). All the yeast isolates showed antagonistic activity against *C. gloeosporioides* according to the analysis (One way ANOVA, P = 0.03), but the yeast isolate Y162 showed the highest mean PIRG % of 57.33%. Interestingly, yeast isolate Y162 showed a higher mean PIRG % when compared to the positive control (29.67%). So the results of the current study revealed that the yeast isolate Y162 has the best antagonistic activity against *C. gloeosporioides*. Therefore, further studies are required to identify the yeast Y162 and its mechanism of inhibition, which would lead to the production of a commercial biological control agent for Anthracnose caused by *C. gloeosporioides*.

Keywords: Anthracnose, *Colletotrichum gloeosporioides*, Fucanazole

Enhancement of Cellulolytic Activity through Biofilm Action for Bioethanol Production

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Cellulosic biomass is a biopolymer with great potential for bioconversion to value-added products. However, efficient degradation of cellulose is a problem in many industries including bioethanol production. Although a variety of microorganisms are capable of degrading cellulose, few of them produce significant quantities of enzyme fractions which hydrolyze cellulose to simple sugars. Extensive studies on bio-degradation by cellulolytic mixed microbial cultures would be beneficial in cellulosic biofuel production. Thus, this study was focused to evaluate the efficiency of cellulolytic activity of mono and mixed microbial cultures. Microbial isolations were carried out using soil samples obtained from a land at Kuliyapitiya, in Kurunegala district, Sri Lanka. They were streaked on Cellulose-Congo red Agar medium to screen for potential cellulolytic microorganisms. The selected microorganisms were inoculated on Carboxy Methyl Cellulose Agar medium to screen the most effective cellulolytic fungi and bacteria. Fungal-bacterial biofilms (FBB) were developed from the selected cellulolytic fungi and bacteria using Combine Carbon Broth. The efficiency of cellulolytic activity of the selected microbial combinations was evaluated using the production of reducing sugar through 3,5-Dinitro Salicylic acid after treating with cellulose powder. Two fungal (F1 and F2) and three bacterial isolates (B1, B2 and B3) were selected as the best cellulolytic microorganisms. Out of the selected cellulolytic microorganism, F2 and B1 showed the significantly highest cellulolytic activities ($P < 0.05$). This mean reducing sugar level (113.90 ppm) was observed with the F2B1 combination after twenty three days of incubation. In addition, F2, B1 and B2 mono cultures showed significantly higher yield of reducing sugar than that of the other mono and mixed cultures, except F2B1. Thus, the selected FBB combination can be used to enhance the hydrolysis efficiency of cellulose for bioethanol production.

Keywords: Cellulose, Cellulolytic activity, Fungal-bacterial biofilms, Reducing sugar

Comparison of Antioxidant Activity of Hydrolysate Products of Crude Collagen Extracted from Chicken Egg Shell Membrane Using Different Methods

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Collagen is a highly valuable protein used in food industry. Egg shell membrane is a safe source for collagen. Extraction of collagen from chicken membrane and producing its hydrolysates were carried out using different methods. Objective of this study was to extract collagen from chicken egg membrane with simple and non-toxic method followed by hydrolysis to find out the functional properties of the hydrolysates. Shell membrane was separated by manual peeling by adding 0.5 M Acetic acid, 0.5 M Citric acid followed with extraction of collagen with pepsin digestion. pH of the extracted collagen was adjusted to 6.5 and hydrolyzed using protease with different time combinations (0, 3, 6, 9, 12, 24 hours) at 37 °C followed by heat inactivation at 100 °C for 15 min. Best hydrolysates were selected by 10% SDS-PAGE by visual observations. Selected hydrolysates were subjected to antioxidant activity by Thiobarbituric Acid Reactive Substances (TBARS) method and Diphenyl-1-picryhydrazyl (DPPH) radical scavenging activity. The highest collagen yield was observed from citric acid ($0.15 \text{ g}10\text{g}^{-1}$) extraction than acetic acid ($0.08 \text{ g}10\text{g}^{-1}$) treatment ($P > 0.05$). SDS-PAGE did not show bands even 0 hours, so, 0 hour hydrolysates were selected for antioxidant testing. In DPPH analysis, citric acid extraction shows higher scavenging activity (96.79%) than acetic acid (72.37%) ($P < 0.05$). However in TBARS method also did not show significant difference among the treatments ($P > 0.05$) and it showed 0.00 mg l⁻¹ level of Melonaldehyde. This concludes that collagen hydrolysates showed good antioxidant activity with citric acid extraction than acetic acid extraction comparing with the ascorbic acid as positive control which can be used as a natural antioxidant in food industry.

Keywords: Collagen, Hydrolysates, Antioxidant activity, Pepsin, Protease

Extraction of Crude Bone Collagen from Yellowfin Tuna (*Thunnus albacares*) and Determination of Anti-oxidative Activity of Its Hydrolysates

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Fish bones are significant part of fish processing by-product and rich source of collagen proteins. Utilization of yellowfin tuna bones are important economically as well as environmentally. Objective of this research was to extract crude collagen from yellowfin tuna bones and to identify the anti-oxidative activities of its hydrolysates which can be a potential natural anti-oxidative agent in food industry. Acid-pepsin soluble collagens were extracted from fresh yellowfin tuna bones. As with the pre-treatment process EDTA and citric acid were tested to decalcify. Extracted collagens from two treatments were subjected to the hydrolysis using protease enzyme with different time combinations (0, 3, 6, 9, 12, 24 h) at 37 °C followed with heat inactivation at 100 °C for 15 minutes. Antioxidant activity of the best hydrolysates were evaluated using thiobarbituric acid reactive substances (TBARS) assay and 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging activity method. All treatments were replicated (n = 3). Resulting extracts with citric acid treatment (1.23±0.05%) showed higher yield compared to the EDTA treatment (0.62±0.18%) ($p < 0.05$). Both treatments showed similar band patterns with 08% SDS-PAGE gel electrophoresis confirming the extracted collagen are same. Hydrolysates produced after incubating for 3 hours at 37 °C followed with heat inactivation was selected as the best ($p < 0.05$). The results showed that collagen hydrolysate of yellowfin tuna bones inhibited lipid oxidation in oil emulsion system and also control free radicals (DPPH). TBARS results of EDTA and citric acid treatment showed no significance difference with the control($p > 0.05$). EDTA (86.14±1.88%) and citric acid (87.92±7.72%) treatments showed DPPH free radical scavenging activity compared with ascorbic acid (89.10±0.64%). These results suggest that hydrolysates produced from yellowfin tuna bones with citric acid can be used as a potential natural antioxidant agent in food industry.

Keywords: Fish bone, Collagen, Hydrolysates, Anti-oxidant, Pepsin

Biological Activities of Polysaccharides Extracted from *Vernonia cinerea* and *Vernonia zeylanica*

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Many members of the genus Vernonia are shown to have biological activity which contained important chemical compounds. In recent years, there has been a growing interest in polysaccharides obtained from higher plants that may have biological activities. This study was focused to investigate the antioxidant, antimicrobial and protease inhibition activity of crude polysaccharides extracted from *Vernonia cinerea* and *Vernonia zeylanica*. Plant materials were collected from Ankumbura forest area in Kandy district, Sri Lanka. Polysaccharides were extracted from the powdered above ground plant materials by hot water and alkali extraction methods and were fractionated separately. FT-IR analysis was performed using potassium bromide powder for the purified polysaccharide fractions in the frequency range of 400 to 4000 cm⁻¹. Total carbohydrate analysis and antimicrobial activity were performed using phenol sulfuric acid method and agar well diffusion method against *Staphylococcus aureus* and *Cladosporium cladosporoides* respectively. Antioxidant activity was determined by DPPH radical scavenging activity assay and OH scavenging activity assay. The highest total carbohydrate content (9.1 mg ml⁻¹) was recorded from NaOH extraction of *V.zeylanica*. The FTIR analysis confirmed the presence of polysaccharides, which displayed bands characteristic to O-H, C-O-C, and C-O groups. NaOH extraction of Polysaccharide from *V.zeylanica* displayed the highest antibacterial activity against *Staphylococcus aureus*. NaOH extraction of *V. zeylanica* showed the highest significant scavenging abilities ($p < 0.05$) on hydroxyl radicals (IC_{50} , 4.832 mg ml⁻¹) whereas the highest significant scavenging abilities ($p < 0.05$) on DPPH radicals (IC_{50} , 9.594 mg ml⁻¹) was shown by the hot water extraction. Significant difference was not observed in all fractions for protease inhibition activity. Thus, this study reveals that polysaccharides extracted from *V. zeylanica* have significant biological activities.

Keywords: Functional food, Polysaccharides, *Vernonia cinerea*, *Vernonia zeylanica*, Bioactivities

Studies Towards the Isolation of Antibacterial Compounds from Endophytic Fungi of *Cyperus rotundus*

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Endophytic fungi are a relatively new source for the isolation of antibiotics effective against resistant pathogenic bacterial species. The main aim of this study is to investigate the antibacterial producing potential of endophytic fungi of *Cyperus rotundus* with a view to isolating novel antibiotics. Initially, antibacterial activities of the crude ethyl acetate extracts of endophytic fungi isolated from surface sterilized *C. rotundus* were evaluated using an agar disc diffusion assay against *Staphylococcus aureus*, *Bacillus cereus*, *Pseudomonas aeruginosa* and *Escherichia coli*. Next the fungus with the most promising overall activity, identified using molecular techniques, was grown in 200 PDA Petri dishes and bioassay guided fractionation of its crude extract was conducted to isolate the active compound/s. Out of the 13 isolated endophytic fungi 11 fungal extracts were active against at least one bacterium tested while the highest activity (15 mm zones of inhibition against *B. cereus* and *S. aureus*) was shown by an endophytic *Agrocybe* sp. The ethyl acetate (EtOAc) crude extract (280 mg) of cultured *Agrocybe* sp. was partitioned between hexane, chloroform, EtOAc and water and the resulting fractions were subjected to antibacterial assay at 200 µg disc⁻¹ which revealed hexane as the most active fraction. Next, the hexane fraction (100 mg) was further purified by normal phase silica chromatography using a gradient elution. Bioassay for the fractions combined according to the TLC profile, showed that fraction B and D to be active with 16 and 20 mm inhibition zones respectively against *S. aureus* at 400 µg disc⁻¹. TLC of fraction D showed the presence of a single compound while fraction B consisted of more than one compound. Continued research towards further purification of fraction B is in progress. Spectroscopic data will reveal the structures of the active compounds. This study has shown that there is a good potential for the discovery of antimicrobial compounds from endophytes of *C. rotundus* which may in turn contribute towards developing new clinically useful antibiotics.

Keywords: *Cyperus rotundus*, Endophytic fungi, Antibacterial, *Agrocybe* sp.

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Production of Biodiesel from Yellowfin Tuna (*Thunnus albacares*) Fish Skin Wastage

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Yellowfin tuna (*Thunnus albacares*) is one of the major exporting fish species in Sri Lanka. Approximately 50% of the total large pelagic catch in Sri Lanka constitutes tuna-like fish species and usually fillets, steaks, cubes are exported. The rest, which is approximately 1/3 of the harvest is discarded which contain head, skin, tail, viscera and fins. Roughly 5000 tons of fish waste are generated every year in Sri Lanka. Dumping such waste in to the environment can cause various environmental problems. This study was focused to add value to such waste by producing biodiesel as an alternative energy source for petroleum. Tuna fish skins were collected from local processing factory and brought to the laboratory under 4 °C and cut in to small pieces. Fish oil was extracted using different solvents; absolute ethanol, ether, n-hexane and 1:1 mixture of ethanol and water using ultra sonication and soxhlet extraction method. Fatty acid profile, energy and the yield was calculated. Accordingly there were no any significant difference in yield of the extracted oil with single solvents used ($p > 0.05$). But ether was selected as the best solvent (3.24 g±0.61). Among the two methods, Soxhlet method showed the highest oil yield (20 mL/kg of fish skin). Fish oil profile was obtained by using Thin Layer Chromatography (TLC) and Gas Chromatography-Mass Spectroscopy (GC-MS). The extracted oil was used to produce biodiesel using single step transesterification with potassium methoxide. The percent conversion of oil in to biodiesel was 88%. Fourier Transmission Infrared (FTIR) Spectroscopy method was used to characterize the fish oil as well as the biodiesel. The energy capacity of the synthesized biodiesel was measured using a Differential Scanning Calorimeter. All the test results were benchmarked against the commercially available petrochemical based diesel. Accordingly, ether soxhlet separation can be used as a potential biodiesel production from Yellowfin tuna fish skin.

Keywords: Biodiesel, Yellowfin Tuna, Soxhlet, Ether, Sonication

Antioxidant and Metal Chelation Activities of Fish Protein Hydrolysates Produced from (*Scomber japonicus*) Pacific Mackerel Canned Fish Processing Fin Wastage

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Pacific chub mackerel (*Scomber japonicus*) is a salience fish species which highly utilized in canned fish processing. In production, around 30% of raw fishes are discarded as wastes which lead to economic losses and environmental pollution. Hence, production of Fish Protein Hydrolysates (FPH) utilizing fish wastes, which contains bioactive compounds may be an ideal remedy. In this study *Scomber japonicus* canned fish processing fin wastage was collected and blended. Aqueous extracts of Fish Protein Concentrates (FPC) were produced with 04 different ratios as sample: distilled water, 1:1, 1:2, 1:3 and 1:4. Crude extraction was observed using 10% SDS-PAGE. Extracted FPCs were hydrolyzed using Papain, Pepsin, Trypsin and Protease enzymes (1:100) under 370C with their optimum pH conditions for 0, 3, 6, 9, 12 and 24 hours followed by heat inactivation at 1000C for 15 minutes. Hydrolyzed samples were lyophilized and observed for antioxidant activities by TBARS and DPPH scavenging assay and metal chelation activity by Fe (II) chelating activity. According to the observations there was no significant difference between the 04 ratios in yield ($p > 0.05$). So 1:1 ratio was selected with periods as Papain-24 h, Pepsin3 h, Trypsin-3 h, Protease-0 h for further experiments. According to the results obtained from TBARS assay, none of the FPHs showed antioxidant properties ($p < 0.05$), instead all showed high oxidative activity. However DPPH scavenging assay showed significance difference among the treatments ($p < 0.05$). Results obtained by Fe (II) chelation activity analysis revealed that the produced FPHs show Fe(II) releasing activity instead of chelation (1.84, 13.99, 16.48, 1.84%,), while FPHs produced according to standard protocol showed a slight chelating activity (0.73%). This concludes the FPHs produced using aqueous extracts of *Scomber japonicus* do not contain strong antioxidant activity and they have iron releasing properties.

Keywords: Fish Protein Hydrolysates (FPH), Enzyme Treatment, Antioxidant, Metal Chelating

**Somatic Embryo Induction from *in vitro* Leaf Callus of Tea
[*Camellia sinensis* (L.) O. Kuntze] Cultivars, 'TRI2024' and 'TRI2043'**

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Tea [*Camellia sinensis* (L.) O. Kuntze] is a major plantation crop that plays a key role in the economy of Sri Lanka. Thus, the aim of this study was to improve the indirect somatic embryogenesis and initiate embryogenic callus formation in tea. The explants of green colour compact *in vitro* leaf callus of TRI2024 and TRI2043 cultivars were cultured on the solid and in liquid MS media containing different plant growth regulators to induce the embryogenic callus under *in vitro* condition. The three factorial CRD with cultivar, treatment and media formulation as factors were used as the experimental design with ten replicates for each treatments. The highest average relative growth rate (82.3%) was occurred in leaf callus of TRI2024 cultivar on MS solid medium supplemented with 2 mg l⁻¹ BAP + 3 mg l⁻¹ NAA. The highest average growth index (17.6) was occurred in leaf callus of TRI2024 cultivar on MS solid medium supplemented with 2mg/L BAP + 3 mg l⁻¹ NAA + 8.6 mg l⁻¹ AgNO₃. However, the highest average relative growth rate and average growth index for callus of TRI2043 cultivar was observed in liquid media than solid media. Somatic embryo induction was initially observed on *in vitro* leaf callus of TRI2024 cultivar within ten weeks of culture. There is a significant difference between the cultivars, media and media formulations (solid and liquid) and interaction between cultivars in callus induction and proliferation. The MS solid medium containing 2 mg l⁻¹ BAP + 3 mg l⁻¹ NAA was reported as the best medium for indirect somatic embryogenesis from the *in vitro* leaf callus of tea cultivar TRI2024. This protocol with further extended experiments will be used to obtain embryogenic callus from *in vitro* leaf callus of tea. Therefore it will be beneficial for mass propagation of selected elite clones of tea in the future.

Keywords: *Camellia sinensis* (L.), Indirect somatic embryogenesis, *in vitro* propagation, Tea

Phytochemical Screening and Antioxidant Activities of Selected Tropical Underutilized Fruits

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Fruits are rich sources of bioactive compounds as majority of them have antioxidant properties. The objectives of this study were to screen particular phytochemicals and to determine the antioxidant properties of selected fruit species, namely *Cynometra cauliflora*, *Psidium cattleianum*, *Annona squamosa* and *Diospyros discolor*. Phytochemical screening was done using colourimetric qualitative analysis to screen phenol, flavonoid, tannin, alkaloid and saponin. *Cynometra cauliflora* seed and *Psidium cattleianum* fruit extracts were positive for all the tested phytochemicals. Antioxidant properties of fruit extracts were determined by *in vitro* antioxidant assays using 96 well micro plates. Total Phenolic Content, Total Flavonoid Content, Ferric Reducing Antioxidant Power and Oxygen Radical Absorbance Capacity were determined by using standard procedures. All values of antioxidant properties were significantly different for the tested fruits ($p < 0.05$). The highest total phenolic content value was recorded for *Cynometra cauliflora* seed (306 ± 1.64 mg of Gallic Acid Equivalents per g of extract) while the lowest value was recorded for *Annona squamosa* (19.17 ± 4.78 Gallic Acid Equivalents per g of extract). The highest total flavonoid content value was shown by *Psidium cattleianum* (4.76 ± 0.19 Quercetin Equivalents per g of extract) while the lowest value was shown by *Diospyros discolor* (0.35 ± 0.02 Quercetin Equivalents g^{-1} of extract). The highest ferric reducing antioxidant power value was shown by *Cynometra cauliflora* seed (685.38 ± 1.63 Trolox Equivalents per g of extract) while the lowest value was shown by *Cynometra cauliflora* pericarp (30.74 ± 1.3 Trolox Equivalents per g of extract). The highest oxygen radical absorbance capacity value was recorded for *Psidium cattleianum* (549.79 ± 6.91 Trolox Equivalents per g of extract) and the lowest value was recorded by *Annona squamosa* (33.57 ± 0.31 Trolox Equivalents per g of extract). Overall results of the study revealed *Cynometra cauliflora* seed, *Cynometra cauliflora* pericarp, *Psidium cattleianum*, *Annona squamosa* and *Diospyros discolor* extracts posses antioxidant properties and in general *Cynometra cauliflora* seed and *Psidium cattleianum* have high antioxidant properties.

Keywords: Antioxidant, Free radicals, Phytochemicals

Determination of Genetic Purity of the Yellow Dwarf Coconut Seedlings Rejected from Nurseries Using SSR Markers

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Hybrids coconut cultivars usually produce 40% higher yields over commonly grown Sri Lankan Talls. At present about 10,000 yellow dwarf coconut seedlings are rejected yearly from nurseries, as there is not true to type hybrids based on yellow color petiole as a visible marker for hybrid seedlings. The ambiguity of this phenotypic marker for selection often results in considerable wastage of true hybrid seedlings from the nurseries widening the gap between the demand and the supply of hybrid planting material. In the current study, microsatellite (SSR) marker-based approach was used to test the true hybridity of seedlings raised in the nursery. One hundred rejected seedlings were screened with 2 SSR primers, namely CAC 68 and CAC 23 which exhibited potential to distinguish parental varieties, Sri Lanka Tall (SLT), Sri Lanka Yellow Dwarf (SLYD), and resulting hybrids. The results of the study revealed that on average 36% of the rejected plants were true hybrids which are suitable for planting. The percentages of parental types, the true contaminants were 62% comprising with 6% Tall types and 56% SLYD types. As a result the current visible marker used to select off type seedlings from the coconut nursery is inaccurate resulting a loss of 36 true hybrids to the industry for every 100 seedlings rejected. The two SSR markers can be used to confirm the hybridity of seedlings derived from SLT X SLYD crosses reducing the loss by authenticated plants from the nurseries.

Keywords: Genetic purity, Hybridity testing, SSRs, Yellow dwarf coconuts, Phenotypic marker.

Degradation of Cellulose and Pectin in Organic Wastes by Developed Fungal-Bacterial Biofilms

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An organic waste consists of cellulose and pectin which are resistant to rapid degradation due to their complexity. The objective of this study was to find out the most efficient fungal-bacterial biofilm/s (FBB/s) for the organic waste degradation. Pectinolytic and cellulolytic activity of isolates were tested by standard plate assays and best strains were used to develop 25 FBBs. The best FBBs were selected based on the physical attachment of bacterial cells to fungal filaments (light microscopic observations), and those were symbolized as F3B1, F5B1, F2B2, F3B2, F3B3, F4B3, F2B5 and F3B5. Coffee silver skin, barely skin and rice husk were the organic wastes used. Developed FBBs were inoculated separately to 10 g of above wastes in petri dishes and were incubated for 40 days. The control was maintained without FBBs inoculation. Three replicates were maintained for each treatment and the experiment was arranged in a completely randomized design. The mass reduction, Fourier Transform Infrared Spectroscopy (FTIR) and sugar accumulation of samples were analyzed within five day intervals. Data were analyzed by ANOVA. Results revealed that in the 40th day, the sugar production was highest in barley husk treated by F3B5. In coffee silver skin, the sugar accumulation was similar under all FBBs. In rice husk, F3B1 showed the highest sugar level in 15th day, but F4B3 dominated on the 25th day. The mean weights of the samples decreased with time, but after 25th day they came into a plateau with having 0.1-0.3 % weight loss percentage. According to FTIR data, all FBBs except F3B3 showed the degradation of barely husk. F2B5 was the best in terms of weight loss during the last five days of incubation. F4B3, F3B2 and F5B3 were the best biofilms in terms of weight loss at the end of 10th, 15th and 20th days, respectively. It can be concluded that F3B3 and F3B2 were the best FBBs for degradation of all three types of organic wastes.

Keywords: Cellulose, Pectin, Degradation, Organic waste, Fungal-bacterial biofilm

Unexplored Plant Family (Violaceae) in Sri Lanka; Potential for Bioactive Cyclic Peptides

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Cyclotides are a unique class of ribosomally synthesized cysteine-rich mini proteins. Their compact structure consists of a head-to-tail cyclized backbone stabilized by the knotted arrangement of three conserved disulfide bonds, in the combination known as cyclic cysteine knot (CCK) motif. Due to these unique features that imparts ultra -stability to its structure, cyclotide has attracted interest as peptide-based templates for drug design applications. Although cyclotides have a wide range of biological activities such as antimicrobial, anti-HIV, antineurotensin, cytotoxic and hemolytic activities, their natural bioactivity in plants is thought to be as insecticidal with a role in plant defense. To date, the plant families Rubiaceae, Solanaceae, Fabaceae, Cucurbitaceae and Violaceae have been shown to contain cyclotides. However, until the current study was initiated, the cyclotides distribution in Sri Lankan plant species remained unexplored. This investigation was conducted according to a systematic screening of plants belonging to the family Violaceae for the presence of cyclotides. Gel filtration followed by Liquid Chromatography Mass Spectroscopy (LC-MS) techniques were used to identify the molecular weights of cyclotides in the crude fractions of *Viola* species. Further confirmation of cyclic peptides was carried out by reduction and alkylation reactions. Out of the four plants screened for the discovery of cyclotide masses, presence of cyclotides was confirmed in three *Viola* species. In the LC-MS chromatogram scan range of 400 to 2000 Da, the cyclotides retention times were in the range from 25 min to 40 min with molecular weights detected at $(M+2H)^{2+}$. Our study reinforces that investigating of cyclotides in unexplored geographical locations by a systematic approach guided by ethnomedical evidence is a promising strategy to expand our knowledge on the biodiversity and bioactivities of cyclotides.

Keywords: Medicinal plants, Cyclotides, Violaceae family, LC-MS

Antioxidant Activity of Selected Ten Underutilized Fruit Species

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The study was conducted to assess the antioxidant potential of ten underutilized fruit species namely *Phyllanthus emblica* L., *Flacourzia* sp., *Elaeocarpus serratus* L., *Phyllanthus acidus* (L.) Skeels, *Averrhoa carambola* L., *Averrhoa bilimbi* L., *Cynometra cauliflora* L., *Morus* sp., *Spondias* sp. and *Manilkara zapota* (L.) P. Royen grown in Sri Lanka. Fruit extracts were prepared by centrifuging (4500 rpm) finely ground fresh fruit samples (20 g) with distilled water (40 ml) for 90 minutes. The extraction was repeated twice and the supernatants were used for analysis. Total Ascorbic Acid Content (TAsC) was determined using an iodometric titration technique, calculated as mol per gram of fresh weight. Antioxidant potential was determined using DPPH• and ABTS•+ radical scavenging assays. The DPPH• Radical Scavenging Activity (RSA) of the extracts was expressed as IC₅₀ values. The ABTS•+ activity (RSA) was calculated as percentage of discoloration. This experiment was conducted by following complete randomized design with 3 replicates. Ascorbic acid was used as a positive control and distilled water was used as a negative control. The TAsC varied among the species from $0.125 \times 10^{-3} \pm 0.000025$ mol g⁻¹ of fresh fruit of *C. cauliflora* L. to $4.608 \times 10^{-3} \pm 0.0001665$ mol g⁻¹ of fresh fruit of *P. emblica* L. The TAsC and antioxidant activity (DPPH• and ABTS•+ assays) were found in order to, *C. cauliflora* L. < *Spondias* sp. < *A. carambola* L. < *Morus* sp. < *P. acidus* L. < *A. bilimbi* L. < *E. serratus* L. < *Flacourzia* sp. < *M. zapota* L. < *P. emblica* L. The significant antioxidant potential was possessed *P. emblica* L. as it showed 93.38±0.97% ABTS•+discoloration and 28.03±1.81 µg ml⁻¹ of fresh fruit needed for IC₅₀. The lowest antioxidant potential was possessed *C. cauliflora* L. as it showed 1.75±1.16% ABTS•+discoloration and 381.1±3.15 µg ml⁻¹ of fresh fruit needed for IC₅₀. These results suggested that underutilized fruit species could be exploited as an ingredient in developing a potential antioxidant supplement.

Keywords: Antioxidants, Fruits, DPPH, ABTS, IC₅₀

Anti-oxidant Activities of Bioactive Compounds Extracted from *Pterygoplichthys pardalis* (Scavenger Fish) Harvested at Digana, Central Province, Sri Lanka

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Pterygoplichthys pardalis (Scavenger fish) survive by competing with native biota. This species is an omnivore which threat to endemic fish species and inland aquaculture industry. However, these fishes contain compounds which autolysis proteins under low temperatures. Objective of this study was to check the difference in the water soluble proteins which can be used as bioactive compounds separated from scavenger fish after slaughtering stored at 4 °C for 24 hrs. Female fish (n = 3) were collected from local reservoir and slaughtered in the field. Slaughtered fish which stored at 4 °C were separated into 4 main components as flesh, GI tract, mucus and other gonads in 0, 3, 6, 9, 12 and 24 hrs of storing. Separated parts were homogenized with distilled water (1:4) and centrifuged to collect the supernatant. Level of separation was observed using SDS-PAGE gel electrophoresis. Then samples were lyophilized and used for further analysis. Antioxidant activity was measured using TBARS inhibitory assay and DPPH scavenging activities. SDS-PAGE images confirmed that there were no differences in the extracted compounds after 03 hrs of slaughtering. According to the TBARS assay, three extractions from flesh, mucus and other organs had stronger antioxidant properties compared to the control ($p < 0.05$). While DPPH scavenging results showed over 75% activity (other organs- $91.26 \pm 8.28\%$, flesh- $87.07 \pm 4.49\%$, GI- $86.20 \pm 3.94\%$, mucus- $75.20 \pm 4.09\%$) but no difference was observed among the extracted compounds ($p > 0.05$). Concluding water extracted in 0-3 hrs after slaughtering of female scavenger fish showed strong antioxidant activities and this can be used as natural anti-oxidant agent in food industry.

Keywords: Scavenger fish, Antioxidant properties, TBARS assay, DPPH assay

Antioxidant Activity of the Crude Extract of *Ulva lactuca* (Sea Lettuce) Collected from the South Coast of Sri Lanka

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Ulva lactuca is one of the famous edible seaweeds around the world. It is a rich source of many nutrients and bioactive compounds. Solvent extraction method is commonly used in extracting bioactive compounds in seaweeds which may be non-food grade. The objective of this study was to develop a simple, food grade extraction method to extract bioactive compounds from *Ulva lactuca* and identify the antioxidant activity of the crude water soluble extract and compare with a commonly used solvent extraction method. Four types of seaweed treatments (05 g) namely Fresh, Air-dried (AD), Oven-dried (OD) and Freeze-dried (FD) were used for the water extraction using three different ratios as 1:10, 1:20 and 1:30 and Air-dried sample using Methanol as the control. The crude extracts derived from different extraction methods were used for analyzing the antioxidant activity by Thiobarbituric Reactive Substance (TBARS) assay and 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging assay. All the trials were done in triplicates. Data were analyzed using the Minitab 18. In TBARS assay, methanol extracts showed the lowest TBARS value (-1.10 ± 0.08) and AD (1:30) and OD (1:10, 1:20, 1:30) showed no significant difference ($p > 0.05$) compared to antioxidant activity of the methanol extracts. Almost all the samples showed antioxidant activity except Fresh (1:10, 1:20) and AD (1:10). However, In DPPH scavenging assay, DPPH scavenging activity of Fresh (1:10, 1:20, 1:30), AD (1:10, 1:20, 1:30), OD (1:10, 1:30) and FD (1:30) showed no significant difference ($p > 0.05$) compared to that of methanol extracts. AD (1:10) showed the highest DPPH scavenging activity ($89.54 \pm 4.56\%$) which is higher than methanol (87.75 ± 2.87) and Ascorbic acid (85.73 ± 0.19). Therefore it can be concluded that considering the time of production, simplicity, toxicity and cost; water extraction of Fresh (1:10) or AD (1:10) can be used as a best extraction for producing antioxidant agents in food industry.

Keywords: *Ulva lactuca*, Water extraction, Antioxidant, TBARS, DPPH

Effects of Different Cooking Methods on Antioxidant Activity of Selected Underutilized Tuber Crops of Sri Lanka

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This study was carried out to investigate the effect of cooking on antioxidant activity of five underutilized tuber crops of Sri Lanka namely, *Dioscorea alata* (raja ala), *D. esculenta* (kukulala), *Amorphophallus paeoniifolius* (kidaran), *D. alata* (kondol), *D. alata* (hingurala). The two cooking methods tested in the study were frying and boiling. Selected tubers were peeled, cut into strips of 0.5 W x 4 L x 0.5 H cm separately. Then the strips were cooked separately either by boiling in water until soft or fried in coconut oil until golden brown and crispy for 15 minutes. Uncooked strips from each tuber variety served as controls. Methanolic extracts were prepared for boiled, fried and fresh tuber strips by shaking (780 rpm) shade dried finely powdered samples (20 g) with 30 ml of methanol. Total ascorbic acid content of each extract was measured by Iodometric titration method and total antioxidant activity was measured by 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) radical scavenging assays. Each experiment was conducted as 3 replicates. Results indicated that total ascorbic acid content of boiled yam extracts were significantly lower ($p < 0.05$) than the control and fried tubers. Raw yam extracts of all five varieties had higher ascorbic acid and antioxidant contents than cooked tuber extracts. The DPPH and ABTS radical scavenging capacity of boiled yam extracts were significantly lower ($p < 0.05$) than fried tubers. Amongst five varieties, highest radical scavenging capacity was shown by *Amorphophallus paeoniifolius* raw yam extract and lowest value was obtained for *D. alata* (hingurala) boiled yam extract ($p < 0.05$). IC₅₀ values (concentration for 50% inhibition of DPPH) and ABTS discoloration percentage of each variety was $85.2 \pm 2.7 \mu\text{g ml}^{-1}$, $86 \pm 1\%$ and $910.8 \pm 11.8 \mu\text{g ml}^{-1}$, $9.57 \pm 1.89\%$ respectively. Antioxidant activities of all cooked tubers are lower than the raw tubers. For all tubers boiling in water had lower antioxidant activity.

Keywords: Tuber Crops, Effects of cooking methods, Antioxidant activity, DPPH and ABTS assay

**Effect of Methanolic Extracts of *Emilia sonchifolia* (Lilac tassel flower),
Ageratum conyzoides (Billy goat weed) and *Mikania micrantha* (Bitter
vine) on Protease Enzyme Inhibition**

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According to previous studies, methanolic extracts of *Emilia sonchifolia*, *Ageratum conyzoides* and *Mikania micrantha* have shown significant antimicrobial activity against *Staphylococcus aureus*. But their mode of action on the microorganisms is still unknown. It is expected that these three plants may have acted as protease inhibitors in the respective microorganism. So in the present study, 40 g of shade dried leaves of each plants, *E. sonchifolia*, *A. conyzoides* and *M. micrantha* were extracted using methanol and subsequently subjected to solvent-solvent partitioning using hexane, chloroform and ethyl acetate. Those fractions were evaporated to obtain concentrated fractions. Then these concentrated fractions were used to prepare four concentration gradients, such as: 250 µg ml⁻¹, 500 µg ml⁻¹, 750 µg ml⁻¹ and 1000 µg ml⁻¹ and tested against protease enzyme. The protease enzyme assay was carried out based on Kunitz method, using casein as the substrate. According to the results obtained, highest inhibitory percentage was shown by *E. sonchifolia*. Even though statistical output has shown a significant difference of inhibition percentage among the concentration gradient of the plant fractions used (p value = 0.000), the range of the values are narrowed from 83.8% and 93.5% only for all three plants. So the results do not confirm the protease inhibitory activity of the extracts of the selected plants. Protease inhibitors control the action of proteases that are vital for the growth and development of the organism. Therefore, the reason for the antimicrobial activity of the methanolic extracts of these plants may not be due to protease inhibitory reaction but due to some other reasons.

Keywords: Protease, Protease inhibitors

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Detecting Mislabelling of Packaged Frozen Seafood Products in Sri Lanka: A DNA Barcoding Approach

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Seafood trade has conquered a vast market in global, as well as the local context. Substitution of high value species with those of low cost has become an emerging problem for the expanding market, since some of the products are visually unrecognizable and morphologically indistinguishable. The objective of this study was to assess the suitability of DNA barcoding as a method for species identification of packaged seafood to detect any mislabelling. Eight packaged frozen seafood product samples including finfish, crab, shrimp and cuttlefish were obtained from randomly selected supermarkets and subjected to DNA extraction by standard phenol chloroform DNA extraction protocol. Mitochondrial cytochrome oxidase subunit I gene (COI) was amplified in those samples with appropriate primers. Then successful five PCR products of tuna (T1 & T2), sailfish (SF1 & SF2) and crab (C1) were selected for sequencing to build DNA barcodes. The prepared DNA sequences were compared with the Barcode of Life Database (BOLD) system for species identification. Close related sequences of each sample were downloaded from NCBI Genbank and phylogenetic trees were constructed using Maximum Parsimony, Maximum Likelihood and Neighbor Joining methods. Samples were identified as follows, T1 - *Thunnus albacares* (100%) and T2 - *Thunnus alalunga* (99.85%), SF1 and SF2 - *Istiophorus platypterus* (100%) and C1 - *Portunus pelagicus* (97.71%). Identical tree topologies were resulted from three methods and three major clades were revealed in the phylogenetic tree as tuna, sailfish and crab groups. All selected five samples were matched (100%) showing that correct labelling had been done. This study concluded that DNA barcoding is a feasible, efficient and reproducible method for detection of mislabelling of packaged frozen seafood. However, the packaged frozen seafood trade has not reached high extent in Sri Lanka yet, hence substitution of seafood products does not occur frequently.

Keywords: Seafood, Identification, DNA Barcoding, Phylogenetics, Mislabelling

Protein Overexpression in Different *E. coli* Strains for Industrial Scale Drug Development in Sri Lanka

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Research and industrial scale protein overexpression for pharmaceutical products uses *Escherichia coli* (*E. coli*) strains due to their well-characterised genome and easy manipulation. This review addresses the current scope of *E. coli* strains for protein overexpression, at global scale and in Sri Lanka, and the feasibility of development of pharmaceutical protein manufacturing in Sri Lanka, through a published literature at PubMed and Google Scholar. We identified that globally *E. coli* BL21 is the most common host strain due to properties such as mutation of Lon Protease coding gene and *hsdSB* gene that degrade foreign and extracellular proteins, respectively. It is developed into BL21(DE3) for T7 expression system, C41(DE3) for toxic and C43(DE3) for highly toxic and membrane proteins, hence, useful for large clade of enzymes in system biology. In K-12 lineage, the AD494 and Origami™ strains were developed with thioredoxin reductase mutation enhancing disulphide bond formation in cytoplasm. HMS174 stain with *recA* mutation carries higher plasmid stability. In Sri Lanka, however, only few published data were available, mainly focused on pathogenicity of *E. coli* with small published research at local institutes for overexpression of growth hormone like protein of *Setaria digitata*, multiepitope IgG/IgM proteins, in *E. coli* BL21(DE3). Although, this evidenced the availability of required technology and assets in Sri Lanka for necessary protocols, protein products such as pharmaceutical drugs being imported at high cost than developing research to optimise protein overexpression in the country. Through this review, we suggest the optimum utilisation of available laboratory infrastructure, personnel assets and protocols by developing research not only with BL21(DE3), but other strains for specific protein expressions, where the research can be developed for industrialising to meet the demands of the pharmaceutical industry and many other biomedical researches in Sri Lanka.

Keywords: *Escherichia coli*, Protein overexpression, Pharmaceutical

Genome Analysis on Drought Resistance of *Hevea brasiliensis*

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Hevea brasiliensis (para rubber tree) plays an important role in the economy of Sri Lanka. Potential drought stress conditions due to climatic changes will have a severe effect on the yield and the survival of the rubber tree. Understanding the underlying genetic basis of drought tolerance through identification and systematic analyses of the candidate genes associated with drought tolerance of *Hevea* will help rubber breeding by marker assisted selection and transgenic improvement. This study was undertaken to generate information about the genes related to drought tolerance in *Hevea*. Biologically validated eighteen *Arabidopsis thaliana* genes with known functional pathways were used as query sequences to find orthologous *Hevea* genes from the ASM165405v1 genome assembly using the BLASTP program of the BLAST tool. Query coverage higher than 50%, bit score higher than 80 and E-value lower than 1×10^{-50} were taken as cut off criteria for the search. Nine *Hevea* orthologous genes were identified and they represented six functional groups involved with both physiological and molecular adaptation to drought. Highest number of candidate genes identified encodes transcription factors. Systematic analyses of the identified genes related to drought tolerance suggest that transcription regulation, phospholipid metabolism, growth control, detoxification signaling, osmolyte biosynthesis and signal transduction pathways play important roles in drought tolerance in *Hevea*. Identification and analysis of conserved regions was conducted for the identified three transcription factors using the MEME and InterPro tools respectively. Three domains were identified which shared Gene Ontology terms related to drought tolerance. The results of the research not only enrich information about the genes related to drought tolerance, but also provide new insights into understanding the drought tolerance mechanisms in rubber tree.

Keywords: *Hevea brasiliensis*, Drought tolerance, Orthologous genes, Transcription factors

Effect of Solvent Type and Extraction Time on Yield and Purity of Lotus (*Nelumbo nucifera*) Leaf Wax

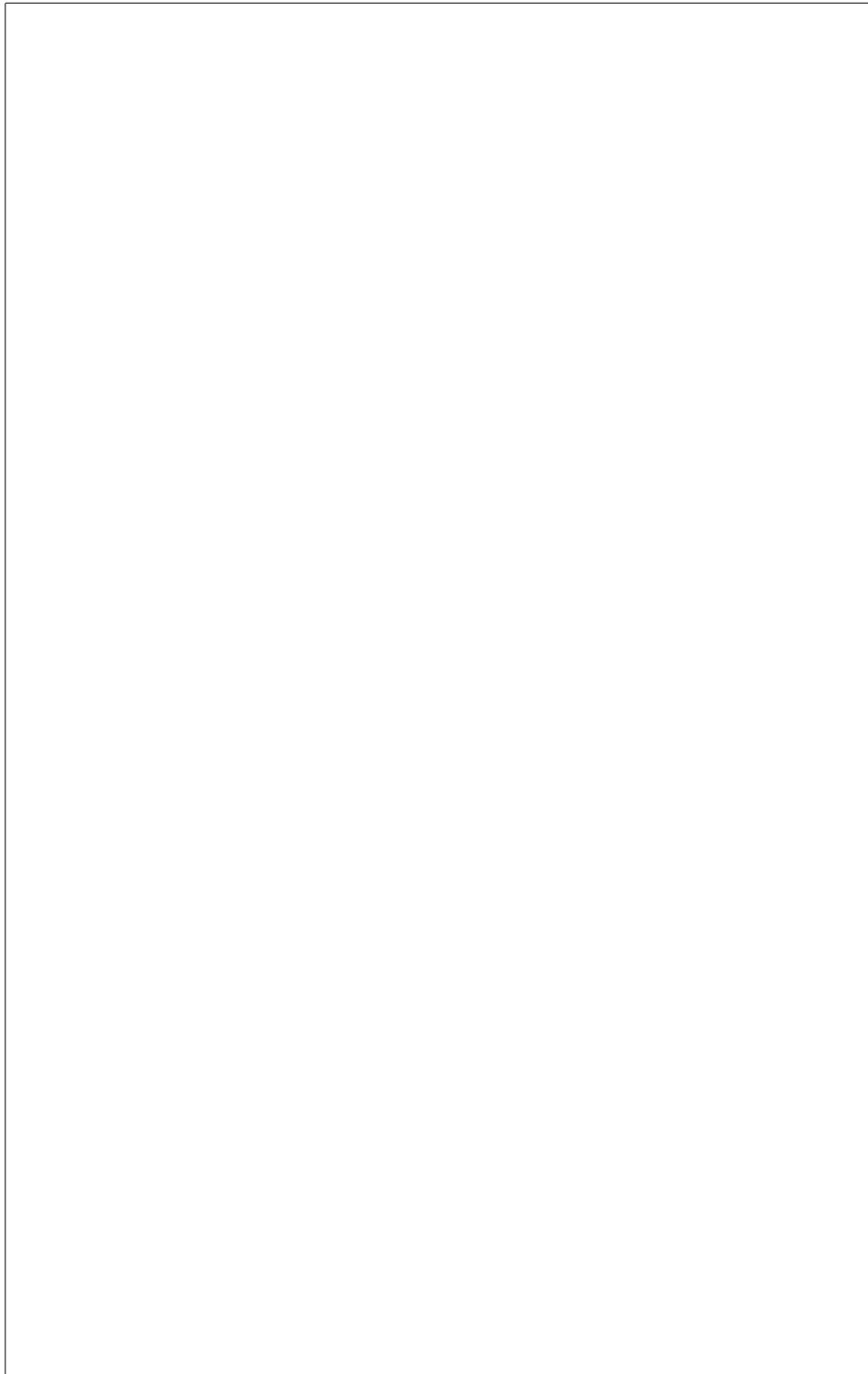
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This study was conducted with the main objective of extracting lotus leaf wax using a simple methodology and to analyze the wax yield and purity of the extracted wax corresponding to different time treatments. Past studies have found that lotus plant leaf wax contains a mixture of aliphatic compounds mainly nonacosanol and nonacosanediols. Fresh, cleaned lotus leaves with 1 cm² in surface area were exposed to three organic solvents (methanol, acetone and chloroform) and time taken for the presence of light green colour (due to the extraction of chlorophyll) in the medium was recorded to find out the most efficient organic solvent. Further, contact angle measurements of water drops placed on each of the leaf samples treated with different solvents were calculated to find out the efficiency of wax extraction. Based on the results obtained from this study leaf samples with surface area of 72.41 cm² were exposed to chloroform by changing the dipping time duration ranging from two seconds to 30 minutes with time intervals of two seconds for the first five treatments ,15 seconds for the next three and five minutes for the last seven treatments. Extracted wax was subjected to the FTIR analysis to find out the purity of the wax. According to the results it was revealed that green colour was appeared in methanol within the first five minutes and there was no color change in the chloroform and acetone for about 30 minutes. Moreover, least change of the contact angle was shown by the leaf sample which was treated with acetone and it reveals that wax extraction was not done in an efficient manner. Chloroform is the best solvent to extract lotus leaf wax among three organic solvents used. The highest mean yield gives out by the time treatment with the dipping time of 20 minutes. And it shows that the purity decreases with the increase of the dipping time duration.

Keywords: Lotus leaf, Wax, Extraction, FTIR



Computing and Information Science

- Artificial Intelligence
- Communication Systems and Networks
- Data Mining, Data Warehousing and Database
- Management Information Systems
- Software Engineering, Web Engineering and Applications
- Big Data and Analytics

An Accurate Multiple Sequence Alignment Algorithm for Biological Sequence Sets with High Length Variations

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Multiple sequence alignment (MSA) is used for many studies in modern biology. There are many algorithms available for the alignment of multiple sequences. Among them, progressive alignment algorithm is the most commonly used heuristic alignment strategy for MSA. It solves MSA with an economic complexity but does not provide accurate solutions, because there is a conflict between accuracy and complexity. The existing similarity score method in progressive alignment algorithm does not consider the lengths of the sequences in the considered sequence set. So, if the protein or DNA sequences are with high length variations, the initial alignment scores may not produce a correct measure of similarity between the sequences. This leads to less accurate initial alignment scores, and as a consequence, final multiple sequence alignment may produce inaccurate results. In this research, we present a modified progressive alignment algorithm especially for sequences with high length variations. We modify the latest version of ClustalW 2.1 by replacing the similarity distance measure in ClustalW algorithm with a novel distance measure. The new distance score method captures the distance between each sequence pairs in sequence set and the obtained distance measure is utilized to generate a better guide tree for progressive alignment. In order to determine the pairwise similarity distance measure, we used lengths of the *shortest common super-sequence* (SCS) and the *Longest Common Sub-sequence* (LCS). We assessed our algorithm with BALIBASE 3.0 protein benchmark and compared the obtained results to those obtained with ClustalW alignment algorithm using the Quality score (Q Score) and the Sum of Pairs Score (SPS). We obtained better Q scores and SP scores for the alignments from modified ClustalW algorithm over original ClustalW algorithm. Furthermore, the alignment speed of modified ClustalW algorithm is multiple times faster than the original ClustalW algorithm.

Keywords: Multiple sequence alignment, Distance measure, Shortest Common Super-sequence, Longest Common Sub-sequence.

Sixty Seconds Robot - An Effective Development Approach for Robot Programming

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Nowadays, a lot of people are interested in robotics technology. However, most of them do not have a required knowledge in robotics and programming. Therefore, it has become a major barrier for innovations in robotics. However, if the basic process is automated, the entire problem can be solved without wasting programmers' effort and time. There are some visual programming software existed for programming in robotics such as Visuino, GUINO, XOD.IO, etc. The main problem of those types of advanced software is that the learning difficulties at the beginner level. Some of those tools are not much user-friendly for novice learners. Some of them do not facilitate to identify hardware related errors in the robot. To overcome these barriers, an efficient software tool has been introduced in this research to design the basic structure of a robot. The automated IDE can identify hardware related errors. There are many types of robots, such as line follow, wall detect, arm based, etc. The user can select a template from the IDE for one of the types and customize it. Also, it can be used for tuning sensors, Proportional Integral Derivative (PID) generators, etc. In this solution, the user has only to customize the template, and then the code for Arduino circuit that is generated automatically. Since, this is a full GUI application to do Arduino robotics, this provides a platform for the beginners to learn robotics and make their own projects with less errors. Our future development is mainly focused on developing solid work based on a universal template for more Artificial Intelligent (AI) based robots, radio signal based robots, etc. Ultimately, those extensions can be used in simple applications to more advanced applications such as robot based toys, military tools, drone technology, etc. In addition to that, the researchers have planned to develop a community for that where anyone can create libraries for implemented robotics platforms.

Keywords: Robotics, Arduino, Visual Programming, Error Detection

**Resource Creation for English-Maithili Machine Translation (EMMT) -
A Divergence Perspective**

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Maithili is one of the 22 scheduled Indian languages with almost no language technology resource. Absence of basic tools in this language has affected resource creation. Since English is the dominant language, translation from it can help creating the required corpora for tools development in Maithili. The present work discusses efforts for Language Technology Resource (LTR) creation and divergence study for an EMMT system, which is a Statistical Machine Translation (SMT) system. Creating any SMT system requires sizeable parallel, aligned corpora for training and testing. Creating general-purpose source corpora for English language and creating translation equivalents with possible alignments requires time and effort. The paper focuses on the data collection methods, cleaning, the size and structure of the text corpora, alignment and parallelization strategies, training, testing and a study of divergence between the language pair.

Keywords: Divergence, Machine Translation, English-Maithili, Indian languages, MT Hub

Optimizing Boyer Moore Algorithm using Parallel Processing Techniques

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Although computer processing power, memory and parallel processing capabilities have been significantly improved, most of the algorithms are still not improved based on novel technologies. *Boyer Moore string searching* algorithm is one of a mechanism that uses frequently. Thus, we optimized *Boyer Moore String searching* mechanism using parallel computing mechanism. Existing implementations were analyzed, compared the performance using CPU time with different pattern sizes in same condition. Python parallel version was implemented using three threads. Serial Python code uses main thread for two shifting rules calculation and searching mechanism. Thus, we used two threads for shifting rules calculation and one thread for searching mechanism. Existing implementations used one way searching mechanism to search the pattern in the text field. Then searching mechanism was changed into *bidirectional* searching process using a parallel Python implementation of the Boyer Moore Algorithm with six threads. To optimize the algorithm than bidirectional searching parallel python version, processing logic of the Algorithm was changed and used four threads. Two threads for the sifting rule calculation and after those two threads finished, string text is divided in to two parts and search begins with two threads for each part. Existing serial python version took 165.44 seconds for found correct pattern. However, our first implementation took 163.33 seconds for found correct pattern. Because of bidirectional searching way, the second implementation took 320.94 seconds,. Third implementation took 100.98 seconds for found correct pattern. Measure the time in the same conditions with the same text (T) and same pattern (P). Time is depending on text (T) size, pattern (P) size and machine type that we use to run the codes. Final implementation is bidirectional searching parallel python version with four threads. It is 38.96% effective than existing serial python version.

Keywords: Boyer Moore String searching, bidirectional

Characterization of the Mechanical Behavior of Packaging Material Using Digital Image Processing

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Among various packaging materials polymers, polymer blends and polymer composites are ubiquitous owing to their low cost, high flexibility, lightweight and reusability. However, their behavior drastically depends on the forces especially tensile and abrasion that employs on the materials during the packaging. Reusability of the material depends on whether the material is in its elastic or plastic region. However, according to the existing literatures, such regions are difficult to identify without having high-tech instrumentation such as a tensometer. To overcome such barrier, in this study a new prototype optical method, digital image processing (DIP), is proposed. The correlation between the colour variation of the material and its mechanical properties have been investigated. The colour of polymer materials changes in presence of applied force due to the microscopic level molecular arrangement. The traceable color change of several polymer materials in presence of applied force have been captured as a function of time using a digital camera. The captured images were processed to extract the ensemble average mean, median, standard deviation, entropy, and kurtosis in spatial domain. The changes were compared with the stress-strain relationship of the material measured using a tensometer. The kurtosis and the entropy extracted by DIP feature extraction method has some meaningful correlation with the experimentally measured mechanical properties. The correlation between the selected features and the experimentally measured parameters were obtained by quadratic regression fitting. The results obtained in this study illustrate that digital imaging and processing using a correlation algorithm could easily be used to identify the elastic and plastic region of the measured polymers over the traditional methods of extracting such data using tensometer. However, it is necessary to further validate this method for different types of polymers.

Keywords: Tensometer, Mechanical properties, Kurtosis, Regression fit, Features

Deeper Emotional Capture and Extraction of Discussion Pathways in Twitter Data

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The rise of micro-blogging has resulted in people expressing their daily thoughts, often resulting in far more emotion-laden than might normally occur. Recently, it has become a trend to post about the places one has visited and experiences the person had. Finding the emotions expressed through these texts can be used in understanding community thinking and decision making, but it is quite complex since it requires thorough knowledge in psychology and linguistic. Furthermore, processing the microblog text is challenging, because they are informal and less consistent in terms of language. This paper presents a lexicon and rule based approach, which breaks the emotions behind a tweet into the eight basic categories a person is capable of expressing, as defined by Robert Plutchik. Hence, we broke the emotional tone behind a tweet into 8 basic emotions namely anger, anticipation, disgust, fear, joy, sadness, surprise, and trust. In this, we selected a tweet corpus related to Sri Lankan tourism by querying a Twitter tool with suitable keywords often used by tweeters. We have augmented the accuracies of emotions capturing through a series of extensive text preprocessing steps fitting to twitter texts. The experimental results have shown that processing the informal tokens, hashtags and repeating character sequences can make a significant improvement in the emotion capturing accuracies. This research includes separating the tweets into cohesive discussion pathways using an existing incremental unsupervised machine learning algorithm, in order to come up with a rich decision making tool for the selected domain. No previous research has broken down emotions into these eight basic emotions and integrated the separation of discussion pathways into emotional capturing. We have contributed to the research world by succeeding in both these untapped research areas and developing a user friendly tool to use in constructive decision making.

Keywords: Sentiment Analysis, Emotion Detection, Topical Pathway Separation, Pre-processing, Twitter

Vision Based Autonomous Micro Areal Vehicle with Graphic Processing Unit Acceleration

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Autonomous Micro Aerial Vehicles (MAV) are available today to process and navigate within indoor environments. However, lack of processing power of the drone generates unreliable, inaccurate and inefficient navigation results. This paper presents a model for a vision based autonomous hexa-copter for navigating within an indoor environment with the use of GPU acceleration. The MAV is embedded with Jetson TK1 board with GPU computing power, MS Kinect, Arduino Flight controller. Jetson TK1 on development kit gets the outside data using Kinect sensor and build the map itself by Jetson TK1 board with the help of GPU computing. Then drone can navigate without a remote access and it uses the flight controller to control MAV. In addition to that, Real Time Appearance Based Mapping (RTAB) was used to build the 3D map of an indoor environment. RTAB-map is used for the SLAM (Simulation Localization and Mapping) approach. GPU parallel computing power of the Jetson board was used for optimizing SLAM algorithm. MAV estimates position over time using visual odometry. Adaptive Monte Carlo Localization algorithm used for estimate robot position. A Robot Operating System (ROS) uses the Rviz (ROS visualization) framework to visualize all the data. Rviz visualizes the 3D module of MAV and 3D map. ROS uses Rviz framework as a virtual environment and it passes the command to flight controller through serial communication while navigating through this virtual environment. MAV uses the navigation stack for the autonomous navigation. The main feature of this research is MAV process the data itself. The process includes the 3D mapping, real time state estimation, obstacle detection and navigation planning. RTAB-map builds the environment 3D map and navigation stack use for MAV navigation. Although the drone navigates real time itself, embedding all the component within the drone make its weight greater which make the power consumption issues.

Keywords: SLAM, Jetson Tk1, Rtab map, Rviz, ROS, navigation stack, MS Kinect, MAV

Artificial Conversational Agent Based Tour Guide System

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The study designed to show that the tour guidance for tourists can be improved by incorporating an Artificial Conversational Agent (ACA). Although some of the aspects in Sri Lanka are well satisfied in the tourism industry, there is a lack of travel planning and collaborative interaction with the tourists. The implemented system is proposed to fulfil those solution gaps using a web portal with localized data and an ACA, who interacts with the user in natural language to provide information and trip planning functionalities. User expectations are identified by a statistical survey and the relevant dataset is based on localized destinations, intentions, locations, accommodations and route entities in Uva province of Sri Lanka for the Named Entity Recognition (NER) task. The ACA module is integrated with the web portal for users to interact using natural language. Dialogflow Natural Language Processing as a Service (NLPaaS) is used for Natural Language Processing (NLP) and Machine Learning (ML) tasks that are based on the custom entity model and an intents model, used for intent and entity extraction from user utterances. A web application implementing a webhook which is connected with dataset is used to query the data and an HTTP POST request is used to access the application endpoint and send relevant parameters. Optimized trip plan generation is implemented for certain user requirements and made it available to the user by sending an email. Training of ACA is done by Part Of Speech (POS) tagging for entities in potential user utterance corpus for each intent. For more user convenience the ACA is made available via social media channels and it is recommended to extend to the whole country. The effectiveness of the application is affirmed by the local and foreign tourists' feedback and MCQ answers, which are taken after using the application. It concludes that Sri Lankan tourism can be improved by efficient information delivering using emerging communication methods.

Keywords: Artificial Conversational Agent (ACA), Natural Language Processing as a Service (NLPaaS), Natural Language Processing (NLP), Machine Learning (ML)

An E-Management Solution for the Sri Lankan Police Department to Improve the Efficiency of Service

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Lack of information sharing mechanism, duplication of data and delay of services were identified as the main problems in the Police Department of Sri Lanka. Therefore, an e-management solution was introduced to fulfill the above requirement. The efficiency of services in the Police Department will be improved by this e-management solution. Better and efficient services will be provided to the victims as well as police by automating the current manual process. This solution has two parts named web system and the mobile application. The computerized web system will facilitate complain handling and provide reports by printed documents and keeping criminal records on them. The records can be stored and retrieved more securely through this web system. The mobile application was introduced to communicate between police officers in each division in the Police Department very easily and fast. This application mainly consists of parts such as check people identification, check vehicle, add accident, add fines and message. Details of people and vehicle can be verified by police officers, who are out of the police station and messages can be exchanged more securely, fast and clearly by police officers through this application. The web system and the mobile application were connected by using web server through Json API and MySQL server was used to create the database of the research. Efficiency of police performance and procedures can be improved by this e-management solution through integration of previously separates information systems.

Keywords: E-Police, Web System, E-management, Mobile Application

Location Based Exploratory Decision Support Approach for Midwifery and Grama Niladhari Divisions in Hunuwala-North: Ratnapura District, Sri Lanka

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Spatial information is being used as a supportive component for the process of decision making in various disciplines and applications. Generally, the governing activities, facts of citizens and properties, and natural and man-made phenomena are associated with locations. In Sri Lanka, the smallest administration unit is the Grama Niladhari division, whereas the midwife is the closest health care person that the community encounters. Most of the time two divisions are overlapped with each other resulting that they collect common facts about citizens. All the data about villages or citizens collected by Grama Niladharies and midwives become the data sources to make decisions by the top-level officers. The main objective of this study is to develop a location based (spatial) decision support approach for multiple criteria decision model with geo-visualization for decision making officers in various government sectors such as divisional and district secretaries, top-level officers of healthcare sector and their upper administrative levels. Its architecture consists of three major components namely spatial layer, attribute layer and the criteria layer. Each attribute record is associated with at least one spatial record resulting to a geospatial database, which has citizen level data, with predefined rules and criteria compiled according to the administrative policies and healthcare rules and regulations of the government. A proof of concept is developed and tested with the actual data. Therefore, it is proven that the introduced approach has a significant effect for the decision makers to make cognitive decisions rather than emotional decisions.

Keywords: Spatial Information, Decision Support System, Geo-Visualization, Criteria, Attribute Layer

A Novel Method to Measure The Water Content of The Leaves Using Digital Image Processing

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Leafy product industries like Tea, Tobacco, Palmyra, Leafy vegetables, and Ayurveda productions play a significant role to uplift the Sri Lankan economy. The water content in the leaves is an essential factor for leafy productions to maintain their quality. Naked eye observation of an expert is the general method to identify the water content. The objective of this study is to introduce a novel and easy method to measure the water content of the detached plant leaves using digital image processing. As a result, a simple computational water content prediction method has been built using image processing techniques to obtain a quality output at the end of production processes. The findings of this study help to identify the water content without an expert in an efficient manner. First, the colour images were captured in a control environment, while leaves were drying and simultaneously the weight was measured traditionally to find the water loss. Features were analysed from images to find the best features, which show a better correlation with the changes of the water content in the leaves. The basic features such as homogeneity, energy, contrast, variance, mean, median, min, max, range, kurtosis, skewness, standard deviation, entropy, correlation and IQR were extracted. The best features among the selected features have been chosen through correlation test. The classification was done with the K-Nearest neighbour algorithm by training with the selected best features of the training set of images. The green matrix of the RGB image is taken for the feature extraction to get better results. Finally, a simple model was built using the significant features which have a relationship with the water content measurement. 65.3% accuracy has been achieved, and this model can be used to predict the water content of a particular green leaf through images. This model will be a turning point for measuring the water content of the leaves in the industries in an automated manner.

Keywords: Image Processing, Water Content, KNN

Smart Dustbin with a Web Based Point Reward System for Waste Management

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Sri Lanka is facing urbanization with the impact of globalization, which has results in an increase of needs and wants of people and increasing living standards of people tremendously. This economic and social advancement has resulted in a large amount of waste production in the urban areas of the country. The Government is still struggling to find a mechanism to manage this vast waste amount. The main issue government faces when managing waste is collecting pre-categorized garbage at collection points. The main reason behind this issue is lack of motivation of people to put garbage in to correct dustbins. The lack of mechanism to make aware the garbage collection center when the dustbins are full is another problem in current waste collection process. The researchers propose an Arduino based smart dustbin to overcome the above mentioned issues. The smart dustbin is integrated with a RFID reader which can identify its users and opens its lid only for the authorized users. A set of smart dustbins are assigned to certain number of households depending on their waste amount. When the user dump garbage in to the dustbin, the dustbin will measure the weight of the garbage using a load-cell and the user will be rewarded with eco points if a user dumps according to the relevant categories of garbage. Users can convert these eco points to financially benefited offers. The user can view their point balance and their details by accessing their profile through a web site. When the dustbin reaches its overflow level it is identified using an ultrasonic sensor and using a GSM module the relevant authorities are notified with a text message that the dustbin is full and about to overflow. These notifications help authorities to make the waste collection process smooth and effective. Eco points collection mechanism motivate people to dispose garbage in to categories and the smart dustbin make the waste collection process more effective and smooth. If the government involve in replacing conventional dustbin with this smart dustbin, this system will be an environmentally acceptable and economically feasible solution for the disposal of solid waste in Sri Lanka.

Keywords: Smart Dustbin, Waste Management, Arduino, Point Reward, Web System

DIGITAL FORENSIC STEGANALYSIS OF ENCRYPTED INFORMATION WITH SPECIAL REFERENCE TO THE MP4 VIDEOS

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Computerized information correspondence has turned into an integral piece of foundation these days and the security and the privacy of them assumes an essential part. Cryptography and Steganography are being two major methods having a wide usage, which secure information. Steganography conceal secret information and does not leave evident proof of information modification. Out of numerous techniques of application of Steganography, current study focused on End of File Injection technique. The study investigated the Steganalysis of Mp4 type videos, which were encrypted utilizing the above technique. A pool of Mp4 videos consisted of several qualities and capacities were tested and evaluated. A detector system was developed which was capable of identifying the presence of Steganography within the Mp4 videos, thus the system can be further used to scan the suspected Mp4 videos and give the results whether it has embedded data or not. The system reported a higher accuracy level of detecting Mp4 Stego-videos, which used the said techniques for data embedding. Further studies are needed to cover other video formats and other techniques of Steganography. The development of the field would reveal new paths in digital forensic investigations.

Keywords: Steganography, Least Significant Bit, End of File Injection, Steganalysis

**An Intelligent Postal Mail Sorter: Sinhala Hand Written Address
Recognition Method Using Geometric Feature Extraction Technique
and Artificial Neural Network**

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The main objective of this study is to develop a methodology to recognize Sinhala handwritten characters that can be used in postal mail sorting. The Department of Posts, Sri Lanka uses the manual sorting mechanism, while most of the developed countries are using automated sorting machines. The main reason for not having such types of machinery in local postal collecting and distribution centers is the initial cost of implementation. The machines have to be tailor-made due to the localized language. The proposed methodology is based on the geometric feature, such as Corner detection, Curve fitting and Edge detection, extraction technique and Artificial Neural Network backpropagation technique. The benchmarking of the classification system is carried out using 34 Sinhala characters that are mostly related to the district names. The neural network consists of three layers, where the input layer with 108 input nodes, the output layer with 34 nodes and a hidden layer of 78 nodes. The training and testing are performed by 850 characters and 510 characters, respectively. The accuracy of the system is around 78% of giving a correct answer. The resultant set of characters then be extracted and used to control the sorting machine. In order to prove the concept, an embedded system is developed using Arduino microprocessor. The sorting mechanism is simulated by using a servomotor that indicates the relevant mail bucket using a rotating arm.

Keywords: Image Processing, Pattern Recognition, Feature Extraction, Artificial Neural Network, Sinhala Hand-written characters

Online Event Organizing System for Cultural Programme

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This paper proposes to develop an Online Event Organizing System for cultural programme which can provide various event services and give efficient coordination between customers and service providers. People are tired of searching and travelling to find quality and economical event services as they want their traditional larger events, attractive and interesting. Using the existing manual system, an event planning is stressful, time consuming, service providers reputation is unconvincing and customers do not know what to look for in an event service providers. The proposed method consists of establishing requirements, analysis, database design and interface design. The proposed work is a benefit for the users and as well as for service providers. It provides opportunities to service providers advertise and develop their business and show their interesting quality ideas. An event organizing system makes the people easier to plan an event via online. The proposed work is developed an online event organizing system with a mobile front end to manage various events for a cultural programme. The system is developed using HTML, JavaScript and PHP.

Keywords: Database design, Information technology

**Process re-engineering of Sri Lanka's
Downstream petroleum industry stock planning operations.**

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The vision of the Ceylon Petroleum Storage Terminals Limited (CPSTL) is to be the most efficient petroleum terminal operator in South Asia. CPSTL is responsible for 90% of storage and distribution of the Sri Lankan downstream petroleum industry, which constitute of tanker/tank farm operations, island-wide delivery of petroleum products by rail, road, and pipeline. CPSTL provides ERP and laboratory services for the entire industry. The logistical operation is accomplished via 2 main installations and 12 island-wide bulk depots. It involves fuel supply to dealers and consumers, whilst replenishing the island-wide bulk depots. The installations are replenished by tankers from Colombo harbour, Muthurajawela offshore SPBM and the Ceylon petroleum Corporation's (CPC) Sapugaskanda refinery. Bulk depots are replenished by the 2 installations via tank lorries and railway wagons. Although stock planning procedures did exist, various limitations and drawbacks have resulted in underutilization of resources, massive losses in distribution operation, increased risk of storing highly inflammable products and window for various manipulations. The project was implemented with the objective of streamlining the stock planning operation with the utilization of the SAP ERP system. It provides a daily stock quota system for each bulk depot, which optimizes the tank lorry, wagon utilization as per the sale, stock availability, tank capacity, goods receipt status, and vehicle availability. Two important phases of stock planning operations were identified during business process analysis. They were re-engineered and integrated to SAP ERP system. The system ensured island-wide product availability eliminating over/under scheduling. The system included features for tracking of delayed tank lorries and wagons. Various key performance indicators related to the stock planning operation were introduced to facilitate operational monitoring and strategically important decisions.

Keywords: stock planning, downstream petroleum industry, logistics

**Small and Medium Enterprises' Adoption of E-Commerce in Sri Lanka
Case Study on Hospitality and Tourism Industry**

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E-commerce is widely used to buy and sell products using the internet. Hospitality and tourism industry is considered as an information intensive sector. Due to the advancements in the field of IT, the hospitality and tourism industry has been able to derive the benefits of e-commerce. Even though there is a rapid development in new technologies and trends, developing countries like Sri Lanka are still facing an attitudinal barriers in accepting of e-commerce. This research was carried out with the objective of finding the factors that affect the e-commerce adoption of small and medium enterprises related to hospitality and tourism industry in Sri Lanka. A sample selected from small and medium scaled hotels and guest houses registered under the Sri Lanka Tourism Development Authority. Questionnaire and interview methods were used for the purpose of gathering data. The data were analysed using statistical tools and the received information was further processed to derive the main factors affecting the e-commerce adoption. The results of this research show that organizational readiness, attitudes and awareness of the enterprises make a strong impact on e-commerce adoption in Sri Lanka. Financial and technological resources and employee interest were the most influential factors identified under organizational readiness, while government rules and regulations and competitive pressure were the main factors that were recognized under external environmental factors. The knowledge regarding the advantages of using e-commerce was the crucial factor identified under awareness of the enterprise. After carefully analyzing these factors and reviewing related literature, a theoretical framework was developed to depict these main factors which have an impact on e-commerce adoption of small and medium enterprises in hospitality and tourism industry in Sri Lanka. This research recommends small and medium enterprises in the field of hospitality and tourism industry to pay attention to the above factors when adopting e-commerce in their respective enterprises.

Keywords: E-commerce, Small and Medium Enterprises (SMEs), Hospitality and Tourism Industry

Artificial Intelligent Base Virtual Learning Assistant

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E - Learning is the most effective learning method that includes a variety of tools on learning styles and helps students become more versatile learners. Proposed system will encourage active learning of students in online learning and would be able to handle this problem efficiently. Further, whenever user searches for a problem, system will automatically search required information from knowledge base and provide a solution to overcome the problem when user needs, thus, it is a user-friendly system. Currently in Sri Lanka, there is no any specific virtual learning platform that connects all university students. Therefore, the major objective of proposed system was to develop a platform that will connect all university students together as an effective communication portal for academic matters. This System was equipped with a virtual learning assistant called Jarvis. Thus, Windows + IIS + ASP.NET + MSSQL combination was used for fast, reliable and efficient E-Learning web application and also Artificial Intelligence Markup language (AIML) was used for virtual assistant. Initially, a system was developed based on selected best technologies for efficient e-learning application, then an Artificial Intelligence Markup language based virtual assistant was developed. Finally, all the components were bound to create a complete System. While the implementation of this system, the chatter bot answered the questions of students through speech. Consultants can teach their knowledge to Jarvis when necessary. The proposed system was successfully developed and also tested results complemented with the requirements.

Keywords: E-Learning, Virtual assistant, AIML, Web application, Artificial Intelligent

Recognition of Vowel Distribution for Sri Lankan Traditional Pirith Chants Using Formant Variation

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Pirith is believed to be a doctrine preached by Lord Buddha and regarded to obtain protection from evil, promote health and well-being. Voice source produces a harmonic series, consisting of the fundamental frequency, F_0 and harmonic frequencies called as formants, F_n . Vowels can be mapped using the relationship between lip opening width to the first formant frequency, F_1 and tongue constriction width to second formant frequency, F_2 . This work is dedicated to developing phonetic picture on *Pirith* chants and analyze acoustic properties using computer-aided tools. As reported by several other studies, characteristic vowels and high frequency formants are identified in chanting in contrast to normal speaking. The motive of this study is to investigate vowel distribution of *Pirith* chants with the aim of special pattern recognition. Samples of *Ratana*, *Karaniya Metta* and *Angulimala Suttas* recited by male monk chanters were recorded using high precision microphone array and 15 samples of each *Sutta* were analyzed. Recorded samples were then subjected to splitting of smaller voiced segments of frame length 10 ms using sampling rate of 44.1 kHz. In the computational speech model, a pre-emphasis filter is applied to the sampled time series of voiced segment to cancel out the effect of glottis. Then *frame-by-frame analysis* was used with *hamming windows* and *linear predictive coding (LPC)* and *auto correlation* to extract the formant values. Finally, PDFs of each *Sutta* is generated and compared for first five formants. *Angulimala Sutta* and *Ratana Sutta* show similar patterns in terms of PDFs but *Karaniya Metta Sutta* indicates a clear discrepancy demonstrating a unique set of characteristics. Furthermore, the vowel distribution reveals that *Angulimala Sutta* and *Karaniya Metta Sutta* contain high number of compact vowels comparing that of *Rathana Sutta*.

Keywords: Formant frequencies, Vowels, Probability Distribution Function (PDF)

Analysing Critical Factors Associated with Perceived Risk for Major Types of Cancers in Sri Lanka – using Data Mining Techniques

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Cancer is one of the world recognized critical cause of morbidity and mortality. Identification of demographic, health and life style factors are significant to detect and prevent from the cancers. Since the Sri Lankan public has lack of knowledge about influence of those factors on cancer risk, the research has been conducted using data mining techniques to develop significant patterns in order to identify the critical factors towards the most recorded cancer types in Sri Lanka (Breast, Oral and Oesophagus cancers). Hence, the ultimate objective of the research is to increase the awareness among Sri Lankan public which will be helpful to take preventive approaches. The research was based on the patients' data within a five-year period of time, which was collected from the sources of *Apeksha* hospital, *Maharagama*. By following the Knowledge Discovery in Databases process, data collection and preprocessing were completed manually. Data was analysed through the data mining tool called *Weka*. The research was used Random Forest classification technique, *k-mean* clustering technique, and *Apriori* association rule mining. From the research it has been identified that the gender, number of children, breast feeding, menopause, weight, age at menarche as the critical factors towards the breast cancers. The gender, marital status, weight, smoking, consumption of alcohol, betel chewing were identified as critical factors towards the oral cancers. The gender, consumption of alcohol, occupation, weight and age were identified as critical factors towards the Oesophagus cancers. The patterns were obtained from the above identified critical factors with their approximate values.

Keywords: Cancer, Data mining, Weka, KDD Process

Dynamic Offloading Algorithm for Cyber Foraging

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Advances in semiconductors and computing technologies have enabled small consumer devices such as smart mobile devices to perform heavy computations. Also, the mobile applications we use today are highly resource demanding. Though the mobile devices are capable of running heavy tasks their resources are limited compared to desktop computers or cloud computers. So, we can use the technology called Cyber Foraging which enables mobile devices to use cloud resources to perform resource demanding tasks. In this research paper, we are presenting an efficient algorithm to take decisions dynamically about offloading heavy tasks from mobile device to a resource rich cloud platform. We have identified the project named Rapid, which is the best opensource framework for cyber foraging so far and we implemented an algorithm on top of that project. In the Rapid framework offloading process is done in a static manner by annotating identified resource intensive methods at the development phases. Our algorithm considers the situational factors such as network bandwidth and battery level of the mobile device to take the decision. Also, it considers the previous execution details such as average power consumption and average execution time for both remote and local executions. If the battery level is high and power consumption and execution time for certain method is lower, then that method will not be offloaded to the cloud. If the battery level is lower than a threshold value and execution time is higher for certain method, then that method will be offloaded. We have tested our dynamic approach using n-queen algorithm. According to the results the decision-making algorithm helps resource poor mobile devices to execute resource intensive tasks efficiently and thus provides better and smooth user experience.

Keywords: Cyberforaging, Offloading, Rapid

A Conceptual Framework for Flood Early-Warning System for the Lower Flood Plains of Kalu Ganga Using Twitter Crowd-sourcing and Internet of Things

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Flood is one of the common natural disasters in all over the world. Sri Lanka has two major monsoons: Southwest (May to September) and Northeast monsoon (December to February) causing for floods along the one third of low lands. The objective of this study is to develop a framework that is relatively credulous community based flood early-warning system for the populous areas near by the riverbanks of Kalu Ganga in Kalutara district in Sri Lanka. The study focuses on two major affected areas that are Palindanuwara and Agalawatta. There are six major tributaries joined to the river between Kalutara and Ratnapura making Ratnapura as a considerable catchment area for the river. Therefore, the system collects real-time bulletins, associated with predefined keywords and posted by the Twitter crowdsourcing living in Ratnapura and surroundings, using Twitter stream API. It uses hashtags to filter locations and performs the text analysis. While the percentage of likelihood of flooding is estimated based on the number of positive twitters, the possibility of a flood is verified using the incline or decline trend of the water levels collected from Ground Control Units located in flood risk areas. If the Ground Control Unit confirms that there is a possibility of a flood, the system generates a flood-positive alert that can be used to warn people living in those areas. The proof of the concept was successfully tested by simulating the flood situation using the Ground Control Units. Thus, it can be concluded that the Twitter crowd-sourcing can be effectively used to warn the community about upcoming flooding situations beforehand.

Keywords: Crowdsource, Flood, Early-warning system, Internet of Things, Twitter

Preliminary Study on ICT Applications in Agriculture to Enhance Information System using Mobile Crowdsensing

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This study analyzed the existing Information and Communication Technology (ICT) applications in the agriculture information system and proposed a method to enhance a mobile-based information system using mobile crowdsensing. The proposed system enables farmers in Sri Lanka to report events such as diseases, about their crops and get advices for making farming decisions. The lack of real-time information environment makes issues in the farming life cycle and that will affect the national economy and employment. Existing studies were analyzed for identifying the capability to establish a mobile-based information environment in the farmer-community in Sri Lanka. The applications introduced in the studies are covering several aspects such as market price, vendors, crop details, pest and disease information, etc. In order to create a real-time information environment, the real-time data related to farms need to be collected. Mobile sensing is a technique to obtain real-time data from a large group of individuals. Thus, the mobile sensing technique introduces for the farmer-community that allows farmers to participate the system by sharing mobile sensing data like images, text, voice, location, date and time. The knowledge-base of the system contains knowledge about crops, diseases, pests, fertilizer requirements and control methods for growing problems. Thus, the agriculture information in the knowledge-base can be accessed by the farmers according to the shared sensory data. Over the time period, agriculture information can be updated as the technology advancement, seasonal changes or unexpected weather changes. Thus, new knowledge needs to be stored in the agriculture knowledge-base with the help of domain experts. Moreover, by reasoning the collective data shared by farmers and experts, interesting aspects like the suitable crops to grow in a particular area, the crops badly affected by a specified disease in a particular area or treats rapidly spread in a particular period, etc. can be obtained for decision making. Further analysis can be done for future predictions from the large collection of data.

Keywords: Knowledge-base, Agriculture, Mobile Crowdsensing

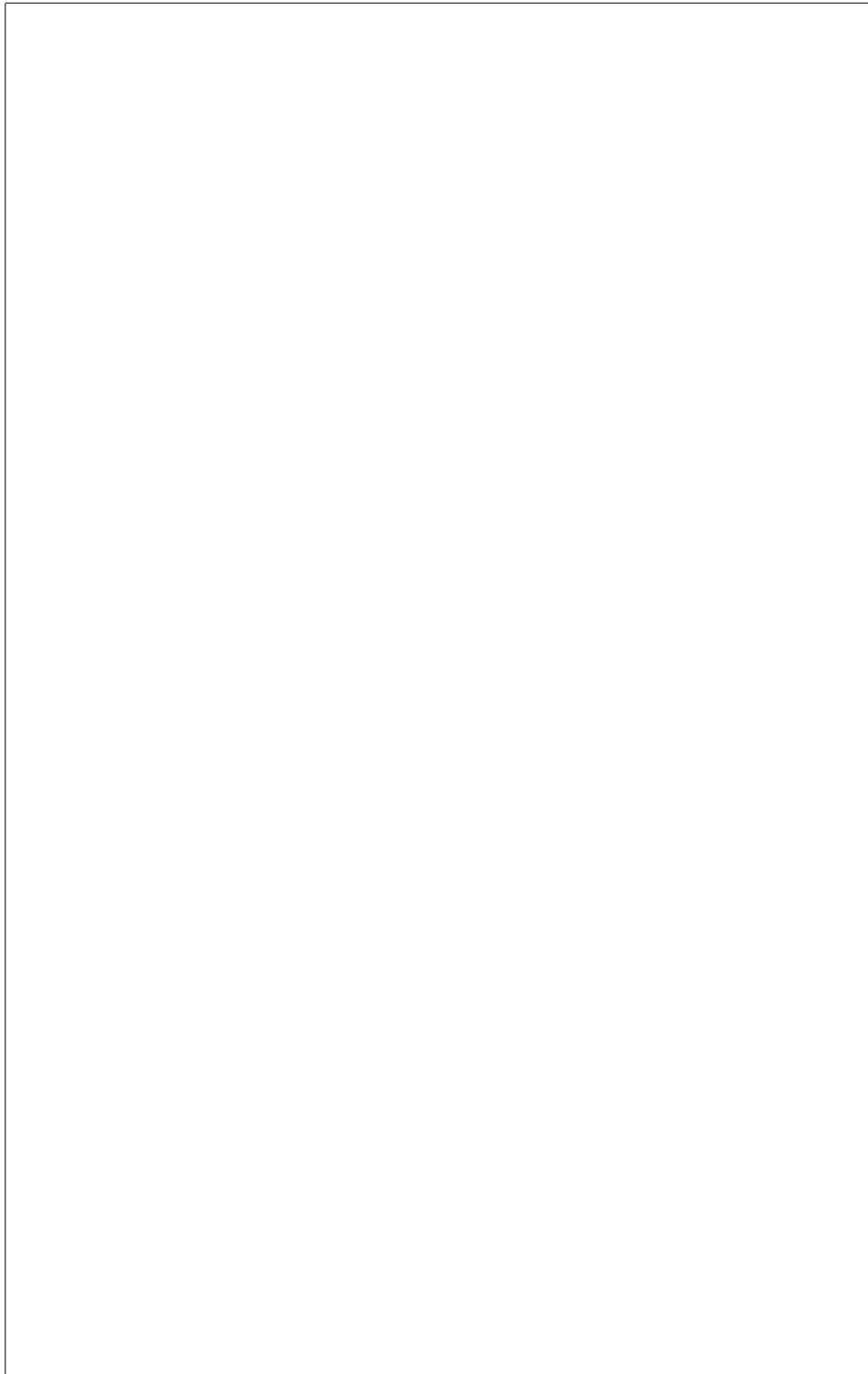
A Personalized Content-Based Recommendation on Knowledge Level of Learner

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e-Learning is considered as one of the most popular research areas in distance and web based education. Nowadays, most of the education institutions such as universities, colleges and vocational training centers are adapted e-Learning environment to give quality and efficient service to learners. This paper presents a novel approach, a framework for building a personalized content-based recommendation system by considering learner's knowledge has been developed. The knowledge, skill, preferences and learning style of each learner is different. Therefore, we should understand different needs of learners and provide a better recommendation to motivate them. The proposed recommendation system consists of four components, Learning model, Domain model, E-Assessment model and Recommendation model. In e-assessment model, the learner takes diagnostic, formative assessments in different levels such as initial, final, practice and assignment. While learner attempts, the system generates recommendations based on level of knowledge. Through the system, each learner's progress can be identified and compared with other e-learners' results. Then, the learner motivates to learn more learning objects and stick to self-learning style. During this research, Content-based filtering is used as filtering approach for making recommendations. Apart from that, web mining techniques has been used to implement result predictions, clustering e-Learners and classifying learning objects. However, cold start problem has been minimized by using an initial test at the start point of each learning module. Furthermore, the impact of introducing the e-assessment model to support and improve the learning process is evaluated following the action research methodology and comprised two main activities: system testing and validation, in a real scenario, a programming course in Bachelor of Information Technology at University of Colombo. In this research, decision support accuracy metrics was used for evaluating recommendation algorithm. A set of students who is following above course was selected to determine knowledge levels and performances. Based on data analysis, it was observed that the use of the system and the models had a positive impact on student learning and performance. Students learned through more interaction with the system and, as a result, their performance in the assignments and final examination had improved. The system also provided added benefits to facilitators for tracking of students' progress throughout the whole course.

Keywords: *e-Learning, Personalization, Content-based filtering, e-assessment, Cold start*



Economics and Statistics

- Applied Statistics
- Operational Research
- Business Economics
- Agricultural Economics
- Economic Development and Policy
- International Business and Economics
- Green Economics

Social cost of crime: a simple model of human interdependence

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Crime creates heavy costs to a society. Cost of direct crime has been categorized and estimated by a number of researchers. Some such categorizations divide crimes into two broad groups namely crimes against property and crimes against human beings. However, such calculations rarely explain the overall aftermaths of crime on other parties than victims. This study makes an attempt to fill this gap by explaining final or accumulated cost of crime. It takes a natural characteristic, namely, interdependence of man and societies into account and builds up a model to explain interrelations between people and extent of cost of crime. Owing to interdependence of human life, availability of consumer goods and services is a function of supply of labour and material wealth of some others. Taking this property into account a simultaneous equation model can be postulated and used to explain that one's life and material property are beneficial for others in producing, providing and satisfying their needs. The model further explains that decrease in overall availability of goods and services is a cost of crime and that crime creates costs not only to victims but also to other related parties. Furthermore, the model is related to social model of crime prevention which proposes to enhance the 'social capital' or the relationships between people to protect people from crime. The study concludes that grave crimes especially homicide undermines human relationships and social network or interdependent nature of human beings. Therefore, crime can be defined as a prohibition on interdependent characteristic of man. Understanding the characteristic of interdependent property among people and including that in legal documents would be avenues to reduce crime and retain peace in the world.

Keywords: Cost of crime, Division of labor, Interdependence

**Determination of Pesticide Usage and Its Environmental Impact
Quotient in Vegetable Cultivation in Kalpitiya Divisional Secretariat
Division of Puttalam District of Sri Lanka**

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Application of synthetic pesticides has been the main method of controlling pests and diseases in crop cultivation. In this context, the objectives of the study were to assess the pesticide usage pattern and determine the environmental impact quotient of pesticide use in vegetable cultivation in Kalpitiya, Sri Lanka. Stratified random sampling method was used to select 100 farmers from Kalpitiya Divisional Secretariat division of Puttalam, which is a predominantly vegetable cultivating area. Pre-tested structured questionnaires were used to collect data during 2016/2017 *Maha* cropping season. Descriptive statistics and probit model were used to analyze the data. Field Use Environmental Impact Quotient (FEIQ) of pesticides used by the farmers was also determined. The results of the study indicated that the foremost problem in the vegetable cultivation was insect damage (92%) followed by diseases (84%) while weed problem was insignificant. The average extent of cultivation was 2.18 acres where only 14% of respondents' cultivated land size was greater than 4 acres. Percentage of farmers having more than 5 years of experience in cultivation was 74%. Only 36% of farmers received extension service. Pesticides were applied on vegetable crops by 94% of the farmers. On an average, pesticide application frequency was 4.4, whereas pesticide use (active ingredient) by weight on the vegetable crops was 0.58 kg ha^{-1} . The average FEIQ of pesticide use in the study area was 75.28 ha^{-1} . Probit analysis revealed that educational level, farming experience and access to extension service had a positive and significant ($p < 0.05$) relationship on farmers awareness of risks from pesticide use. Vegetable farmers of this area use extensive amount of pesticides which cause more damage to the environment. Therefore, it is recommended to provide information to the farmers about the judicious use of less toxic pesticides.

Keywords: Environmental impact quotient, Pesticide use, Vegetable cultivation

Tendencies in Production, Imports and Per Capita Availability of Potato and Its Challenges in Sri Lanka

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Potato is the fourth most vital crop in the world and one of the important crops in Sri Lanka due to its high consumer preference and disposable profit generation. In this context, the objectives of this study were to review the trends in potato production, the area under harvested, imports and per capita availability, and to investigate the government involvement in regulating the prices and importation. The study is mainly based on secondary data which were collected from the annual reports of Central Bank of Sri Lanka and Department of Census and Statistics from 1961 to 2016. The data were first tabulated and then graphs were produced and based on the observed patterns certain interpretations were made. Both total production and area under harvested display the similar trend for the study period with a sudden decline in 1997. Badulla and Nuwara-Eliya districts contributed on average 73% and 26% of the national potato production respectively in the last decade. The yield of potato expresses a gradual increase over the period with frequent fluctuations. The imports of potato were lesser than the production until 2006 with a surge in the years from 1997 to 2001 and thereafter importation was increased drastically and continuously, which is 148,081 metric tons in 2016. Imports of potato contribute 5.1% of the national imports and 41% of the food and beverages imports on average in last five years. Per capita availability of potato showed an increasing trend where it was doubled from 3.89 kg/year to 7.79 kg/year during the period from 1995 to 1997 and reached its peak of 10.5 kg/year in 2016. The government imposes several policies such as maximum retail price and special commodity levy time to time in order to protect the local farmers as well as to make the availability of potatoes to consumers when demanded. Several input subsidies have been introduced to promote potato cultivation. Therefore, these modes of government interventions should remain to retain the potato sector competently.

Keywords: Imports, per capita availability, Potato, Production

Minimizing the Cutting Damages While Maximizing the Cutting Efficiency in the Apparel Industry

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In the apparel industry, higher number of garments should be sewed under the given requirements. Damaged panels can be fixed by replacing them with a re-cut. Area allocated for the finished cut (market place) is contributed to the sewing department to achieve targets aligned to lean. A pre-plan under some constraints will maximize daily cut quantities which will increase the number of sewed garments. The objective of this paper is to use principles of optimization related to minimizing wastage of the fabric while maximizing the cutting efficiency by identifying the parameters which are related to the laying and the cutting process of the garment industry. Related factors are identified during the laying process as ratio, marker length and number of plies for the size variation. The problem is broken down into roll format and lap format which are 2 laying formats. Size variation of 3 parts of a garment called front panel, back panel and gusset, marker length, ratio, number of plies, cutting time and laying time per layer and the cut quantity has being recorded (per unit) under the mentioned 2 formats. According to the analysis panel variation does not depend on the ratio, number of plies and marker length. In conclusion the cutting efficiency is maximized by changing those 3 variables. The results show that the optimal ratios are less than 25 and 27 for the lap format and roll format respectively. The cutting process requires an average time of 72 minutes per layer. This method reduces laying and cutting time per layer by 20-30 minutes by keeping the quality of the cut panels unchanged. In comparison, due to the decreased ratio and increased number of plies, the marker length is automatically reduced along with the length of the cutting tables which contributes to save some square feet for the sewing department. 80% of marker efficiency can also be satisfied with the new solution. Using these multiple objectives, daily production can be increased.

Keywords: Marker length, Number of garments per layer, Number of plies

Factors Affecting Adoption of Organic Farming: A Case of Pepper Farmers in Udadumbara DS Division of Kandy District

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The main objective of this research was to find out the determinants of the adoption of organic farming by pepper farmers. A sample of 60 pepper farmers from Udadumbara Divisional Secretariats division in Kandy district was randomly selected and the data were collected using a field survey during July-September, 2017. The data analysis was done using frequency, chi-square and binary logistic regression. According to the results, 36.67% farmers were adopters and 63.33% were non-adopters. Adopters of organic have more knowledge on organic farming practices. According to the binary logistic regression, gender (female) negatively affects the adoption for organic pepper farming while trainings attended and full-time involvement in farming positively affect the adoption towards organic farming. According to the SWOT analysis, high quality of Sri Lankan pepper, less contaminated pepper fields are the most significant strengths while high labor cost, high cost for organic certification, yield reduction due to adverse climatic conditions and slow adoption for organic farming are the major weaknesses. Growing international demand is the major opportunity whereas price competitiveness and low price of imported organic pepper are the main threats to organic pepper production. In developing organic pepper farming, the importance of systematic awareness programs for farmers regarding market information, organic certification and rising world demand for organic pepper in order to increase the rate of adoption is obvious. An appreciation for the positive externality of organic farming is desirable to motivate farmers. Furthermore, a government authority is required to control organic certification, farm gate price of organic pepper in order to receive the farmers a fair value for their commitment.

Keywords: Pepper cultivation, Organic farming, Adoption, Farmer's perception, Kandy district

Present Status of Rural Home Gardens and their Impacts on Rural Livelihoods: A Study on Balangoda DS Division

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This study was conducted to investigate the present situation of home gardening in the Balangoda DS division and study their impacts on rural livelihoods. A sample of 150 households was randomly selected from farmers' lists of five GN divisions and data were collected using a survey from July to September 2017. Descriptive statistics and regression analysis were used to analyze the data. Results showed that most of the households are engaged in home gardening. In evaluating plant species available in home gardens, 18 species of vegetables and 17 species of fruits were found. Majority of the respondents are less likely to use chemical fertilizers and are preparing compost by themselves. They gain knowledge through their own experience. The two severe problems they face in home gardening are water scarcity and wild animal attacks. Furthermore except Imbulamura Grama Niladhari (GN) division, other four GN divisions are capable of fulfilling the minimum dietary requirement from the products of home gardens. In analyzing relationships, no relationship was found in between saving and the earnings from the home gardening. According to regression analysis, there is a negative relationship between purchased items from the market and farmers' time involvement in home gardening. Therefore, purchase items from the market to meet the minimum dietary requirement have reduced with increase in the time involvement in the home gardening. As per the mean analysis, majority of rural households have positive attitude towards home gardening and they are willing to develop it furthermore in future as it is highly contributing to enhance the nutrition intake of households. Proper plan for water supply in drought period and a plan to decrease the wild animal problem with the government support are the timely important factors to improve the home gardening in these areas.

Keywords: Food security, Home gardening, Minimum dietary requirement, Ratnapura district, Rural livelihood

Integer Non-Linear Programming Technique to Solve Examination Timetable Scheduling

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Scheduling a Timetable is a major administrative activity for many academic institutions. One of such activities is university timetabling, which can be divided into two main categories: class timetabling and examination timetabling. Examination timetabling can be defined as scheduling of a set of examinations of particular courses in a degree programme to a certain number of time slots subject to a set of constraints which may be either hard or soft. This study concentrates on examination timetabling which must be prepared in each semester of an academic year. In past few years, researchers have used different optimization techniques such as simulated annealing, genetic algorithm and integer programming approach to solve problems of this nature. Most commonly used method is 0 - 1 integer linear programming technique. In particular, formulation of a timetable is extremely difficult because of the diversity of the constraints that must be taken into account. When constructing the mathematical model of the timetabling problem, hard constraints have to be met and at the same time effort is made to satisfy as many soft constraints as possible. Therefore, in this study the main purpose is to formulate a mathematical model to determine which examination of a course unit is scheduled on which day, time slot and room while avoiding conflicts and minimizing the inconvenience for students and supervisors. Proposed model is formulated as an integer non-linear programming technique and to test the model, it is applied to prepare the examination timetable of the first year second semester students in the Faculty of Applied Sciences, Rajarata University of Sri Lanka. The optimization model is solved using LINGO optimization software package. This research highlights the importance of a constraint satisfaction problem and concludes how examination timetables can be efficiently and accurately scheduled using the integer non-linear programming approach.

Keywords: Optimization, Programming, Timetabling

An Application to Project Management to Minimize Fabric Printing Processing Time

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By considering the competition occurring in today's industries, it is necessary to have diverse product lines that can be manufactured and delivered to the customer in the minimum possible time. One way to improve the time efficiency of a manufacturing process is by reducing the time required to change one manufactured product to another which is known as changeover reduction. In this research, we focus on a fabric printing production plant located in Sri Lanka. Currently, the fabric printing company loses daily availability because of the time consumed for changeover is unacceptable. Therefore, the objective of this research is to facilitate decision making and thereby to reduce the changeover time in the printing machine. We also focus on determining the minimum project completion time and estimating possibilities for the activities to be critical and finally finding a technique to make the changeover within the minimum time. To achieve this, one of the most popular project management tools known as Critical Path Method (CPM) is used. CPM manages the time necessary to perform the activities of the project and identifies which activities are critical and noncritical. Here, the time required for each activity is considered to be deterministic. But the time taken for these activities is uncertain and follows a triangular distribution. To rectify this problem, in the next step, another project management tool known as Program Evaluation and Review Technique (PERT) is used. Furthermore, simulation technique is applied to minimize the error in the time duration estimations of the activities. From the results of the analysis, it can be concluded that certain activities in the process are critical in delaying the printing process. Also, the findings of the simulation reveal that certain noncritical activities have a little possibility of being critical. Hence, it is recommended to the management to take extra precautionary measures on these noncritical activities as well.

Keywords: Changeover, Critical path method, Model, Program evaluation and review technique, Simulation

Modeling and Forecasting on Foreign Exchange Rates

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Foreign currency exchange is a rapidly growing trade around the world, known as FOREX. Despite the high risk involved in FOREX trading, the fact remains that the traders are always fascinated by FOREX market. This research was carried out to understand the behavior of currency exchange rates, to identify adequate models for exchange rates and to forecast exchange rates for a future time period. The dataset was considered as four sections which were EUR/USD, USD/CHF, GBP/USD and USD/JPY from 1999 to 2015. According to the literature, there is a low accuracy of the forecast using fitted models for daily exchange rates. To overcome the problem, monthly average of daily exchange rates were considered for the analysis. Time series analysis was used to identify models and Akaike Information Criteria was used to identify the best fitting models. Unit Root Test recognized the existence of the stationary while Ljung-Box Test and Box-Pierce Test recognized adequacy of fitted models. Existences of ARCH effects were tested and ARCH models were fitted with relevant orders. Ljung-Box Test was used to check the adequacy of ARCH models. Decisions were made under p-value of 0.05 throughout the study. The formats of the fitted models for log-transformed EUR/USD, USD/CHF, GBP/USD and USD/JPY were ARIMA (1,1,0) with ARCH (1), ARIMA (0,1,0), ARIMA (3,1,2) with ARCH (1) and ARIMA (2,2,1) respectively. Forecasting was done using adequate models for a time period of six months. According to the results, the actual values are within the forecasted 95% confidence interval. For a short time period, obtained methods can be used, but forecasting for a long time may lead to an aberration. In conclusion, the developed models and the calculated confidence limits can be successfully used to buy currency without losses.

Keywords: ARCH, ARIMA, Exchange rates, FOREX, Time series analysis

International Remittances and Household Expenditure Patterns in Sri Lanka

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International migration in Sri Lanka is in an increasing trend over the past two decades and international remittances follow the same. Sri Lanka is one of the leading economies in the South Asian region with a rapid growth in foreign workers' remittances. The recent literature argues that the international remittance significantly affects the expenditure patterns of the households. Hence, this paper examines the impacts of international remittance on the household expenditure patterns in the Sri Lankan context and how remittances are utilized by the remittance receiving households. The main data source utilized for this study is the Household Income and Expenditure Survey (HIES) 2012/13, conducted by the Department of Census and Statistics (DCS). The main objective of the study is to analyze the relationship between the international remittances and the total household expenditure disaggregated by food, non-food, and liquor, drugs and tobacco expenditure. The study uses Ordinary Least Square (OLS) as one of the main analytical techniques while, Propensity Score Matching (PSM) method is applied to overcome the possible selection bias generated by the Ordinary Least Square method. The results of the study finds that, compared to the households non-receiving remittance, households which receive international remittances spend more on non-food items such as durable goods, healthcare, education and investments and spend less on food, liquor, drugs and tobacco. Hence it is encouraged to create more investment opportunities for remittance to be invested.

Keywords: Household expenditure patterns, International remittances, Migration, Ordinary least square, Propensity score matching

An Implementation of Goal Programming Model to Analyze the Factors Affecting on Early Childhood Development; A Case Study

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A good foundation in early childhood development makes a significant impact on children who will become decision makers in future. Areas of early childhood development are mainly considered as social development, language development, self-care development, physical development and cognitive development. This study examined the impact of birth weight of child, gender, household size and parents' education level on early childhood development in Mihintale, Rambukkana and Polgahawela Divisional Secretariat divisions. A Goal Programming model is developed to find minimum birth weight, gender, household size and parents' education level which are mostly affected on early childhood development. A sample survey using a questionnaire is used to collect the data under each development category. Reliability Analysis and Pearson Correlation Analysis is done by using MINITAB software and constructed Goal Programming model is solved by using LINGO. Pearson correlation analysis concluded that birth weight ($r = 0.73$), household size ($r = 0.65$) and parents' education level ($r = 0.61$) positively and significantly associates with early childhood development. The results further indicated that, there is no relationship between gender and early childhood development. According to the solutions of the goal programming model, the group of children whose birth weight is more than 3.0 kg, household size 4 - 5 and having parents with higher education have better early childhood development.

Keywords: Early childhood development, Goal programming

Strategic Asset Allocation for Central Bank's Reserve Management

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Central banks play a vital role in shaping global financial flows and real interest rate. They choose an appropriate strategic asset allocation of the foreign exchange reserves in agreement with the overall policy and corporate objectives. Strategic asset allocation is defined as the long-term allocation of capital to different asset classes such as bonds, equity, real estate and other investment opportunities with an aim of increasing the capital and making an appreciable and optimum return. The main objective of this paper is to propose a possible tranching methodology for the Central Bank for the purpose of working capital, liquidity and investment based on the concepts of Mean-variance portfolio theory, Behavioral portfolio theory, Portfolio optimization with mental accounts and the theory of the Utility. This study has two sub objectives to support the main objective of the study. A descriptive statistic model was built to propose the need of foreign reserves based on the external debt condition of the country and developed a hypothetical equation to allocate foreign reserves in different currencies. The study was based on the secondary data. This study built a mathematical model for the Central Bank to find out the future requirement of the assets based on external debt of the country because debt has a proportional relationship with debt payments (Capitol + Interest). Results were found as Sri Lanka should keep foreign reserves in four types of currencies according to the past currency composition data of Sri Lanka to pay off the debt with an interest in the future. The study developed a way to allocate foreign reserves in different currencies according to the hypothetical equation as $A \times (\text{USD}) + B \times (\text{SDR}) + C \times (\text{YEN}) + D \times (\text{EURO})$. Here A, B, C and D denote the percentage values. Thereafter, the study developed a possible tranching methodology for of working capital, liquidity and investment.

Keywords: Foreign reserves, Reserve management, Strategic asset allocation

Relationship between Foreign Direct Investment and Selected Macro Economic Variables in Sri Lanka – An Econometric Analysis

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After the independence, Sri Lanka has gone through three major trade policy phases relatively open, a trade regime biased against exports and strong liberalization effort respectively. Sri Lanka has been more or less following free market economic policies ever since 1977. Thus, Sri Lanka provides an interesting story of an individual country's experience relating choice of a trade regime to resource allocation and growth. The majority of past empirical studies have concluded that foreign direct investment inflows promote and increase the economic growth of relevant countries. This study tries to do descriptive analyses about the relationship between the Sri Lankan foreign direct investment and economic growth with empirical analysis. The main objective of the study is to examine the relationship between foreign direct investment and economic growth in Sri Lanka during 1980-2016. The data are taken from World Bank Reports, United Nations Conference on Trade and Development Reports. Data is analyzed using E-views 9. Gross Domestic Production is the dependent while Foreign Direct Investment, Employment, Gross Fixed Capital Formation, and Openness are considered as independent variables. Results conclude that foreign direct investment is a significant variable with a positive sign for interpretation of the economic growth. Developing countries such as Sri Lanka however, seek foreign direct investment because of its potential contribution to technology transfer and skill development, new industries and export markets and the creation of linkages with and associated upgrading of competencies of local enterprises to enhance the country's national competitiveness in the world economy. Hence, foreign direct investment flows are crucial for Sri Lanka. The study highlights the importance of investigating the Sri Lankan context.

Keywords: Economic development, Exports, Foreign trade, Import substitution

Household Level Impacts of Uma Oya Development Project

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Negative Effects on the community around Uma Oya Multi-Development project is a debating topic at present scenario. Therefore, the purpose of this study is to find out the specific socio, economic and environmental factors affecting the impact of Uma Oya Multi-Development Project at household level in one of the most affected areas, Bandarawela Divisional Secretariat. A total sample of 152 households was selected for the study. 76 households from the construction area were used to assess the real impact of the ongoing constructions. The remaining 76 households from the non-construction area were considered to assess the dissipating effects to nearby areas. The performed methods of analysis included frequency distribution, descriptive analysis, Mann-Whitney test and logistic regression. The findings revealed that distance to the construction site and selected areas for the study have a negative relationship with the household level impact. Further, the results suggest that the project has a negative impact on residential area of the households and the residences, water sources, and land extent of crops. The impact on non-construction areas and construction areas was compared through Mann-Whitney tests and the results revealed that there is a significant difference between non-construction areas and construction with respect to the farming status, water scarcity, damage to the households, damage to the land, degree of crop losses and government assistance. It can be finally concluded that there are significant differences between tested construction areas and non-construction areas on the impact of Uma Oya Multi-Development Project in Bandarawela Divisional Secretariat.

Keywords: Construction area, Impact factors on households Non-construction area, Uma Oya multi-development project

Willingness of Consumers to 3 in 1 Instant Milk Tea Sachet Packets

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The 3 in 1 instant milk tea sachet packet is one of the latest products which entered into the value added tea product line. The newness of this product has led tea manufacturers and marketers to explore deeply the potential market and consumer reaction. Hence, this research was conducted to find out the factors affecting the consumer willingness to 3 in 1 instant milk tea sachet packets and to identify the level of sensory factors that affect the consumer preference on a selected 3 in 1 instant milk tea product. 260 respondents representing four occupation categories (Lecturers, Students, Security Officers and Minor Workers) were randomly selected from the Uva Wellassa University of Sri Lanka. The data related to the preference level of the sensory factors, demography and the consumption behavior of the respondents were gathered using a sensory sheet and a structured questionnaire. Data were analyzed by using descriptive techniques and binary logistic regression. Results of the regression analysis show that the consumer willingness to buy this product depends on the over-all acceptability of the sensory factors of the tea and price acceptability. Above all, the consumers who are used to drink milk tea as their bed tea express more willingness. Consumers who purchase tea products from places like canteens and tea centers have no interest for this kind of products. The vanilla flavor decreases the consumer willingness to buy the product. The sensory test resulted that the selected 3 in 1 instant milk tea product has moderate sweetness, moderate milk flavor and moderate astringency. Further, it has pleasant aroma and appearance. As the conclusion of the sensory results, the selected 3 in 1 instant milk tea sample is in a consumer acceptable level.

Keywords: Consumer willingness, Instant milk tea, Logistic regression, Sensory evaluation

Determinants of Manufacturer's Price of Silver Tips

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Silver tips is a name given to a rare white tea produced in Sri Lanka for export market. Moreover, the price of this product fluctuates frequently. Therefore, this study is an attempt to find the determinants of manufacturer's price of silver tips, in the year 2016. Data were gathered using a structured questionnaire and interviewing the 50 silver tips exporting companies and 60 randomly selected silver tips manufacturing factories within Sri Lanka. Multiple linear regression model was used to determine the factors affecting the manufacturer's price of silver tips and descriptive statistics were used to identify the current situation of manufacturers in terms of silver tips production and exporters in terms of silver tips exportation. Regression analysis resulted that the number of years of factory experience in silver tips manufacturing in the year 2016, the amount of silver tips tea buds purchased for silver tips manufacturing (silver tips crop) in the same year had positive significant effect on the price set by the manufacturer. Moreover, the suitability of the weather condition for the growth of silver tips in the same year had significant negative impact on manufacturer's silver tips price. However, the descriptive analysis showed that most of the manufacturers produce very low amount of silver tips monthly, focusing more on manufacturing black tea and green tea. And also, silver tips tea is highly purchased by the Middle East countries. Finally, this study suggests to provide the knowledge, financial support and any other relevant contribution from supporting services for manufacturers to increase the production volume of silver tips in Sri Lanka. Therefore, it could be expected to increase the manufacturer's price of silver tips and increase the export volume of silver tips that exported to the foreign countries.

Keywords: Exporters, Manufacturers, Price, Silver tips, Willingness

Adoption of Machinery in Tea Cultivation and Management by Tea Small Holders in Kalutara District

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Use of machinery is a vital investment to enhance the productivity and overall performance of the tea industry. It is considered to be a better solution for the problems of labor shortage and high cost of production. The purpose of this study was to identify the factors affecting the adoption level of machinery. A sample of 154 tea small holders in Kalutara district was selected using multistage sampling technique. Data were collected using structured questionnaire and by interviewing the tea small holders at their residences. Data were analyzed using descriptive techniques as well as a Tobit regression model. According to the results of the descriptive analysis, overall adoption level of machineries is 12.73%. Small holders have higher adoption regarding pruning machine (29.22%) and TRI selective tea harvester (20.13%) while lower adoption on Holing machine (7.14%), Fuel operated plucking machine (5.19%) and Battery operated plucking machine (1.95%). The Tobit regression analysis revealed that farming experience, gender, family labor, information by TRI, land ownership and yield positively affect the adoption level while educational level of the farmer, age of the farmer and time spending in the tea land negatively affect the adoption level of machinery. Therefore, more attention should be given on these significant variables to find the appropriate strategies for increasing the machinery usage by tea small holders in the study area. Awareness programs on machineries should be arranged frequently to improve the knowledge and awareness of the tea small holders in Kalutara district.

Keywords: Adoption level of machinery, Holing machine, Plucking machines, Pruning machine, Tea small holding sector

**The Impact of Migration and Remittances on Education of Children
Left-behind: Evidence from Rural Sector of Sri Lanka**

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World literature supports the view that labor migration and remittances play a significant role in children's education of families left-behind although such evidence from Sri Lanka is lacking. Therefore, by taking a nationally representative sample of rural sector households of Sri Lanka, this study investigates the impact of migration and remittances on school enrollment of children left-behind. The data for this are coming from Department of Census and Statistics and they were analyzed using probit models. The results suggests that having an internal migrant or/ and an international migrant in rural households increase the propensity of school enrollment. However, with respect to the receipt of remittances, only internal remittances play a significant role in school enrolment.

Keywords: Children's education, Out-migration, Probit regression, Remittances

Determinants of Turnover Intention of Officers in Charge: A Case Study of Kurunegala Plantations Limited

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In modern day agriculture, employee turnover has become one of the major problems causing a challenge to very sustenance of agriculture sector in Sri Lanka. Therefore, finding what causes the employees to leave the sector is utmost important in making policy decisions. Hence, this study explores the determinants of turnover intention of Officers in Charge in one of the government owned Plantation Company in Sri Lanka. The data for the study were collected from all the 72 Officers in Charge in the company through a questionnaire. The data were analyzed using Descriptive Techniques and Logistic Regression. The results revealed that monetary rewards and additional benefits to employees, satisfaction with human resource management practices and satisfaction with job reduce the turnover intention. Our results further suggest that young married Officers in Charge with prior job experience, having other income sources, whose residences are located in faraway places from the company, tend to leave the job. The study recommended that the organizations' human resource management should apply strategies such as to create conducive job environment, improve housing facilities and infrastructure facilities within workplace, supply necessary tools for field work, supply adequate space and appropriate equipment to perform duties, support for employee personal life balance, offer employee reward programs, produce proper job description and develop a succession plan to get promotions to reduce Officers in Charge turnover.

Keywords: Job satisfaction, Logistic regression, Turnover intention

Valuation of Glyphosate in Tea Sector of Uva Region in Sri Lanka

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Banning of Glyphosate without providing any alternative, parallel chemical method to manage the weeds, has left the tea industry vulnerable for increasing cost of production (COP). This is because planters have to mainly depend on manual weeding which incurs a high cost. The aim of this study is to find out the value of Glyphosate per square meter (m^2) taking the area of Thelbedda and Ury estates in Uva region into account and apply it to determine the total value of Glyphosate for the entire tea sector in Uva region of Sri Lanka. We applied ‘Benefit Transfer’ as the valuation technique and evaluated Ury and Thelbedda estates in *Uva* region. We obtained annual cost of manual weed management and annual yield in the years 2016 & 2017. For the valuation, we assumed that the effects from climatic factors on weed management and yield is negligible, wage rate as well as weed growth rate is constant and effect of Glyphosate lasts till the end of the year 2015. Value of Glyphosate was determined by deducting the cost of manual weeding for the year 2016 from 2017. Values of Glyphosate per square meter of Thelbedda and Ury estates are Rs. 0.95 and Rs. 1.95 respectively. The value of Glyphosate for the entire tea sector of Uva region was determined by multiplying the average by the extent of tea sector ($281,330,000\ m^2$) in the Uva region and that is Rs. 407,726,059.90. Accordingly, the value of Glyphosate calculated depicts the worth of Glyphosate to the entire tea sector in Uva region under the valuation method of benefit transfer. The manual weeding cost has a significant increment in the following two years since the banning of Glyphosate application in 2015. The yield too has shown a drastic decline. Since an alternative herbicide has not yet been introduced the demand for labour has increased for manual weeding and so the cost. So Glyphosate is a crucial factor that affects the tea industry in terms of profit.

Keywords: Cost of production, Glyphosate, Manual weeding, Sri Lanka, Uva region

Site-specific Fertilizer Application in Paddy: Implementation Guidance for Policy Makers of Sri Lanka

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Application of correct dose of fertilizer is vital to replenish the soil nutrients, which are lost due to continuous cultivation. The Department of Agriculture has identified site-specific fertilizer recommendation as a strategy to supplement the nutrients based on the properties of specific soils and it is more suitable than the existing blanket fertilizer recommendation. However, a controversial issue still exists on the “optimal use” of fertilizers. Among different views, soil practitioners believe that the soil test-based fertilizer recommendation is the best in terms of maximum utilization of fertilizers and cost cut-off. Therefore, this study was conducted to analyze the farmers’ perspectives on site-specific fertilizer application and to estimate the farmers’ willingness to pay for soil testing. A survey was conducted in 2017 and data were collect from 110 farmers in Polonnaruwa and Anuradhapura districts following a multi-stage random sampling. Eleven different statements on farmer’s perspectives with five point Likert scale were assessed by factor analysis, which was followed by a multiple regression. Farmer’s willingness to pay for a soil testing was elicited using Single-Bounded Dichotomous Choice questions (3 bid values; based on value of soil test kit) of Contingent Valuation Method and estimated using probit regression. The results of the study revealed that, the farmer’s perspectives were significantly associated with age, education, training received and type of district. The estimated marginal willingness to pay for a soil test were Rs. 347 and Rs. 302 for Polonnaruwa and Anuradhapura, respectively, while age, farming status, farming experience and per hectare fertilizer cost, type of district and the bid value significantly influenced the decision. Further, with the incremental bid value, farmer preference for paying a soil test decreases and also the trainings received has a significant influence on the positive perception on the technology. The policy implications highlight that training can enhance the diffusion and adoption of the proposed technology in the targeted community.

Keywords: Contingent valuation method, Paddy, Site-specific fertilizer application
Willingness to pay

An Analysis of Factors Affecting on Tourism Receipts in Sri Lanka after the Liberalization of the Economy

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Tourism can be primarily defined as travel for pleasure or business that provides many employment opportunities, income & other benefits. It is evident in literature that tourism industry positively contributes to economic growth of developing countries. It is more important to identify the factors that affect the growth of performances (tourist receipts) of tourism industry. Based on this background, the general objective of this study is to estimate the contribution of factors affecting tourist receipts in Sri Lanka. Existing literature suggests that tourist arrivals, excursionist arrivals, tourist nights, accommodation capacity & annual occupancy rate etc. affect tourist receipts. The secondary data from 1977 to 2016 were extracted from Central Bank annual reports & time series analysis was used to analyse the data. Prior to analysis, optimal number of lag value was identified as 3 by using Akaike Information Criteria. Augmented Dickey Fuller test indicated that all the variables become stationary at their 1st deference while excursionist arrivals become stationary at 2nd deference. There is a long run relationship among all the variables due to Johansen test of cointegration which implied as 5 cointegrating equations. Presence of long run relationship lead to run Vector Error Correction Model to identify the short run impact. Among the factors, there is a significant positive impact of tourist arrivals & excursionist arrivals on tourist receipts in the short run although accommodation capacity, annual occupancy rate have a significant negative impact. In addition, tourist nights do not indicate any significanc short run impact on tourist receipts. Hence, it can be concluded that there is a positive impact of tourist arrivals & excursionist arrivals on tourist receipts in short run based on the Sri Lankan context.

Keywords: Accommodation Capacity, Excursionist Arrivals, Time Series Analysis, Tourist Arrivals, Tourist Receipts

Effectiveness of Purchasing Managers' Index as an Indicator of the Economic Growth in Sri Lanka

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Purchasing Managers' Index (PMI) is an indicator of the economic health of manufacturing and service sector of a country and it provides information on current business conditions to company decision makers, purchasing managers and analysts. PMI surveys have become key benchmark indicators of economic conditions in the world's largest economies and emerging markets. Under Sri Lankan context, PMI is prepared on monthly basis. As sub-indices of PMI directly connect with the factors which include in GDP, it is worthwhile to examine the representativeness of PMI for economic growth. Hence, the objective of this study is to examine the effectiveness of PMI as an indicator of economic growth in Sri Lanka. Considering the period May, 2015 - December, 2016, this study used simple linear regression and Pearson Correlation analysis to analyze data. Weighted PMI (WPMI) was used to make sure the accuracy of the results. According to the results of Pearson Correlation analysis, the correlation between WPMI and GDP is 0.60 which indicates that the positive correlation between these two variables is considerably high. Likewise, the correlation between PMI_M (manufacturing) and GDP_I (industrial) is 0.43 and, 0.58 is the correlation coefficient between the PMI_S (Services) and GDP_S (Services) indicating that service sector of GDP and PMI is slightly higher than the manufacturing sector's positive correlation. According to the results of OLS regression analysis WPMI is significant at 1% significant level and the coefficient is 0.29 and the R-squared is 46% indicating that WPMI explains the GDP growth rate only in some extent. Hence, the overall result implies that PMI seems to be a good indicator in explaining economic growth in Sri Lanka but, it is not a perfect indicator since it doesn't cover all components of GDP suggesting that compilation of PMI should concern wider range of economic activities to become a more effective indicator of the economic growth in Sri Lanka.

Keywords: Economic growth, Pearson correlation analysis, Purchasing managers' index, Simple linear regression

Study on Farmers' Perception on Providing Cash Grant Instead of Fertilizer Subsidy in Paddy Cultivation: A Study in Badulla District

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This study was conducted to analyze farmers' perception on cash grant including socio-economic characteristics of cash grant receiving paddy farmers, effect of new policy on fertilizer usage and paddy yield. Strengths, Weaknesses, Opportunities and Threats (SWOT) of cash grant program were also evaluated. A field survey using a questionnaire was conducted to collect data from 120 cash grant receiving paddy farmers in Badulla district from August to October 2017. Data were analyzed using descriptive statistics, one sample T-test and paired T-test. Result revealed that majority of the respondents are male, married, educated up to O/L and their main occupation is farming. Further, respondents have positive attitude regarding five statements; "cash grant program is a chance to buy quality fertilizer", "easier than fertilizer subsidy", "low corruptions", "opportunity to move organic agriculture" and "cash grant is successful". However, they have negative attitude towards "cash is inadequate to buy required fertilizer" and "cash is not receiving at right time". Furthermore, there is a reduction in fertilizer usage and thus paddy yield during this period. In focusing SWOT of cash grant program, reduction of wastage and corruptions, support of farmer organizations and easiness of cash grant are strengths while farmers' negative attitude is a weakness. Also, promotion of organic agriculture and high environmental concern were recognized as opportunities for the cash grant and higher market price of fertilizer, delaying cash grant receiving time and tenant farmer conflicts are the existing threats. However, they have comparatively positive perception on cash grant program. In order to get maximum returns of cash grant program, payment of cash at right time is crucial. Also motivation of farmers towards organic agriculture through appropriate training programs will be highly important.

Keywords: Badulla district, Cash grant, Fertilizer subsidy, Organic farming, Paddy farmers

Agricultural, Economical and Ecological Importance of *Phoenix pusilla* (Ceylon Date Palm) and Its Future Research Perspectives

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Phoenix pusilla, commonly known as Ceylon date palm (Indi) is a native palm species to Sri Lanka, belonging to the Family *Arecaceae* and Genus *Phoenix*. It is closely related but distinct from *Phoenix dactylifera* (date palm) by many morphological features. *P.pusilla* grows naturally in many parts of Northern and Eastern regions in Sri Lanka, and occasionally raised as an ornamental crop. It is considered as an underutilized fruit crop, and an untouched genetic resource, facing a severe genetic loss due to the negligence of the public and lack of scientific research. The aim of the review was to study the existing knowledge on agricultural, economical and ecological importance of *P.pusilla*. An extensive literature search was carried out in “Google scholar”, “NCBI” and “AGRIS” databases using search terms “Ceylon date palm” and “*P.pusilla*” which resulted total of seven research articles. One study depicted that it is a multipurpose plant with many valuable traits, but with an inconsiderable attention within the country and globally. Three research papers showed the importance of its edible fruit in treating fever, hyperdipsia, consumption, cardiac and general debility, burning sensation, seminal weakness, and gasteropathy. Furthermore, leaflets have been used to weave mats, brooms and baskets. It is ecologically important as a nursing plant in improving degraded tropical dry evergreen forest landscapes, by conserving soil and maintaining favorable conditions for the growth of woody plants. It is highly drought tolerant and has been used to pollinate *P.dactylifera* which has produced commercially valuable dwarf hybrids bearing seedless, edible fruits. In conclusion, further studies are essential to understand the physiology of *P.pusilla* to biotic and abiotic stresses, its ecological adaptations, nutritional and medicinal properties and phylogenetic relationships for the development as a cash crop and to improve other *Phoenix* species through interspecies hybridization.

Keywords: Agriculture, Ecology, *Phoenix pusilla*, Underutilized crops

Variance-Covariance Method and the Historical method to Measure Value at Risk of a Portfolio: A Case Study on Sri Lanka Stock Exchange

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In this study two different methods are used to measure and compare Value at Risk (VaR) of four different portfolios. Twenty securities which are used to calculate S&P 20 SL index in Colombo Stock Exchange were used to construct four different portfolios each worth Rs.100,000. Data was obtained from Colombo Stock Exchange during the period of 1st of January 2012 to 30th of September 2016. Four portfolios were constructed using the securities with the mean closing prices: less than Rs.100, Rs.100 - Rs.200, Rs.200 - Rs.300 and greater than Rs.300. Equally weighted VaR models were constructed for selected portfolio securities. Value at Risk is calculated using two different methods namely the Variance-Covariance method and the Historical method at three different significant levels. Variance-Covariance method calculates Value at Risk as a multiple of the standard deviation of the portfolio. Historical method calculates Value at Risk using an ordered array of the daily profit/loss. When making decisions about a portfolio it is best to make decisions by considering the maximum loss that can be expected when investing in a particular portfolio. The study concluded that the Monte Carlo method as the best method to calculate Value at Risk of a portfolio at 90% and 95% level of significance while Historical method is the best method to calculate Value at Risk of a portfolio at 99% level of significance. Further it could be seen that the portfolio that constructed using the securities with mean closing prices between Rs.100 and Rs.200 gives the lowest Value at Risk value and the portfolio that is constructed using the securities with mean closing prices above Rs.300 gives the highest Value at Risk value.

Keywords: Historical method, Value at risk, Variance covariance method

Impact of Socio-economic Status of Tea Smallholders on the Production of Tea Lands in Passara Tea Inspector (TI) Range

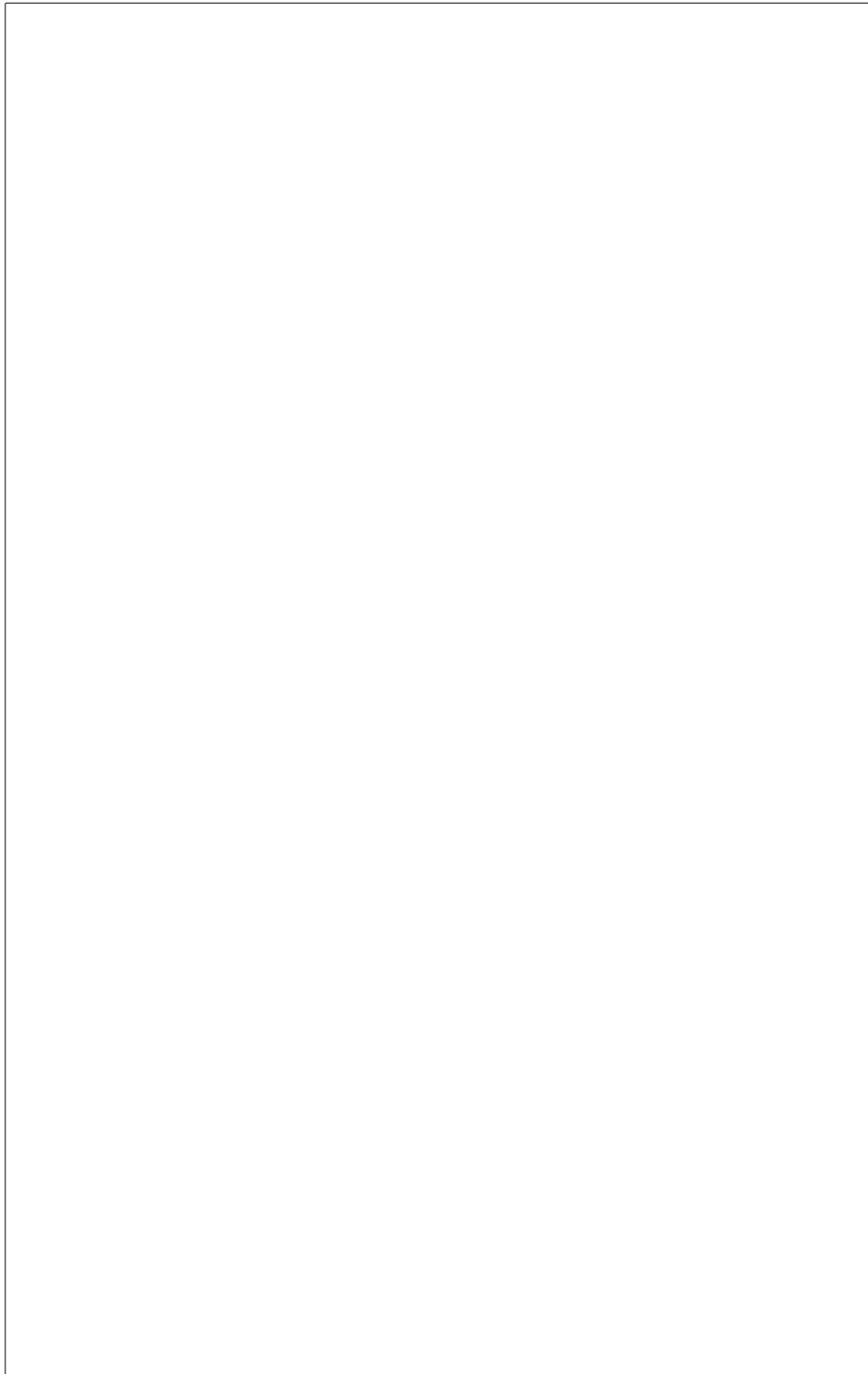
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Contribution of smallholders to the Sri Lankan tea sector is higher than the plantation sector. Knowing the socio-economic status helps find the strategies for improving smallholder's living conditions and their production. This study was undertaken to assess the impact of socio-economic status of tea small holders in the Passara tea inspector range on the production of their tea lands and also to identify the constraints faced by them in socio-economic upliftment. Data were collected from randomly selected 150 smallholders who are registered in five smallholding development societies out of 15 societies in Passara area by using a structured questionnaire through a face to face interview. Descriptive statistics and regression techniques were used to analyze the data. Simple linear regression results revealed that gender, education level, farming experience of the smallholder, monthly fertilizer cost and farm size positively affect the production while marital status of the smallholder negatively affect the production. Major constraints faced by the smallholders are poor infrastructure facilities, high cost for children's education, high cost of field operations, and pest and disease attack on tea cultivation. Proper extension services and field training programmes are suggested to offer them to gain their knowledge and experience on proper field practices. Continuously providing sufficient amount of fertilizer allowance and supplying of credit facilities are also needed. Infrastructure facilities should be developed in the Passara area. Various social organizations and societies should come forward to improve the socio-economic status of the small scale tea growers.

Keywords: Constraints of tea small holders, Socio-economic status, Tea smallholding sector



Entrepreneurship and Management

- Marketing Management
- Human Resources Management
- Accounting and Finance
- Organization Behaviour

Systemic Challenges Faced by the Administrative Officers of the Higher Educational Institutions in Sri Lanka

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There are 552 Administrative officers are placing in the Higher Educational Institutions in Sri Lanka by the University Grants Commission. This is 5.3% of total number of Non-teaching staff in the system. The mentioned Administrative officers are facing lot of challenges by the systemic issues such as recruitment, promotion, transfer, confirmation and other related benefits. The objective of this study is to find out the solutions to overcome the above challenges. The qualitative historical research methodology is used in this study by refer existing University Act, Circulars, Establishment code which are available legal documents in the system and government sectors. Altogether 32 documents were analyzed and compared. The opinion of the individual is not considered into this study as it concentrated only the systemic challenges. There are several issues are identified specially in the recruitment, promotion and confirmation which has to rectify to ensure the standard of the Administrative system of Higher Educational Institution of Sri Lanka. Recruitment criteria is time to time changed. Promotion is also done against available vacancy carders as the new appointment. The proper transfer policy is not adopted. The promoted officer should be in the probationary period for one year. If anyone fails in the Efficiency Bar exam in Middle level category they also able to get the promotion without considering the result of efficiency bar Exam. There are some common salary codes are used for Administrative staff and Non-administrative staff. There are some systemic differences identified from other equal related all island services. It creates inequality among the same kind of officers to get and enjoy the benefits from their employment. The study has find out there is no proper mechanism or service minutes for the carrier development of Administrative officers of the system. This study emphasizes to develop an all island service in the name of Sri Lankan Higher Educational Administrative Service to ensure the quality of the Administrative system of the Higher Educational Institutions of Sri Lanka.

Keywords: Administrative Officers, Systemic issues, Sri Lankan Higher Educational Administrative Service, Circulars

Impact of Compensation Management Practices on the Performance of Small and Medium Enterprises in Western Province of Sri Lanka

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Small and Medium Enterprises (SME) sector is the largest contributor in Gross Domestic Product in Sri Lanka. But they perform more in a way that is entirely different from that of the large firms in economy. Among them human resource practices are in a questionable stage. Because the practices and policies adopted by larger firms does not fit perfectly to the small and medium sized enterprises. When considering about the firm performance, compensation practices directly influences and helps the firm to grow. Though there are number of studies aimed towards investigating the relationship between compensation practices and firm performance, there is only a few number of researches conducted to find whether Nature of the firm moderates the relationship between the compensation practices and firm performance in Small and medium enterprises. Therefore, in order to assess the moderating effect, the current study collected data from a sample of fifty SME firms in Western province of Sri Lanka by using stratified sampling technique and by using a questionnaire. A fair representation was available from all three districts due to use of this method. Using multiple regression analysis, Pearson's correlation and Andrew F. Hayes's moderation assessment model, the data were analyzed. Finally, this study found that there is strong positive relationship between the compensation practices and the firm performance. In addition, the firm size and age of the firm significantly moderates the relationship between Compensation practices and firm performance while the type of industry does not significantly moderate the relationship between compensation practices and small and medium firm performance.

Keywords: Human Resource Practices, Firm Performance, Compensation Practices, Firm Size, Firm Age

**Assessing the Antecedents and Consequences of Work Life Imbalance
(With Special Reference to Female Nurses in Government Hospitals)**

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Work life imbalance has been identified as one of the serious problems among nurses in health care industry of Sri Lanka. Minimizing this critical problem is vital since, the health care industry is directly affecting to the wellbeing of the country's total population and ultimately for the economic development. The overall research study has been structured based on the conceptindicator model built up with referring to the two research objectives, which was identifying the antecedents and consequences of work life imbalance. The qualitative research was conducted through structured interviews, using 20 female nurses who are employed at Colombo District Government Hospitals. Data was collected though convenient sampling, by recording the personal interviews and later these data was transcribed in to word format. Qualitative data was analyzed by using the thematic analysis. The findings of the study revealed that, parental demand, lack of family support, task difficulty, nature of working schedules and lack of staff as the antecedents creating the work life imbalance and intention to leave the job, conflicts in work and home, health problems, feeling overload and stress and demanding leaves as consequences of work life imbalance. Consequently the current study concluded that among the majority of selected participants, the work life imbalance is existing. Based on the in-depth data collected by participants, it identified that they are having struggles in balancing their work lives while balancing their personal lives. Finally study suggest management of hospitals to pay more attention on reducing nurses' work life imbalance by taking necessary steps and actions. Equally, this study will be beneficial in employees' perspective to enhance their work life and personal life by getting a proper understanding of work life imbalance throughout this study findings.

Keywords: Work life imbalance, Antecedents, Consequences

Study of Emotional Factors Influencing Professionals' Adoption to E-Payment in Sri Lanka

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Electronic payment is widely regarded as a fund transfer between parties electronically for commercial purposes and it is increasingly being recognized as a key competitive tool in the present situation. Retailers and businessman utilize e-payment methods in order to gain a wide range of competitive benefits. While businesses are focusing more on rational factors behind consumer acceptance and adoption of e-payment, academic research is lagging in investigating the emotional factors which influence on adoption of e-payment. Absence of knowledge in this background affects negatively for the business's ability to enhance their sales and expand market share as well this study is providing a clear background about how businesses can emotionally influence and motivate consumers to utilize e-payment methods for their day to day transactions. This research helps academics to the diverse body of existing electronic payment literature. A sample of 460 professionals in Sri Lanka was empirically investigated with the aim of identifying the emotional factors influencing professionals to adopt and use e-payment methods. A structured questionnaire was used to collect data through e-mails and face to face method. The pilot study of 50 undergraduates revealed a high reliability level of the questionnaire in all the dimensions of the questionnaire. The Exploratory Factor Analysis identified that the professionals' e-payment adoption was influenced by six different emotional factors. Based on the literature these factors are named as Innovativeness, Professional satisfaction, Optimism, Insecurity, Skepticism and Discomfort. The study revealed that there is an influence from emotional factors not only from rational factors to new technology acceptance and usage in Sri Lanka. These factors determine the professionals' adaptation to e-payment causing different emotions in their mind such as joy, gratitude, serenity, interest, hope, pride, amusement, hate, anger, jealousy and sadness.

Keywords: Electronic Payment, Emotional Factors, Technology Acceptance, Exploratory Factor Analysis, Structured Questionnaire.

**The Effect of Ethnocentrism and Patriotism on Consumer Preference
(Special Reference to Handloom Products in Sri Lanka)**

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Practitioners in marketing impulse of understanding consumer behaviors and attitudes than before. Consumer ethnocentrism is a belief held by consumers that products manufactured in their home country are better than the foreign-country made products. Ethnocentric consumers believe that purchasing a local made product is one way to show their ethnocentrism to the home country. Consumer patriotism is the strong feelings of love and devotion towards one's own country, without a corresponding hostility towards other nations. Recent studies showed that consumer's enthusiasm towards foreign brands was declining. One explanation for such changes may be patriotic, nationalistic or ethnocentric behaviors of consumers. Therefore, the objective of this study to identify the effect of ethnocentrism and patriotism on consumer preference for handloom products. A sample of 150 consumers was randomly selected from handloom outlets in Western Province. Cluster sampling technique was applied for the study. Primary data was collected through a questionnaire. Regression and correlation techniques were used to analyze the collected data. The study concluded that consumers in Western Province was ethnocentric to domestic handloom products according to the Consumer Ethnocentric Tendency Scale. Further, findings concluded that ethnocentrism and patriotism have positive effect on consumer preference for handloom products. However, ethnocentrism was the mostly effecton consumer preference. Finally, the findings of this study will help to marketers to develop their marketing strategies.

Keywords: Consumer Ethnocentrism, Consumer Patriotism, Consumer Ethnocentric Tendency Scale

Comparative Study on the Effect of Formal and Informal Mentoring on Job Involvement with Special Reference to Apparel Industry in Sri Lanka

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Human Resource Management is a formal system of managing people within an organization. Mentoring is one of the critical activity in human resource development which used as a long-term process of developmental, career focused, and covers all life structures to nurture the potential of a person. Mentoring has created many consequences and Job involvement is one of the beneficial outcome of it. This research studies the combine effect of formal and informal mentoring on employees' job involvement with special reference to the apparel industry. Research objectives are to identify the formal and informal mentoring practices of apparel industry, identify the relationship of formal and informal mentoring to the employee's job involvement, determine how formal and informal mentoring impact on employees' job involvement and also to understand the combine effect of formal and informal mentoring on employees' job involvement. Researcher collects data from 150 operational employees in top five apparel sector companies selected by using simple random sampling technique. Questionnaire was used as a data collecting technique. Data were analysed based on objectives by using descriptive statistics, correlation and regression analysis with the support of SPSS 21. The workers are happy with the existing mentoring practices used in apparel industry and also formal and informal mentoring positively associated with the employees' job involvement. Furthermore, there is an impact of formal & informal mentoring on the employees' job involvement. In addition to that the combine effect of formal and informal mentoring is negative on job involvement. Based on the research findings, suggestions and recommendations for management in apparel industry were stated and it reveals that formal mentoring is most effective for the job involvement and researcher suggest to select the most appropriate type of mentoring without combining as it creates negative impact for the employees' job involvement.

Keywords: Apparel Industry, Job Involvement, Formal Mentoring, Informal Mentoring

Factors Affecting to Success of Micro Enterprises (With Special Reference to Kandy District)

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The small and medium enterprises (SMEs) play a critical role in the development of the country. As a part of SMEs', Micro Enterprises have a major role in employment and contribution to the Gross Domestic Production. Nowadays half of the Micro Enterprises are failing in the early stage of their life cycle. Although half of businesses fail in the early stage, there are successful Micro Enterprises which occupy dominant positions in the economy. This study examines the role of key factors affecting to success of Micro Enterprises in Kandy district. The study empirically tested the three factors affecting to success of micro enterprises, namely Personal factors, Organizational factors and External environmental factors. Thus, the study based on the three objectives; first, to develop the profile of successful Entrepreneur, second, to identify the relationship between success factors and success of Micro Enterprises, and finally to identify the most influencing factor for success of Micro Enterprises. Five-point Likert scale questionnaires were distributed by using stratified random sampling technique to collect primary data from 100 owners of Micro Enterprises' in Kandy district. The data were analyzed by using descriptive statistics, correlation coefficient and multiple linear regression. This study concludes that owners' personal qualities directly influence to be a successful entrepreneur and there is a positive relationship between Enterprise success and its success factors. The result shows that Personal factors are the most influencing factor for the success of Micro Enterprises. Most of the Micro Enterprises fail in their early stage because lack of Personal, Organizational and Environmental factors. The study has recommended to Entrepreneurs of Micro Enterprises, policy makers and other interest parties to consider these factors while developing policies and strategies for Micro Enterprises.

Keywords: Business Factors, Enterprise Success, External Environmental Factors, Micro Enterprises, Personal Factors

Examining the Relationship between Organizational Culture and Employee Commitment of Government School Teachers in North-Western Province Sri Lanka

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School teachers have crucial obligation to shape the backbone of future generation in a country. Major Objectives of the present research were assessment of the type and level of employee commitment of teachers, investigation of the type of culture prevailing in the government school system in North Western province, Sri Lanka and analyzing the association between organizational culture and employee commitment of the government school teachers in North Western province for providing conclusions and recommendations to teachers, teacher educators, education planners, educational policymakers and administrators in Sri Lanka. Three hundred and eighty-three government school teachers were selected using stratified sampling method with the representation of both Kurunegala and Puttalam districts in North-Western province, Sri Lanka as the sample of the present study. A self-administered questionnaire consisting of three sections in order to collect responses regarding general information of the teachers, level of employee commitment and nature of the culture, was applied as the primary data collection tool for the present research. Findings proved that there is a significant relationship between organizational culture and level of employee commitment. Four organizational cultural types; adaptability, achievement, bureaucratic and clan culture were tested in the present research and among them, clan culture showed a greater positive relationship with employee commitment than other types of cultures. Findings further proved that teachers showed affective commitment rather than normative and continuance commitment. Accordingly, it is recommended to promote clan culture within schools as that has greater influence for determining the level of employee commitment. As the clan culture creating friendly environment working as a family, more opportunities for promoting togetherness and friendship of the teachers.

Keywords: Employee commitment, Government, Organizational culture, Teachers

Motives and Characteristics of Social Entrepreneurship in Sri Lanka: A Case Study from the Handloom Industry

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The interest among the academia and the practitioners in the field of social entrepreneurship is developing tremendously attributed to its socioeconomic impact. The research in social entrepreneurship of Sri Lanka is significant due to the social entrepreneurs' potential contribution on economic development. Consequently, this research was conducted with two objectives, to analyze 'why' social entrepreneurs emerge and to analyze 'how' social entrepreneurs address the social needs compared with competitive businesses operating in Sri Lanka. Hence, the research was conducted based on a handloom manufacturing company in Kurunegala district. A qualitative inquiry was conducted adopting a case study method as the methodology. The data was generated through semi-structured interviews and observation at the handloom manufacturing company while secondary sources were referred to understand the competitive business practices. Then data was analyzed using a thematic analysis. As the findings suggest, the prime reason for the emergence of the case enterprise was the owner's intention to uplift the lives of the marginalized people living around the area. Secondary objectives such as to maintain an egalitarian structure, to facilitate a participative style of management, to maintain equality in pay, recruitment and working conditions, to promote innovation and to ensure the sustainability of the environment was also evident from the practices. Furthermore, it was evident that there is a clear difference on how social entrepreneurs address the social needs compared with the competitive businesses in perspectives of their objectives, operations, structure, domain, identity, funding, innovations and concern for the environment. Likewise, it was evident from the case organization that the social entrepreneurs emerge to solve social issues creating social wealth and value. Therefore, it is vital to promote social entrepreneurs in Sri Lanka to solve the pressing social issues we face.

Keywords: Social Entrepreneurship, Sri Lanka, Motives

Determinants of the Profitability of Listed Finance Companies in Sri Lanka

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Listed finance companies play a key role in Sri Lankan economy and the well-being of the finance companies is very critical to the development of the economy. Profitability of the finance companies indicates the well-being of the management and it is one of the most important indicator for the investors. Hence, identifying the determinants of profitability of listed finance companies is vitally important. However, the contradictory findings on profitability determinants reported in the literature and relatively low evidence available in this regard in Sri Lankan context creates the necessity for studying this matter in Sri Lanka. This study aims at identifying the firm specific determinants and macro-economic determinants of the profitability of listed finance companies in Sri Lanka. Company size, capital ratio, loan ratio and deposits ratio were taken as firm specific determinants while inflation and GDP growth rates were considered as macro-economic variables. The Return on Assets and Return on Equity was considered as the proxy for the profitability. 125 firm year observations were taken as the sample of this study covering 25 listed finance companies for five years' period from 2011 to 2015. Random effect regression model was used to analyze the strongly balanced panel data set of the study. The result revealed that the company size, capital ratio, loan ratio and GDP growth rate have a positive and significant impact on profitability while GDP growth rate shows the highest relationship. However, the deposits ratio and inflation show a negative impact on profitability. Study recommends the corporate managers to maintain healthy capital ratios, to improve the size with diversified branch networks and invest in more on loans and advances to enhance the profitability.

Keywords: Firm specific factors, Listed finance companies, Macro-economic factors, Profitability determinants

A Study on the impact of Capital Structure on Financial Performance of Listed Companies in Sri Lanka - Evidence from Beverage Food and Tobacco Sector

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Today's business world is very dynamic and competitive compared to the past epoch. The decision making bodies of the businesses must pay sufficient attention on various aspects in order to be success in the market. Financial Management is one of such vital important aspects to an organization. It plays the major role in the success of a business. The scholarly findings have disclosed contradictory ideas on how the capital structure impacts on financial performance of businesses. Hence this study was conducted with the objective of identifying the impact of capital structure on financial performance of listed companies in Sri Lanka based on Beverage Food & Tobacco Sector. Debt to equity ratio was used to measure the capital structure and return on equity, return on assets and earnings per share were used as the proxy for financial performance. 170 firm year observations were used as the sample of this study covering 17 companies out of 21 companies listed in the sector. The sample period consists of 10 years (2006 to 2016). Pearson correlation analysis and panel econometrics techniques namely fixed effect regression model and random effect regression model were used to analyze the data using E-views statistical software. The correlation analysis revealed that the debt ratio has a positive relationship with return on assets, return on equity and earnings per share. The Panel data regression analysis too revealed a positive impact of capital structure on financial performance. As the empirical findings indicate that the capital structure has material effect on financial performance, the researchers recommend the corporate managers to consider the effect of leverage before adjusting the capital structure of their companies while advising the investors to consider the level of debt of the company before making investment decision.

Keywords: Capital Structure, Return on Assets, Return on Equity, Earnings per Share

**The Impact of Job Insecurity on Organizational Commitment
(With special reference to International Non-Governmental
Organizations [INGOs] in Northern Province of Sri Lanka)**

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During the last few decades economic changes leading to transformations in the labour market have taken place in the industrialized world .Many organizations have had to engage in downsizing and restructuring in order to reduce labour costs and to improve competitiveness. These efforts usually result in the reduction of a large number of staff. It generates job insecurity. The objective of this study was to investigate the relationship between job insecurity, and organizational commitment with special reference to Northern Province of Sri Lanka. Researcher used mixed method study. In order to validate the quantitative research findings qualitative research was used. The research was conducted through the responses of employees of International Non-Governmental Organizations in Northern Province of Sri Lanka. Data was collected through questionnaires and personal interviews. Researcher collected data from 100 employees and personal interview was conducted among 20 employees to whom the questionnaires were given. The results demonstrated statistically significant relationships between job insecurity and organizational commitment. A practically significant relationship between variables was also determined; Job insecurity demonstrated a relationship with increased levels of organizational commitment. This study explained that employees would not always reduce their commitment and work effort when confronted with uncertainty as suggested by several studies. Nevertheless, it could be assumed that the survey participants fear being unemployed, feel trapped because of a lack of alternative employment opportunities and wish to employ for next project with the existing organization. These results indicate that insecurity can make people more appreciative of their current work and workplace.

Keywords: Cognitive job insecurity, Affective job insecurity, Organizational commitment, INGO'S

Impact of Working Capital Management on Financial Performance of Diversified Holdings Companies in Sri Lanka: A Panel Data AnalysisL.Kengatharan^{1*}¹*Department of Financial Management, University of Jaffna, Jaffna, Sri Lanka.*

According to the finance theory, management of working capital which aims at maintaining an optimal balance between each of the working capital components, that is, cash, receivables, inventory and payables is a fundamental part of the overall corporate strategy to create value and is an important source of competitive advantage in businesses. Objective of the study was to examine the impact of working capital management on financial performance of diversified holding companies in Sri Lanka. Data were collected from randomly selected 16 diversified holding companies listed on Colombo Stock Exchange for period from 2011 to 2016. Working Capital Management (WCM) was measured by Current Ratio (CR) and Quick Ratio (QR) and firm's financial performance was measured by Return on Equity (ROE). Firm Size was considered as control variable. Impact of working capital management on firm performance was analyzed by using statistical software STATA. Since 16 companies included in the study with the 6 years data, Pooled OLS regression, fixed effect and random effect models were performed to evaluate the impact of WCM on ROE. F test was performed to diagnose the time fixed effect in the fixed effect model and outcome of the test revealed that p value was less than 0.05. Therefore, null hypothesis was rejected that there are time fixed effects in the model. Further, Lagrange Multiplier test for random effect was performed. The result indicated that the p value was 0.000 and rejected the null hypothesis in favor of the alternative which implied that random effect model was more appropriate than pooled OLS. Therefore, Hausman specification test was performed to check which model whether random effect or fixed effect is most suitable in this study. According to the Hausman test, fixed effect model was considered as suitable model. Results of the fixed effect model revealed that there was a significant positive relationship between CR and ROE, while there was a negative significant relationship between QR and ROE. Findings of the study may useful to the companies to maintain optimal level of working capital in order to maximize the financial performance of the companies.

Keywords: Current ratio, Quick ratio, Return on equity

Causes for Internal Audit Outsourcing in Sri Lanka, Evidence from Listed Companies in Colombo Stock Exchange

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Internal audit outsourcing is an undeniably imperative issue for the accounting profession and there is an ongoing debate on internal audit outsourcing in the literature. Yet, there is an increasing trend in outsourcing the internal audit function in Sri Lankan companies. Hence this explanatory study investigates the causes which influence the decision of internal audit outsourcing in Sri Lanka using survey data of 40 companies listed in the Colombo Stock Exchange, who have outsourced some or all of their internal audit functions. The technical competence, cost saving, corporate strategy and firm size were considered as the measures of the independent variable, the causes for Internal Audit outsourcing while the dependent variable is Internal Audit outsourcing. Correlation coefficient analysis and regression analysis techniques were used to analyze the data using SPSS version 16. The results revealed that the technical competence, corporate strategy and firm size are significant and have a positive relationship with the outsourcing decision while the cost saving is an insignificant and negatively affected cause in Internal Audit outsourcing decision. Further, this study revealed that Internal Audit outsourcing is exceedingly connected with the technical competence of the external service provider. These results imply that internal audit outsourcing is a developing business opportunity for professional business organizations. Hence the researcher suggests the professional firms to improve the technical competence in order to get more businesses.

Keywords: Causes, Internal Audit Outsourcing, Technical competence

Stories of the Educational Development Initiatives in the Government Schools in Sri Lanka

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Education development of students is a very significant aspect of any education reform. There was a question in this study that is how schools use strategies to achieve their education development targets. This qualitative case study research includes five cases. Purposively selected School Development Committee members of schools were interviewed, and the interview transcriptions were analyzed by using thematic analysis. Most of the schools display a different pattern of education development, and strategies used for educational development of schools are varied. The main purpose of the majority of schools and parents is to enhancing the examination results of the students. As a result of that, the main intention of those schools has deviated from the total development of students. However, the majority of schools spend reasonable attention on education development of their students, for instance, they conduct additional classes, seminars, workshops etc. For those activities, it appeared that schools organize several funds generating activities. One of the schools in this study usually spends more than ten million rupees for their educational development programmes annually. It was noticed that the examination results of their students are very successful for several years. Schools are provided more authority and autonomy for decision making and resource management, the majority of schools display an inclination in using their maximum authority organizing education development activities. Sometimes, they demonstrate poor results at their educational development programmes. It was noticed that the deteriorating schools are not enthusiastic to learn lessons from the successful schools in the government sector in Sri Lanka. They work individualistically without observing at the neighboring environment of them.

Keywords: Education development, Student performance, School Based Management

**Impact of Leader Member Exchange Relationship on Turnover
Intention in the Apparel Industry
(With Special Reference to Operational Level Employees in the
Katunayaka Export Processing Zone)**

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Turnover intention is one of the critical problems in the apparel industry in Sri Lanka. Novel organizations have become aware that strategies aimed at developing leader member exchange relationships ensure a lower turnover rate. Leader member exchange relationship creates intercommunication between the leader and the subordinate in organizations. Thus, the study empirically tested organizational justice as mediating the relationship between leader member exchange and turnover intentions of operational level employees in apparel companies in Katunayake Export Processing Zone. Questionnaires were distributed by using convenience sampling method to collect data from 100 operational level employees working for 10 apparel firms in the Katunayake Export Processing Zone. The data were analyzed using correlation coefficient, regression, Baron and Kenny mediator assessment method and Sobal test. Findings of the study indicated that there is a negative relationship between leader member exchange relationship and turnover intention. Mediator assessment and Sobal test results indicated that organizational justice significantly and partially mediated the relationship between leader member exchange relationship and turnover intention. The findings show the importance of supervisors building positive and trusting relationships with their operational level staff and maintaining an environment of justice to reduce turnover intention in the apparel industry in Sri Lanka. The study also makes a number of recommendations to managers based on the findings of the study.

Keywords: Apparel Industry, Leader member exchange relationship, Organizational justice, Sri Lanka, Turnover Intention

Do Female Directors Improve Firm Performance in Sri Lanka?

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Boards of Directors play a dominant governance role in organisations and (among other things) seek to ensure that the managerial goals align with those of shareholders and that ineffective management and/or processes do not proliferate. A 100-firms sample, randomly drawn from Colombo stock exchange, was analysed. The results reveal that female board members in Sri Lankan firms averaged 14 percent and ranged from 0-38 percent. Findings also demonstrate that the two performance ratios indicate that each three percent to the observed variability in firm performance is explainable by the female board representation. The significance levels show that both performance models generate statistically insignificant outcomes. Undoubtedly, there is still a gender imbalance in the higher-level governance positions Sri Lanka. Female board representation may be a confounding factor that entangles and prevents the influence of board and company attributes from becoming apparent.

Keywords: Board of directors, Female directors, Firm performance

The Inter correlation Between Organization Culture and Employee Effectiveness in Sri Lankan Public Sector Organizations

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Organizational culture has been understood by diverse researchers to be crucial in relation to organizational effectiveness. The organization cultures of public organizations are having over two hundred years of experience have well organizing and functioning smoothly in the present scenario. On the other hand criticisms have been made against the effectiveness of the public sector. Therefore, present study attempts to study the inter correlation between organization culture and employee effectiveness in Sri Lankan public sector organizations. The study was conducted in during the period of July to December 2013 in association with Sri Lankan public sector organizations covering three provinces (Western, Southern an North Central). The sample of the study was composed of 661 employees belonged to three employee categories such as (managerial, clerical and below clerical), and working in three organization categories (national, provincial and district level). The mix method was used to the study and questionnaire method engaged with gathering quantitative and qualitative data analysis process and which occurred by the use of computer based SPSS package (version 20). Information was gathered through focus group discussion, case study and interview which were in associate with qualitative analysis. The results clearly indicate that 84% of the employees were trust and support their fellow workers, 68% and 73% of employees were disagree with fellow workers and informal group respectively to achieve the organization goals, 92% of the employees were believe that the external viewers keep up their mind positively with the organization, 94% of employees motivate with the organization environment and 90% of employees were agree with informal group information and knowledge sharing. Findings of the study shows that fellow workers trust and support, information and knowledge sharing, positive attitudes of external party about organization, and organization environment to the work have been positive influences on the public sector organizations and their employee's effectiveness. Although the main findings of the study were fellow workers collaboration about the achieving the organization goals, and informal relationships in public sector organizations were exceedingly negative for work, and as a result it may goes to lower effectiveness. In summary concluded that the organizational culture was negatively influence over organization goals in irrespective of to what category (organization/ job) they belonging.

Keywords: Effectiveness, Organization Culture, Organization Goals, External and Internal Group

The Impact of CSR Practices Adopted By Commercial Banks in Sri Lanka on Customer Attraction and Customer Retention

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The concept of Corporate Social Responsibilities (CSR) becomes highly topical in the banking sector; since the banks significantly recognize the importance of moral principles and well-being of society. CSR is one of the best external marketing strategies that commercial banks recently practicing in order to obtain more attention and attraction from the customers' and enhance Customer Retention (CR). Moreover, CR is emerging as the most critical and vital factor that banks have to achieve, due to hyper competitive business environment. The overall research study has been structured referring to four research objectives, which was identified existing CSR practices, relationships between the CSR, CR and Customer Attraction (CA), CSR influence on CR and finally, mediating effect of CA on CSR and CR. The quantitative research was conducted through distributed questionnaires, using 100 of selected five commercial banks' customers and sample was collected though convenient sampling. The findings revealed that commercial banks' customers more satisfy with the economic CSR and there are positive associations between the CSR, CR and CA. Withal CSR influenced the CR and CA significantly and partially mediate the relationship between CSR and CR. The current study compensates strength and evidence for the relationship, that commercial banks practice more CSR activities, will directly lead to the CA and through that banks can retain customers. Finally, those findings highly significant for the commercial bank marketing managers take the decisions regarding the areas of CSR activities they have to be more focus and the amount of money they need to be allocating for the CSR. Besides the study provides a detail description in what premises it better to implement CSR practices for enhanced retention rate of the customers and to obtain more profits and success in near future.

Keywords: Commercial bank, Corporate Social Responsibilities, Customer Attraction, Customer Retention

Impact of Perceived Organizational Support on Employee Retention of Private Banking Sector in Sri Lanka

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Private Banking Sector experiencing a high turnover ratio in Sri Lanka and with that, employee retention became a prominent issue to attain organizational goals and objectives. Now days organizations widely practicing the Perceived Organizational Support (POS) implementations to motivate employees as the strategy of retaining them. Thus the research consists of four objectives. First, it examines the existing level of POS in private banks of Sri Lanka. Second, determines the relationship between POS, Career motivation and employee retention. Third, it aims how POS impact on employee retention and finally explores the mediating role of career motivation within the relationship of POS and employee retention of the private banking sector in Sri Lanka. Questionnaire of 36 items were adopted from past researchers. A research was conducted among 100 employees from top five Private Banks in Sri Lanka. Analysis of data was done by using correlation coefficient, Baron and Kenny mediator analysis method and Sobel test with the SPSS 21.0 version. Results of the current study demonstrate the fact, there is a considerable association between POS and Employee Retention whereas partial mediation of Career Motivation. This relationship was studied in first time in Sri Lanka. The findings of the study support to the human resource managers of the private banking sector to identify career motivation, Supportive working conditions, Individual benefits and working patterns. These factors should be taken into account by private banking sector when keeping their employees for a long period of time.

Keywords: Perceived Organizational Support, Employee Retention, Career Motivation

Impact of Vehicle Branding on Customer Purchasing Behaviour (Special Reference to Film Industry in Sri Lanka)

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The advancement of advertising tools have created cost effective methods of marketing. Accordingly, vehicle branding which means vehicle wrapped advertisement can be identified as one of the cost effective advertising tools. Relatively a few number of papers have published about vehicle branding. It has not yet been covered the impact of vehicle branding on customer purchasing behavior. Moreover, there is a developing competitiveness in Sri Lankan film industry and the recent advertising trend of film promoters is vehicle branding. Hence, intention of this paper is to fill the gap in the literature by examining the impact of vehicle branding on customer purchasing behaviour, ascertaining the relationship between vehicle branding and customer purchasing behaviour and identifying the most influential factor of vehicle wrapped advertisement related to film industry in Sri Lanka. In this study, vehicle branding depends on five dimensions; product's name, format, text composition, creativity and type of vehicle. Primary data were gathered through distributing a questionnaire among 225 movie goers in Western province. Sample was selected using stratified sampling technique. Descriptive statistics, correlation coefficient analysis and regression analysis were used to analyze data. The results suggest that the vehicle branding dimension 'product's name' is the most influencing factor and customer purchasing behaviour dimension "interest" is the most influenced factor. Further, there's a significant positive weak relationship between vehicle branding and customer purchasing behaviour and finally, product identification, format, creativity and type of vehicle significantly impact on customer purchasing behavior except text composition. Accordingly, vehicle branding is a suitable way of giving a first impression about a new film and marketers must concentrate more on film's name when they designing a vehicle wrapped advertisement. Further researches can be conducted covering other industries and for the new trends in vehicle branding such as digital vehicle branding and 3D vehicle branding.

Keywords: Vehicle Branding, Vehicle Wrapped Advertisement, Customer Purchasing Behaviour, Film Industry

An Empirical Study of the Impact of Brand Personality on Brand Commitment: Evidence from Sri Lankan Smartphone Market

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Brand commitment is one of the most-cited concepts in marketing literature, and today, this concept plays a vital role in strategic management. It is surely true that the committed customers to a particular brand seldom switch to another. In Sri Lankan smartphone market context, firms introduce new versions, capture new technology rapidly and product quality and features are getting homogenous due to technological changes, competition and globalization. Thus, to gain customer commitment towards a brand, smartphone manufacturers need to focus on other aspects than product features and quality. Hence this study investigated whether the brand personality can be used to derive customer commitment towards the brand. The study objectives were; firstly to identify the impact of brand personality on brand commitment, secondly to identify the impact of brand personality on affective commitment and continuance commitment separately and finally to identify the relative contribution of brand personality dimensions on brand commitment in Sri Lankan smartphone market. Five brand personality dimensions studied were Sincerity, Excitement, Ruggedness, Competence and Sophistication. 100 smartphone users were considered as the sample and the data were collected using a questionnaire. Descriptive statistics, correlation coefficient, simple linear regression and stepwise regression analysis techniques were used to analyse the data. The results indicated that there is an impact of brand personality on brand commitment, affective brand commitment and continuance brand commitment. Further it revealed that all five brand personality dimensions are positively impact on brand commitment while sophistication showed the highest and the competence showed the next highest contribution. Hence the researcher recommends the smartphone manufacturers to consider on improving brand personality dimensions to derive customer commitment towards such brand.

Keywords: Affective Brand Commitment, Brand Commitment, Brand Personality, Continuance Brand Commitment, Smartphone market

A Study on Career Aspirations of Undergraduates in Sri Lanka

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Studying career aspiration among undergraduates has become an important topic since undergraduates face numerous challenges after completing their university degree especially when seeking for suitable employment opportunities. Therefore, this study mainly investigates the “career aspiration” in the context of current Sri Lankan Undergraduates, identify the factors that affect different career aspirations of undergraduates and the key issues faced by undergraduates with regard to their career aspirations by applying the theory of planned behaviour. In order to achieve the research objectives, the study was devised using descriptive qualitative approach. Data were collected from 20 undergraduates in 04 solitary universities as per the sample and from 03 graduates to conduct case studies based on their successful stories for validation purpose through semi structured interviews. The analysis is done by thematic analysis method by using NVivo 8 qualitative analysis software. Based on the findings of the study the concept career aspiration defined as “identification of an appropriate professional path during the period of undergraduate with realistic vision by considering future career targets, goals and objectives through which the final satisfaction could be achieved”, and indicated that the subjective norms, perceived behavioural control and attitude are the factors which affect different career aspirations of the undergraduates in Sri Lanka. Finally, key issues were identified as lack of experiences, competition, political changes and lack of monetary facilities and all the respondents agree with the statement that the identified issues become great influence to career aspiration. This research is a significant source for the policy makers and decision makers in manipulating the university education system of the island and the universities can meaningfully contribute towards career development of undergraduates.

Keywords: Theory of planned behaviour, Attitudes, Social norms, Perceived behavioural control

**Impact of Green Supply Chain Management on Competitive Advantage
of Business Organizations in Sri Lanka**

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Organizations adopt many strategies to gain competitive advantage from competitors among the firm. One of main strategy is adapting Green Practices in the organization. Green supply Chain Management (GSCM) is a critical issue to gain competitive advantage in the near future scenario. Cost benefit and customer value enhancement is another two strategies to gain competitive advantage. Combining both from greening the supply chain to gain cost benefit and customer value enhancement simultaneously organizations can get a superior competitive advantage. There are contradictory findings on the cost benefit element of adapting GSCM in organizations and also no clear theory how combine elements affect to gain competitive advantage. Thus the study is based on 5 objectives; the primary objective was to identify the impact on GSCM on competitive advantage on business organizations in Sri Lanka. Questionnaires were distributed by using convenience sampling method to collect primary data from 30 organizations that are practicing green practices in Sri Lanka. Secondary data also gathered from the organizations. The data were analyzed using descriptive analysis, correlation coefficient, and simple regression model. The results of the study indicate that there is a strong positive relationship between GSCM and competitive advantage. And also there is a positive relationship with both cost benefit and customer value enhancement elements separately. The results show that rather than focusing on one factor to gain competitive advantage it's better to apply both cost benefit and customer value enhancement simultaneously, to secure a superior competitive advantage. These study's findings are helpful to managers to adopt GSCM practices and to motivate to adopt green practices. Especially to sustainable economic growth in Sri Lanka and to protect the environment, greening the supply chain is very beneficial.

Keywords: Green Supply Chain Management, Cost Benefit, Customer Value Enhancement, Competitive Advantage, Supply Chain

A Study on Impact of Job Stress on Employee Retention of Private Banking Sector in Sri Lanka

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Job stress is a major problem faced by employees in the working environment that affects employee retention. Job stress is identified as the most crucial issue in the private banking sector of Sri Lanka meanwhile it can be harmful for the productivity if skilled workers are wished-for leaving the job. The present study observed the association between job stress and employee retention of private bank employees whether organizational support moderates the relationship between both. Empirical and knowledge gap of how job stress effect the employee retention of employees in private banking sector is associated in the study. Organizational support is a significant aspect reducing the job stress of workforce in the private banks. Nowadays organizations have become aware in organizational support strategies to ensure a higher retention rate. Accordingly, the study based on the four objectives; firstly, it identifies the existing job stress of private bank employees. Second, study aims to identify relationship between job stress and employee retention. Third it determines job stress impact employee retention. Finally, it identifies the moderating role of organizational support on relationship between job stress and employee retention. Survey has done by using questionnaire to collect primary data from 100 employees working in top five private banks in Sri Lanka. The results of the study revealed that job stress has a negative effect on employee retention. The data were analyzed using correlation coefficient, simple regression and multiple regression. The data were analyzed using SPSS 21 version. The study also revealed that organizational support moderates the relationship between job stress and employee retention. The results of the study support to the top management as well as human resource managers to create stress free background to retain the employees by using the organizational support strategies in future.

Keywords: Job Stress, Employee Retention, Organizational Support

**The Impact of Salesperson's Perceived Behaviour on Consumer's Purchase Decisions
(with Reference to Apparel Retail Shops, in Sri Lanka)**

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As a result of today's huge marketing competition, it can be stated that sales firms are challenged with more effective and efficient sale management strategy in order to win in its industry. Therefore, one of the essential goals of most managers is to enhance the performance and skills of their salespeople. Marketing without the salespersons would not lead to its goals. This study examines the impacts of salesperson's behavior on consumer's purchase decisions in apparel retail shops. The literature suggests the behavioral traits of salespersons positively affect consumer's purchase decisions. The study was undertaken among 300 consumers of apparel retail shops and questionnaires were distributed to collect primary data within randomly selected seven provinces of Sri Lanka. The multistage- cluster sampling was applied to choose the sample and the correlation multiple regression and descriptive statistics were performed to test hypotheses. Conceptual framework was adopted from Punwatkar and Verghese (2014) and study explored four behavioral traits of salespersons; ethical behavior, listening ability, emotional intelligence, and relational skills and it provided confirmatory evidence that all four behavioral traits have average positive relationship with the consumer's purchase decisions by encouraging an objective of the research. Another objective was to identify the most influencing trait towards purchasing decisions in apparel retail shops and findings had given the ample support for the claim that salesperson's listening ability is the most influencing behavioral trait on consumer's purchase decisions. Inter-questionnaire limitation was one of a major limitation in this research. This study helps to the Apparel retailers in ensuring that the salespersons to develop the required skills by consistently keeping the check on them and this helps the managers to focus on behavioral traits while recruiting and training salespersons.

Keywords: Ethical Behavior, Relational Skills, Emotional Intelligence, Listening Ability, Consumer's Purchase Decision

**Impact of Human Capital Attributes on SMEs Success
(With Reference to SMEs Owner Managers in Badulla Divisional
Secretariat)**

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The study has been focused on identifying how entrepreneur's Human Capital Attributes impact on success of their SMEs. Human capital is the collective knowledge abilities of an individual. It is emerging as one of the most impacting factor which ensures the growth and survival of SMEs. Thus, the study based on four objectives; first it identifies the level of human capital attributes possess by the SMEs owners. Secondly it explores the relationship between the two variables. Next it investigates the impact of Human Capital on SMEs success. Finally, to determine the most influential Human Capital Attribute. Two levels of Human Capital Attributes, namely General Human Capital and Specific Human Capital and the SMEs success were evaluated. The sample consisted with fifty-three SME owner managers in Badulla Divisional Secretariat. The data were gathered by self-administering questionnaires. Judgmental sampling was used as the sampling technique. The data were analyzed using descriptive statistics, correlation coefficient and regression analysis. The results concluded that moderate level of human capital attributes possessed by the owner managers and there is a strong positive relationship between Human capital and SMEs success and Human Capital Attributes found to be a major determinant of SME success. Industry specific experience is found to be the most influential Human Capital attribute. The findings of the study support to the SMEs owner managers to enhance their existing level of Human Capital and to achieve more success using their human capital.

Keywords: Human Capital, SMEs success, General Human Capital, Specific Human Capital

Effect of Macroeconomic Variables on Profitability of Commercial Banks in Sri Lanka

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Objective of the research was to examine the effect of macroeconomic variables on profitability of commercial banks in Sri Lanka. There are several studies conducted to examine the effect of macroeconomic variables on banks profitability in past. However, it has been viewed that different studies explained different conclusions on the effect of macroeconomic variables on banks profitability. Therefore, there were inconsistencies observed in findings from the previous studies and it can be justified by the nature of sample companies that are analysed in the previous studies, by the methods, research design and approaches to the study, by the background of the firms that are explored. Thus, research problem of the study was that to what extent selected macroeconomic variables effect on banks profitability which was focused on Sri Lankan listed commercial banks. Accordingly, current study was expected to give geographical contribution to the existing literature. There are thirteen domestic licensed commercial banks in Sri Lanka, but only ten licensed domestic commercial banks have been considered in this study as per the availability of the data for ten years period. Secondary data have been collected from selected bank's annual reports and Central Bank reports of Sri Lanka for the ten years period from 2006 to 2015. Interest rate, exchange rate and real output percentage of gross domestic product have been considered as macroeconomic variables. Return on equity has been considered as profitability measure. Pooled ordinary least square was used to examine the effect of selected macroeconomic variables on profitability. Results of the study revealed that interest rate and exchange rate have not significantly affected on the profitability while Gross domestic product has positively significantly influenced on profitability of listed domestic licensed commercial banks in Sri Lanka. Therefore, it can be suggested that interest rate and exchange rate will not effect on bank profitability adversely in all times. Outcome of the study has essential implication for policy makers and regulators in Sri Lankan banks, decision makers want to be attentive in setting up economic policy that will not affect profitability negatively.

Keywords: Interest rate, Exchange rate, Gross Domestic Product, Profitability

Impact of Macro- Economic Factors on Banking Sector Development in Sri Lanka

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Bank plays a vital role in the economic development. Exposure to Macro-economic factors banks is a source of systematic risk that influences the performance of the banking sector. Several macro-economic variables such as interest rates, exchange rates, inflation, GDP are examined to reveal actual factors explaining the behavior of the development. Macro-economic factors will impact on developing countries and recently developing countries affected by adverse economic and financial conditions. This adverse economic condition applied for the Sri Lankan banking sector in some situations. Sri Lankan banking sector is still in an underdeveloped condition. Therefore, it is inherent to investigate the macro- economic factors that directly or indirectly affect the development of the banks. Even though many research studies have focus on this subject area to identify the performance determinants of commercial banks there are lack of studies have conduct on developing countries like Sri Lanka, since this study focus on to identify current and the reason trends macro-economic Environment and Banking Sector Development in Sri Lanka and further Investigate the Impact of macro-economic factors on banking sector Development. Here GDP, interest rate, inflation, money supply and exchange rate used as independent variables and Return on Equity, Net Interest Margin and Capital Adequacy Ratios used as dependent variables. Data of the research Apply 132 months from 2006 to 2016 to gather secondary data through Central Bank reports. Descriptive analysis and multiple regression analysis were used to evaluate the findings. The research findings reveal, banking sector development has significant impact with macro-economic variables. Banking sector development has significantly positive relationship with GDP, and Money Supply, significantly negative relationship with interest rate, insignificant positive relationship with exchange rate and insignificantly negative relationship with inflation.

Keywords: Banking Sector Development, Macro-Economic Variables, Return on Equity, Net Interest Margin, Capital Adequacy Ratio

**Impact of Firms' Adaptation of Eco-Friendly Product Innovations on
Firm Performance
(The Case of SMEs in Kurunegala District)**

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Recently, companies identified the concept of eco-innovation as a key aspect of conducting business. According to National policy framework for Small and medium enterprises, eco-friendly innovation is a major policy initiative, which drives Small and medium enterprises. However, the literature on eco-friendly innovation is more focused on identifying factors affecting adaptation and identifying customer perspective of eco innovations. Also, little research attention has been given in identifying the impact of eco initiatives provided by government and companies themselves for the betterment of organizations. Therefore, this study examines the relationship and the impact of eco-friendly product innovations on the performance of Small and medium enterprises with recognizing the importance of managerial environmental concern. Covering the above aspects, a model was constructed by taking the adaptation of eco-friendly product innovations as the independent variable, firm performance as the dependent variable and managerial environmental concern as the moderate variable. Data were then collected across 50 Small and medium enterprises in Kurunegala district covering eight sectors using convenient sampling. To achieve the desired objectives, the analysis was carried out using Pearson correlation analysis, regression analysis, descriptive statistics and hierarchical regression analysis respectively. Results of the analysis indicated that adaptation of eco-friendly product innovations significantly and positively affects firm performance while managerial environmental concern enhances this relationship. Findings of this study enhance the literature on understanding the impact of eco-friendly product innovations on firm performance and the importance of managerial environmental concern. Also this study suggests implementation of more programmes to integrate eco innovations into SME firms while providing some future research areas.

Keywords: Eco-friendly innovations, Eco-friendly product innovations, Firm performance, managerial environmental concern, Sustainability

Is Commitment a Sign of Leave or Remain? The Role of Educational Qualification of the Relationship between Employee Commitment and Turnover Intentions

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Of late, retaining talent is one of the maladies confronted by many organisations, to wit highly talented, motivated and committed workforce stays on the organisation for a shorter period of time. Drawing on person-job fit theory, the prime objective of this study was to investigate the role educational attainment of employees on the relationship between employee commitment and turnover intentions. Pivoting on strong ontological and epistemological assumptions, this study adopted a survey strategy with a deductive approach. Data were garnered with a self-administrated questionnaire from a randomly selected 150 employees working in eight finance companies based in Jaffna district. In concord with previous studies conducted in Western countries, the data confirm a negative relationship between employee commitment and turnover intentions implying that highly committed workforce would have little intentions to leave the current job. Moreover, this research substantially found a moderating role of educational attainment of the relationship between employee commitment and turnover intentions. Specially, the negative relationship between employee commitment and turnover intentions is stronger for employees who are less qualified, however such relationship turned out to be positive for those who are highly qualified explaining that highly committed workforce with a high level of educational attainment would have the intentions to leave the current job. Therefore, segregation of the levels of commitment would not be the best indicator in deciding employees' stay in an organisation. Unequivocally, this study made theoretical contributions to the frontiers of commitment literature and proffers practical implications and guiding directions for future research studies.

Keywords: Commitment, Educational attainment, person-job fit theory, Turnover intentions

Do Committed Employees Evinced High Performers? Relationship between Commitment to Occupations and Organisations and Employee Performance

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Commitment that employees' feeling of attachment towards the organisation and the occupation has been well entrenched in the realm of organisational studies underscoring its importance of resultant behavioural outcomes such as performance, job satisfaction, turnover intention, etc. Remarkably, the majority of those studies are of Western provenance reflecting such country-specific factors including the lower the unemployment rate, benefit of the dole, labour laws, etc; nonetheless, studies were lopsided in less economically developed nations. Drawing on person-environment fit theory, this study poses a nagging question of whether both commitment to occupation and commitment to organisation are a syndrome of employee's performance under a high level of unemployment and less supportive labour laws. Therefore, the overriding purpose of this study was to investigate the relationship between both nature of commitments (occupation and organisation) and employees' performance. Hinging on strong ontological and epistemological assumptions, this study adopted a survey strategy with the deductive approach. Data were gleaned from a randomly selected 150 employees working in eight finance companies using a self-reported questionnaire. The results of the study revealed that both commitment to occupation and commitment to organisation were positively associated. Albeit the commitment to occupation was significantly positively related to employees' performance, on the contrary, the commitment to organisation was negatively impacted the employees' performance. The negative relationship would be attributed to country-specific factors such as unemployment level, low level of employment protection, labour laws, etc. This study indisputably makes theoretical contributions to the frontiers of commitment literature and underscored the usefulness of practical implications for management and practitioners.

Keywords: Commitment to occupation, Commitment to organisation, Employee Performance, Person-environment fit theory

**Impacts of Perceived Integrated Marketing Communication (IMC) Mix
on Consumer Purchase Intention of Green Products
(With Special Reference to FMCG Sector in Sri Lanka)**

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The force of “going green” is now expanding to the Asian region in the world. Green product is a most emerging concept in the today’s business environment. Further there are many green products manufacturers in the current competitive market. According to the literature on green products, consumers have problems in green products identification. Further consumers have lack of awareness regarding available green products in the market. Therefore, though there are various marketing tools to promote green products in current business environment, it’s essential to identify exact methods or marketing tools to communicate and grab the consumers who intend to consume the green products. The main objective of this study is to identify the impact of perceived IMC mix on consumer purchasing intention of green product of FMCG (Fast Moving Consumer Goods) sector in Sri Lanka. Data were collected through a questionnaire filled by 120 consumers who purchase green FMCGs from supermarket premises in western province. Convenient sampling method was adopted to derive the respondents. To achieve the desired objectives, the data analysis was carried out using descriptive analysis, correlation analysis and multiple regression analysis respectively through SPSS package. Findings depict that consumers have responded in agreed level to IMC variables. Further, the results claimed that perceived integrated marketing communication (IMC) mix including advertising, sales promotion; personal selling, direct marketing and public relations have positive relationship with consumer’s green FMCG purchasing intention. Advertising is the most influencing` factor of consumer green FMCG purchasing intention. Then consecutively direct marketing and personal selling influence to consumer’s green FMCG purchasing intention. As managerial implications, organizations should be more focused on advertising, direct marketing and personal selling methods to improve the consumer’s green products purchase intention.

Keywords: Green products, Perceived integrated marketing communication, Purchase intention, Fast moving consumer goods

The Impact of Organizational Learning Culture on Organizational Citizenship Behavior in Apparel Industry in Sri Lanka (With Special Reference to Gampaha District)

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Apparel industry as the largest industry in Sri Lankan economy, provides more benefits for employees through different learning practices. But still have to measure the extent of these practices impact on the behavior and attitudes of employees. The literature showed some contradictory ideas in the relationship between Organizational Learning Culture and Organizational Citizenship Behavior. Organizations can be succeeded through satisfying and motivating their employees. Hence, the study focused to identify the Impact of Organizational Learning Culture on Organizational Citizenship Behavior in Apparel industry in Sri Lanka by using four major research objectives. Moreover, Organizational Commitment was used as the mediator to measure the indirect relationship also. The population was all operational level employees in Apparel Companies in Gampaha District. The sample of 150 employees was selected through stratified sampling technique from 3 Export Processing Zones in Gampaha District. Data gathered from self-administered questionnaires which consist of seven point likert scale questions was analyzed by SPSS 21 software. Descriptive statistics, correlation, regression and Sobel test were used to analyze data. Organizational Learning Culture was measured by seven indicators while Organizational Citizenship Behavior was measuring by five indicators. Further, Organizational Commitment was measured by four indicators. The study found a positive relationship between two variables with the presence of the mediator. Managers can increase Organizational Citizenship Behavior when increasing Organizational Learning Culture through Organizational Commitment. The study suggests to reduce the workload, give more learning opportunities, increase incentives, conduct training programs, motivate innovations and etc.

Keywords: Organizational Learning Culture, Organizational Commitment, Organizational Citizenship Behavior

Intellectual capital on Financial Performance: Sri Lankan Market

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The current theory of the firm posits that firms maximise their value by making decisions to maximise the wealth of their stakeholders. Intellectual capital is a key input to achieving that goal, is a major strategic asset capable of garnering sustainable competitive advantage. The data used in this study comes from 150 Sri Lanka (Colombo stock exchange listed firms). The research questions are answered via a quantitative research design that uses secondary data. This study finds that intellectual capital has a significant impact on ROA whereas the insignificant impact found between the intellectual and Tobin Q can be explained by other factors (e.g., Tobin Q may not handle the high levels of intangible assets present in rising knowledge economy of Sri Lanka) which validates the assertion that Sri Lankan culture may be more individualistic. Findings also demonstrate the Sri Lankan firms more closely adhere to the ethical branch of stakeholder theory.

Keywords: Intellectual capital, Financial performance, Sri Lanka

Impact of Fashion Involvement and Hedonic Consumption on Impulse Buying Tendency of Sri Lankan Apparel Consumers: The Moderating Effect of Age and Gender

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Fashion and clothing is a foremost aspect of human life. Early studies have identified many variables as antecedents of fashion related impulse purchases and role of fashion involvement and hedonic consumption as predictors of fashion related impulse buying are less examined. Literature suggests that there can be a moderating effect of age and gender on the relationship between fashion involvement, hedonic consumption and impulse purchases of apparels. The purpose of this research is to examine the impact of fashion involvement and hedonic consumption on impulse buying tendency of Sri Lankan apparel consumers with moderating effect of age and gender. Researcher employed single cross-sectional research design for study and population was Sri Lankan apparel consumers who were above twenty years old. Sample of study was drawn from Colombo district where 324 responses were obtained using a structured questionnaire. According to multiple regression analysis, there was a positive impact of fashion involvement and hedonic consumption on impulse buying tendency of Sri Lankan apparel consumers. Hedonic consumption had a higher relative strength to predict impulse purchases of Sri Lankan apparel consumers in comparison to fashion involvement. Further, the researcher examined the moderating effect of age and gender on relationships between fashion involvement, impulse buying and hedonic consumption, impulse buying. However, it was revealed that there is no significant moderating effect from age and gender on aforesaid relationship. Based on the findings of study, it is suggested to practitioners of fashion retailing to stimulate and fulfill hedonic needs and desires of fashion consumers to persuade consumers for more fashion-oriented impulse purchases. Future studies under the same topic can be conducted with cultural influences on the impulse purchase of fashions and situational factors such as time and money availability.

Keywords: Impulse Buying, Fashion Involvement, Hedonic Consumption, Apparel Consumers, Moderating Effect

Motivational Factors that Induce Sri Lankan IT Undergraduate to Engage in E-Lancing

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E-Lancing is a self-employment arrangement emerged with the new internet developments in the 21st century. Interested Individuals are being hired by the clients who are looking for such individuals and work remotely through a networked online platform called e-Lance marketplace. Such platforms create a global pool of human and intellectual capital for internet-based problem-solving, economic production and service delivery. Information Technology (IT) sector has a high demand and benefits potential with the current global e-Lancing trends. As a developing country, Sri Lanka has a fierce potential to boost the economy while reducing the unemployment by promoting e-Lancing in the university scales, especially focusing on IT sector. Better understanding why individuals engage in e-Lancing is imperative not only to devise strategies to achieve it but also to explore new applications of the concept. This study aims to address that deficiency with the objective of finding out the motivational factors that induce IT undergraduates to engage in e-Lance activities. In order to achieve it, this study was designed using a qualitative approach. A sample of 20 IT undergraduates who are already engaged in e-Lancing was selected utilizing snowball sampling method representing both government and non-government universities. The qualitative data was collected by conducting semi-structured interviews. The interview transcripts were analyzed to identify patterns using thematic analysis techniques with the support of Qualitative Data Analysis (QDA) software. This study came up with fourteen motivational factors that include the followings; Financial incentives, Financial emancipation; Higher Returns; e-money for e-purchases; Opportunity to develop skills and Knowledge; Freedom and Flexibility; Marketplace Reputation; Experience; Trust of payment; Peer success and support; Career opportunities; Passion and Enjoyment; Recognition; and international customer relations. Results of this study add rich qualitative data to the e-Lancing literature as well as to the other social and managerial implications.

Keywords: E-Lance, Motivations, E-Lance marketplace, IT undergraduates, Online freelancing

Impact of Board Practices of Corporate Governance on Corporate Risk of the Companies Listed in Colombo Stock Exchange

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In reaction to recent financial crisis and corporate failures at the beginning of the millennium, the business community has shifted their attention towards internal control and risk management issues. Recent past, Sri Lanka has also experienced a number of corporate failures. Such failures were results of imprudent related party transactions and investments; weak risk management systems and unethical business practices. Cost of failure of a single corporate has a fatal effect over the economy as a whole than in the past. Good governance ensure that all directors and senior executives have a shared understanding of risk, which effect on uncertainty of an entity in achieving its strategic objectives and maintaining its long-term viability. Management is responsible for developing and implementing a sound system of risk management and internal control. As a result, discussion on the impact of corporate governance practices on risk has reached an unprecedented level for academics and practitioners. Therefore, the objective of this study is to investigate the impact of board practices of corporate governance on corporate risk of listed companies in Colombo Stock Exchange in Sri Lanka. Study was based on secondary data. 64 listed companies were selected during the period of 2012 to 2016. The Board structure, Board Independence and Board procedures were considered as independent variables, whereas, corporate risk as dependent variable. Corporate risk was represented the financial risk, operating risk and market risk faced by the listed companies. A regression model was used to establish the negative relationship between board practices and corporate risk. The overall results and findings statistically confirmed that the board independence was significantly and negatively impact over the corporate risk. The board structure and board procedures have no significant impact on corporate risk. Therefore, study infers that higher the representation of non-executive and independent directors of the board is contributed to reduce the corporate risk. The greater representation of non-executive directors improves the controls and strategic functions of the board through close monitoring and taking effective decisions. In this context this study recommended to strengthen the effectiveness of corporate boards and their committees by increasing the number of independent non-executive directors to reduce excessive risk-taking by the company.

Keywords: Corporate governance, Corporate risk

Factors Influence to Select a Bank for Financing by Small and Medium Scale Enterprises: Evidence from North Central Province

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Small and Medium Scale Enterprises have been recognized as a strategically important sector which contributes in generating high economic growth, employment opportunities and regional development in Sri Lanka. Meanwhile the ability of accessing financial resources has been identified as a dominant constraint and it influences on survival of Small and Medium Scale Enterprises. Therefore, main objective of current study is to develop a model to analyze factors influence to select a bank for financing and investigate whether identified factors significantly influence on selecting decision in Sri Lankan context. Through a sound literature review; Quality of the service, Availability of credit, Bank attributes, Staff attributes and Rules and regulations have been considered as independent variables while a decision to select a bank treated as dependent variable. Self-administrated questionnaire based on five point Likert scale was used and it was able to collect data from 65 owners of SMEs in North Central Province according to the purposive sampling method. Multiple Regression Analysis was applied as main statistical tool to test hypothesis of the study. R-Square value was 51.4% which implies a good level of explanatory power of independent variables on dependent variable. The findings reveals that availability of credit, bank attributes and rules and regulations are significantly influence while staff attributes and quality of the service are not significant determinants on selecting a bank. Therefore it can be concluded that the determinants of availability of credit, bank attributes and rules and regulations should be highly considered to improve accessibility to financial resources for Small and Medium Scale Enterprises.

Keywords: Financial sources, Small and Medium Scale Enterprises

Factors Influencing Telecommuters' Satisfaction: A Study of Telecommuting Practitioners in IT Industry, Sri Lanka

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Current workers in many industries are inclined to work from home. Rapid increment of usage of telecommuting by information and knowledge workers has been adopted by the availability of enabling new dimensions of technologies. Handheld computers, user friendly software, high speed information & communication media make work from home concept possible. This study quests to understand the satisfaction of telecommuting practitioners towards their job. Eighty-four professionals who are working in an IT organization located in Colombo are selected for this study using simple random sampling method. A Likert scale questionnaire was designed as the survey instrument to collect data on the satisfaction of Telecommuting Practitioners. Telecommuting perception is deeply examined by work related attitude, perceived net benefits, organizational support and cognitive absorption on the level of satisfaction towards their job. A schematic diagram and four testable hypotheses were developed based on this situation. Data were analysed using a linear regression analysis. The Multicollinearity was examined by the construction of pairwise correlation matrix, Variance Inflation Factor and tolerance statistics. It found that regression outcome is free from the multicollinearity. The regression result reveals that perceived net benefits significantly influence Telecommuters' satisfaction towards their job. Organization has to understand what are the benefits that each employee can gain from telecommuting. According to the finding, telecommuting as alternate working method may bring number of benefits for individuals, organization and the society. It also proved that pure benefits that can be gained from telecommuting gives contribution to the satisfaction of telecommuting practitioners.

Keywords: Telecommuting Practitioners, IT Industry

Impact of Micro Finance on Performance of Women Entrepreneurs in Sri Lanka: Evidence from Batticaloa District

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Micro finance is considered as major instrument used to protect people from poverty throughout the world. Micro finance institutions in each country are supporting much to women entrepreneurs for achieving their goal by assisting them with providing micro credits, training, saving facilities. The major purpose of this study is to examine the impact of micro finance on performance of women entrepreneurs in Sri Lanka. Credit, savings and training were considered as predictor variables and criterion variable was performance of women entrepreneurs. Standard questionnaire with five point likert scales was used to collect the data from 100 women entrepreneurs functioning in Batticaloa district using stratified sampling method. Descriptive and inferential statistics have been carried out with the use of SPSS package to analyze the data. Cronbach's Alpha was used to ensure the reliability of collected data. It exposed that all the data collected are reliable, since cronbach's Alpha for entire variable was more than 0.6. Coefficient of determination of model revealed that 60% of total variance in performance of women entrepreneur is explained by micro credit, savings and training. The result of this study revealed that training and saving have positive and significant impact on performance of women entrepreneur while micro credit has no significant impact on performance. According to the finding of this study, researcher can conclude that women entrepreneurs can be motivated further by increasing number of training programmes per year since most of women entrepreneurs dropped out of school education and savings to improve performance of their entrepreneur activities. Micro finance institutions can increase loan amount and reduce interest rate to make higher impact on performance of women entrepreneurs. Further result of this study can help to motivate more women in rural areas to engage in entrepreneurial actives for reducing poverty.

Keywords: Microfinance, Microcredit, Savings, Training

It's a Tough Nut to Crack: Consequences of Mutual Interference of Work and Family

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A plethora of studies on work family conflict have been conducted in developed nations with an individualist cultural milieu, nonetheless scant attention paid to the systematic studies in developing nations representing the collectivist culture. Most recently, the insidious effect of work family conflict flagged up the many research scholars to look at the consequences and the whys and the wherefores of work family conflict in developing countries. Consequently, drawing on a synthesis of role theory and work family border theory, this study was designed to paint a vivid picture of work family conflict and resultant consequences that employees confront. In adherence to robust ontological and epistemological assumption, this study adopted an objectivist-deductive approach with a cross-sectional time horizon. Using a convenience sampling technique, data were garnered with a self-reported questionnaire from 569 employees working in a banking sector in Sri Lanka. The study found that work to family conflict has a significant negative impact on job satisfaction and the role performance and a positive relationship with emotional exhaustion and, however, data were not in support of any significant relationship with life satisfaction and turnover intentions. In a similar vein, family to work conflict was negatively impacted life satisfaction and the role performance, nonetheless a positive relationship was found with turnover intentions and the data were not related to job satisfaction and emotional exhaustion. The practical implications of work family conflict and its consequent impact on employees and the organisation were discussed. Needless to say, this study unequivocally made a contribution to the frontier of the work family literature and becomes a mother lode for the future research studies.

Keywords: Family to work conflict, Role theory, Work family border theory, Work to family conflict.

Exploring Critical Project Management Resources in NGOs: An Empirical Study in Sri Lankan NGOs.

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The aim of this paper is to explore the critical PM resources in Sri Lankan NGOs. The number of NGOs has increased rapidly in the last four decades, in part due to increasing economic, social and environmental turbulence. These NGOs face pressures to improve performance from a number of areas including other NGOs, government and private sector led initiatives. As a result, NGOs have grown in both scale and sophistication as they seek to meet complex societal challenges along with increased demands for accountability and improved performance from stakeholders. Existing NGO tools are based on capacity development approaches which, to date, have limited success in improving NGO PM project delivery. This paper seeks to identify the underlying PM resources support successful project delivery by NGOs. The research setting, Sri Lanka, is an appropriate environment to examine NGO activities because of a long history of voluntary service and the recent increase in the number of NGOs due to war and disaster. Data collection was done using a quantitative survey study which obtained 447 survey responses from NGOs. Exploratory Factor Analysis (Principal Axis Factoring) and Confirmatory Factor Analysis were performed to identify and confirm the critical PM resources of NGOs. The study confirmed that PM resources can be evaluated in three levels: Team, Organisational and Collaborative Social. Firstly, four team PM resources identified, namely: Brainstorming sessions, Success and failure stories, Team cohesion and trust and Team PM values. Secondly, four Organisational PM resources explored, namely: Effective PM office, PM methodology, standards and process, PM tools and techniques, Project communication system and technology and finally, four Collaborative social PM resources: Project advisory from donors, NGOs intra and consortium meetings, Networking with stakeholders and Project marketing are discovered. These findings can support the development of new development approaches that can help NGOs deliver projects successfully.

Keywords: Critical PM Resources, NGOs

Consumers Behavior and Its Impacts on Green Banking Practices in Banking in Sri Lanka

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Banking system is absolutely essential in this modern world. When considering the economy of a country, an important role is played by the banking system for the growth of economy in a developing country and forms the core of the money market in an advanced country. The banking sector all over the world is going through vast changes owing to the decrease of rules and controls, technological innovations, globalization, increasing competitions, etc. at this present world. But the banking sector of Sri Lanka is very slow to adopt the changes taking place recently and tries to adjust their activities to be shown as world class bank. The purpose of this study is to understand the impacts of consumers' behavior on the adoption of Green Banking practices in banking industry in Sri Lanka. The research objective of this study is to understand the impacts of consumers' behavior on the adoption of Green Banking practices in banking industry in Sri Lanka. In order to achieve this objective, the data were collected from 300 officers and clerical staff of commercial banks, by establishing variables to measure the consumers' behavior and its impacts on adoption of Green Banking practices. Convenient sampling method is used for this study by issuing the questionnaires. The research framework of study consists of a variable – consumers' behaviors which were used to measure the level of the consumers' behaviors influencing the intention to adoption of Green Banking practices in Commercial Banks in Sri Lanka. This study was quantitative in nature. Univariate, correlation and hypothesis methods are used to analyze the results of the data and Findings of the research shows that the consumers' behaviors and its impacts at moderate level in adopt of Green Banking practices. The results of the hypothesis testing shown there is positive relationship between consumers' behaviors and intention to adoption of green banking practices in commercial banks in Sri Lanka. Initially, this study provides empirical support to findings and observations relating to the factors that has indeed accelerated the adoption of Green Banking. This research will help managers to figure out the relevant factors that are required to adopt Green Banking.

Keywords: Consumer Behaviors, Green Banking, Intention to Adoption

**A Study of Key Factors Affecting to Consumer Buying Behavior on
Bottled Drinking Water
(Special Reference to North Central Province in Sri Lanka)**

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Drinking water is the basic need of the human life. So consumer should select most suitable source of the water to drink for the betterment of their life. As this industry growing and competition is intensifying, the companies have to know the factors that influence consumers in buying bottled drinking Water. In some of the areas of North central province is poor in quality due to the presence of high levels of Fluoride. Therefore, rural people in these areas face many problems due to lack of safe and clean water, especially for drinking purposes. There is very limited research regarding bottled drinking water in North central province. The aim of this study was to find out the relationship between key factors and consumer buying behavior through that identify the most significant factors which affecting to consumer buying behavior on bottled drinking water in North central province. Data were gathered from 100 householders in Padaviya, Medawacchiya and Medirigiriya town areas. A multi-stage cluster sampling method was used. Data were analyzed using descriptive statistics, correlation analysis and multiple regression analysis to test the proposed hypotheses. The findings suggest that beliefs and attitude, health appearance, lifestyle, income and perception are positively related to Consumer buying behavior on bottled drinking water. Therefore the result is a positive and significant relationship between key factors and buying behavior on bottled drinking water. The findings suggest that beliefs and attitude, health appearance, lifestyle, income and perception are positively related to consumer buying behavior on bottled drinking water. Further findings reveal that health appearance is most significant factor towards consumer buying behavior on bottled drinking water. Thus, this research result can be used by entrepreneurs who are currently in bottled drinking water business and also for those who want to open the business in this industry.

Keywords: Key Factors, Consumer Buying Behavior, Bottled Drinking Water, North Central Province

Identify the Customers' Purchase Intention towards the Sponsored Products (Special Reference to Reality Shows)

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Reality shows are the current trend of many Medias, because of the higher popularity of the reality shows many sponsors are sponsoring to those programs. Main purpose of the sponsorships is increase the market share through reality marketing. Even though sponsors are expected to increase market share and profit through sponsorship, sponsors are not aware about the actual impact of reality sponsorship. The main objective of this research study is explore the relationship between reality sponsorships and customers' purchase intention towards the sponsored products. Addition to the main objectives, researcher explores the level of these three variables, attitudes, subjective norms and perceive behavioral control. The conceptual model researcher tested by utilizing questionnaire and collected data from three hundred sample of reality spectators; sample consists with two categories as live spectators and TV spectators. Researcher tested collected data by utilizing SPSS software; main analysis methods are correlation analysis and regression analysis methods. Correlation reveals that subjective norms and perceive behavioral control determine the purchase intention while attitudes not influence on purchase intention. According to the results researcher has identified that there is a positive relationship between the sponsorships and purchase intention. Finally as the results organizations should aware on the customers' expectations when sponsoring to the program. In addition, sponsors should more stress on subjective norms and perceive behavioral control rather than attitudes. Moreover, researcher has identified there are many factors which affect purchase intention rather than subjective norms and perceive behavioral control. Managers should focus on these results when they are designing marketing strategies for reality shows.

Keywords: Subjective norms, Perceive behavioral control, Purchase intention

Impact of Workplace Diversity on the Employees' Performance in Private Banks

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As a multi ethnic country, it is obvious that Sri Lankan organizations have diverse mix of employees with various personalities for their business activities. Nowadays, Competition for acquisition of best talents with multiple skills has become a common practise in private banks of Sri Lanka. Diversity can be described as differences in culture, gender, age, religion, language and etc. Effective management of this diverse workforce is essential responsibility of every organization. Because, workplace bias to treat the diverse employees will damage the quality of employees' performance. Diversity among employees can enhance organizations' market share and customer base whereas lack of diversity work force leads to poor attraction of workplace. On this regard, main objective of this study was to investigate the impact of workforce diversity's dimensions on employees' performance of Private Banks in Batticaloa. Hypothesis was developed to measure the relationship between independent variable, workplace diversity and its dimensions, Gender, Age, Ethnicity and Education with dependent variable, Employees' Performance. Structured questionnaires were distributed among a sample of 150 employees which was selected by convenient sampling technique. However, response rate was 81.33%. SPSS 22.0 was used for the Univariate analysis and Multi-variate data analysis. The result revealed that, there is a positive relationship between workplace diversity and employees' performance. However, among those four dimensions, 63% of variance in employees' performance can be explained using age, gender and ethnicity. Therefore, researcher concluded that, workplace diversity in terms of Age, Gender and Ethnicity are the predictors of the performance of employees and effective management of the diversity can create positive environment which facilitates employees to do their work better.

Keywords: Workplace diversity, Employees' Performance, Gender, Ethnicity, Education

Impact of Social Network Advertising towards Consumer Purchase Intention (Special Reference to Apparel Products Advertising in Facebook)

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Majority of businesses are using social network advertising as a marketing tool and it has helped big companies and small companies to reach out to their potential customers in their purchasing decisions by connecting through social network sites. Social network mania apparently attracts people looking for business opportunities. According to statistics, it reveals that two thirds of the world's internet population visits social networking sites. The central objectives of this the study is to find out most influential dimension (informativeness, entertainment, irritation, credibility) which influence towards the consumer purchase intention. Further the study examines the level of involvement of customers in social network advertising, and to find the impact of social network advertising towards the consumer purchase intention. Facebook Apparel product users were represented the population of this research and data collected from 200 sample from online and offline respondents. Significance of this research study is that, social network advertising is open for wide audience, therefore marketers can easily promote the products via social media. In this study researcher has measured mainly reliability, descriptive statistics, correlation, regression of the relevant variables. The research findings reveal that, social network dimensions such as informativeness Entertainment and the credibility showing strong positive relationships with the consumer purchase intention. As well as Irritation showing strong negative relationship with consumer purchase intention. Furthermore, multiple regression analysis has been proved that credibility entertainment and informativeness were the major predictors of the consumer purchase intention. Therefore, according to the regression analysis most influencing factor was credibility. The study recommends that customers are most like to give their attention on a product when it is entertaining, informative and trustworthy sources.

Keywords: Social network advertising, Informativeness, Irritation, Credibility, Consumer Purchase intention

Impact of Television Advertisements on Consumer Purchase Intention of Dairy Milk Powder (With Special Reference to Colombo District)

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Television advertisement has become one of the major factors which increase the consumer purchase intention of the particular Product. Further, it affects in acquiring life time consumers to the particular organization. In present context majority of consumers consider get attention, processing information, information evaluation, and attitude formation in evaluating product attributes before purchase the dairy milk powder. The purpose of this study was to identify the level of involvement of consumers for TV advertisements, to identify the relationship between television advertisements and consumer purchase intention of dairy milk powder and to find out the most influencing television advertisements factor on consumer purchase intention of dairy milk powder. Sample of 100 families select based on convenience sampling method. Questionnaire method was used to collect data. Statistical tool SPSS used to analyze the gathered data. This study revealed that get attention, information evaluation, attitude formation have a strong positive relationship with consumer purchase intention. Further, there is a weak positive correlation between processing information and consumer purchase intention. Finally, get attention, and information evaluation moderately considered by consumers when select milk powder packets. Processing information and attitude formation are having less consideration when purchasing milk powder packets. Hence this study recommends the dairy milk powder manufacturers to implement strategies through television to improve the customer purchase intention 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: Consumer purchase intention, Dairy milk powder, Television advertisement

A Study on the Factors Influence to Advertisement Avoidance in Social Media (with Special Reference to Female Professionals in Colombo District)

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The new era of marketing activities require blending of conventional and modern methods. The service companies in Sri Lanka have adopted various E-marketing techniques like pop-up and banner advertisements with large-traffic websites. Among them some people just close those ads and banners without even looking at them, some seek this as a huge irritation. Therefore companies should consider whether those advertising techniques are effective or not. Conceptual framework adopted from Cho & Cheon (2004) avoidance model and study explores the factors of advertising avoidance; perceived goal impediment, perceived advertisement clutter and prior negative experience in social media in Sri Lanka. The objective is to identify the most influencing factor towards advertising avoidance in social media. Both primary and secondary data has been collected and sample consists with 160 female social media users in Colombo district and adopted correlation coefficient and multiple linear regression for analyze the data. Findings revealed the strong positive relationship between factors of advertising avoidance and advertising avoidance. Prior negative experience has been identified as the most significant factor towards the Advertising avoidance. Since Sri Lankan organizations spends around billion rupees a year, it is important to consider effectiveness of the advertising in social media. Effective targeting based on customer profile should be done and awareness on advertising avoidance is crucial excessively.

Keywords: Advertisement Avoidance, Social Media, Perceived Goal Impediment, Perceived Advertisement Clutter, Prior Negative Experience

Factors effecting job Satisfaction of the Private Bank Workforce in Gampaha District, Sri Lanka

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Job satisfaction is a subjective pointer that betokens how contented an individual feel while performing his/her responsibilities. Target and achievement depend on employee satisfaction and in turn contribute to organizational prosperity and growth, enhances the productivity, and increases the quality of work. The Sri Lankan banking and financial services industry is stable, vibrant and market driven one. The Broad Objective of this research is to quantify the job satisfaction and the association between various factors effecting job-satisfaction in private-bank sectors in Gampaha district. The sample of the present research was employees of three private banks situated in Gampaha District. A total of 45 subjects were selected randomly from these banks. Based on the mean score and standard deviation, 64.44% employees are satisfied while 35.56% employees are dissatisfied with their job. Findings denote that Major Factors that are affecting employee dissatisfaction are the occupational motivation, job security, responsibilities, conflict resolution, organizational environment, and salary. The foremost factor affecting lower satisfaction was job Security. Employees are satisfied from all other factors. In terms of the correlation between different factors and overall job satisfaction, all factors show a positive correlation. It implicatively insinuates that job contentment has positive linear dependence with the other variable. Least correlation is identified with career opportunities, followed by the occupation itself, and sodality of the job with individual aspiration and ambition. The highest degree of correlation is found with nature of supervision, innovation & technology and overall remuneration. In conclusion, job security is one of the most paramount ingredients of job satisfaction. Secure job environment enhances the degree of job satisfaction. Management must engender an environment of job security among the workforce.

Keywords: Banks, Employees, Job Satisfaction, Workforce

Likeable Attributes Of Beauty Product TV Advertisements Impact on Female Consumer Purchase Intention (With Special Reference to Kandy Area)

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Likeable attributes are one of the most impacting factors in the TV advertisements. Because it encouraging customers to watch and remember particular advertisements. Also it impact on consumers' purchase intention. In beauty product TV advertisements there mostly can see this kind of attributes. It also enhances the ability to increase brand salience. For this to occur, respondents have to correctly associate the right brand with the particular beauty product TV advertisements. Yet there are reasons to assume that making an advertisement likeable might make it more difficult to effectively brand. The modeling was conducted on data from an advertising tracking monitor in beauty product TV advertisements. Data was collected on approximately 10 individual television ads (mainly considered 04 brands which are common in TV advertisements) from over 150 female respondents in Kandy area. Statistical tool SPSS used to analyze the gathered data. A very clear association, at the aggregate level, between likeable attributes and female consumer purchase intention is demonstrated showing that ads that are more likeable tend to have higher rates of correct purchase decisions. This paper revealed that some of likeable attributes in beauty product TV advertisements (general tactics, and strategy) have strong relationship with female consumer purchase intention. Further there is an average correlation with media specific tactics of the beauty product TV advertisements.

Keywords: Likeable attributes, Purchase intention, Beauty products, TV advertisements

Impact of Employees' Engagement in Sport Activities on Job Performance in Sri Lankan Business Organizations

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With the high competition in the current business world, organizations have extra focused on personnel performance by considering sports. In most of the organizations due to the lack of knowledge about the importance of sports most of the employees are not engaging in sports. In foreign countries, they have understood its importance in relation to employee performance. But in the Sri Lankan context, there were lack of researches relates to impact of employee's Engagement in Sports activities on Job Performance in Sri Lankan Business Organizations with the mediating role of Vigor. Thus, the study mainly attaches with four objectives. First, recognize the existing level of sports engagement, vigorous and job performance of the employees. Second, determine relationships among sports engagement, vigorous and job performance. Third, identify, engage in sports activities impact employees' job performance and finally identify the mediating role of vigorous on the relationship between engagement in sport activities and employee performance. Questionnaires were distributed by using a convenience sampling method to collect primary data from 140 employees in business organizations who are champions and runners up team members of Sri Lanka mercantile playing team games. The data were analyzed using correlation coefficient, Regression analysis, Baron and Kenny mediator analysis method and Sobel test with the support of SPSS 21.0. The findings of the study indicated that employees' engagement in sport activities is positively impact on job performance. Further, it found that Vigorous is significantly and partially mediates the relationship between engagement in sport activities and job performance. The findings of the research support to the businesses to make decisions regarding the improvement of employee's engagement in sport activities as the door to the enhancement of performance and to encourage employees towards sports.

Keywords: Engage in Sport Activities, Employee Performance, Vigorous, Business Organization, Physical fitness

Intellectual Capital Disclosure: A Study of Australia and Sri Lanka

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This study considers whether national development level influences a firm's voluntary intellectual capital disclosure (ICD) provided by a sample of 100 Australian and 100 Sri Lankan firms in terms of a two-years during 2015-16. This two-nation study uses a content analysis and literature-review analysis to provide an understanding of the underlying forces and issues. It was found that Australian firms tend to rely heavily on external structure disclosures (with particular attention to brands, customer loyalty, and research collaborations), but Sri Lankan relatively larger firms prefer intellectual property disclosures and the smaller firms tend to be as adept at external structure as their Australian counterparts. It was also found that the nature of a firm tends to trump the nurture of the development level of the country in which the firm is embedded. While a wider diffusion of better ICD methodology under International Financial Reporting Standard (IFRS) could improve the cost-effectiveness of financial reporting and generally increase efficiency, this is unlikely to occur until competition is more of a spur.

Keywords: Intellectual capital, Australia, Sri Lanka

**The Influence of Visual Merchandising on Consumer Buying Behaviour
(With Special Reference to Stationery Sector in Colombo District)**

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Stationery Industry is a very heterogeneous group of business, usually associated with the education institutes, offices and plays a very crucial role in working of any organization across the globe (Himanshu Talwar, 2009). Sri Lankan stationery industry has today reached international standards keeping up with the latest trends as well Sri Lankan stationery manufacturers have proactively expanded their range of products.(Sri Lanka Export Development Board). According to the prevailing literatures, Visual Merchandising plays a vital role in retailing. Therefore, every marketer must pay attention to this aspect and retailers today are using the merchandising tool to differentiate themselves from other competitors and to be prominent in the market. The objective of this study was to identify the influence of Visual Merchandising on Consumer Buying Behaviour in Stationery Sector. This study was based on both primary and secondary data. Primary data was collected through the structured questionnaire which was designed to obtain consumer's attitudes regarding major variables of Visual Merchandising on their buying behaviour. Visual Merchandising was grouped into five variables namely Lighting, Design Layouts, Product Display, Cleanliness and Music. The study was considered a sample of 5 stationery outlets from under the SPC, STC and private sector within the Colombo district. Hypotheses were tested by the multiple regression and ANOVA analysis by employing SPSS software. Out of all five hypotheses, four were accepted and the results indicated that there is a strong positive relationship between Visual Merchandising and Consumer Buying Behaviour.

Keywords: Visual Merchandising, Consumer Buying Behaviour, Stationery Industry

Consumers' Moral Response to the Company Response in a Product Harm Crisis: A Role of Gender

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Product harm crises, defined as well-publicized incidences wherein products are found to be defective or dangerous. "Moral response" is a relatively new concept in the marketing literature. As product harm crises are grounded by consumer ethical beliefs, it is perfectly rational to consider consumers' moral thoughts in a product harm crisis ground. Irrespective of the different response strategies adapted by companies to manage product harm crises, product harm crises are increasing at an accelerating rate throughout the world recently. The mounting frequency of product harm crises resulting prolong devastating effect on company's reputation demands an innovative lens to search the effect of crisis response strategies on consumer perception. Therefore, main objective of the current research is to explore how gender shapes consumers' moral perceptions in response to crisis response in a product harm crisis. A self-administrated, pre-tested questionnaire survey was conducted related to fictitious product harm crisis situation. Yogurt was taken as the main stimulus brand. Two main crisis response strategies were considered as Voluntary response and Super effort response. After documenting the product harm crisis scenario related to the yogurt brand, first it described the Voluntary response strategies and questions related to consumer moral reputation towards the crisis company. Then it described Super effort response strategy and same questions related to consumer moral reputation towards the crisis company. The survey instrument included three (3) item constructed measures of consumer moral reputation towards the company, measured with 7- point Likert scales ranging from 1= "strongly disagree" to 7= "strongly agree." Gender was measured as 1=male and 2=female. A sample (n=101) of Sri Lankan young consumers participated the survey. MANOVA (2 gender X 2 response) results revealed a significant effect of gender on consumers' moral reputation toward the troubled company in response to two main crisis response strategies; Voluntary and Super effort. Voluntary response strategy seems fruitful related to male consumers whereas super effort strategy benefits to use with respect to female. Therefore, study shows the importance of using gender specific crisis response strategies in midst of product harm crises. In fact, companies produce gender specific products and study reveals that the effectiveness of response strategies depends on gender. Therefore, study recommends using appropriate response strategies with respect to gender-specific product harm crises. These findings provide useful guidance for crisis managers, marketers, practitioners and for further academic inquiries.

Keywords: Crisis response strategies, Gender, Voluntary, Super effort, Moral reputation, Product Harm Crisis, Sri Lanka

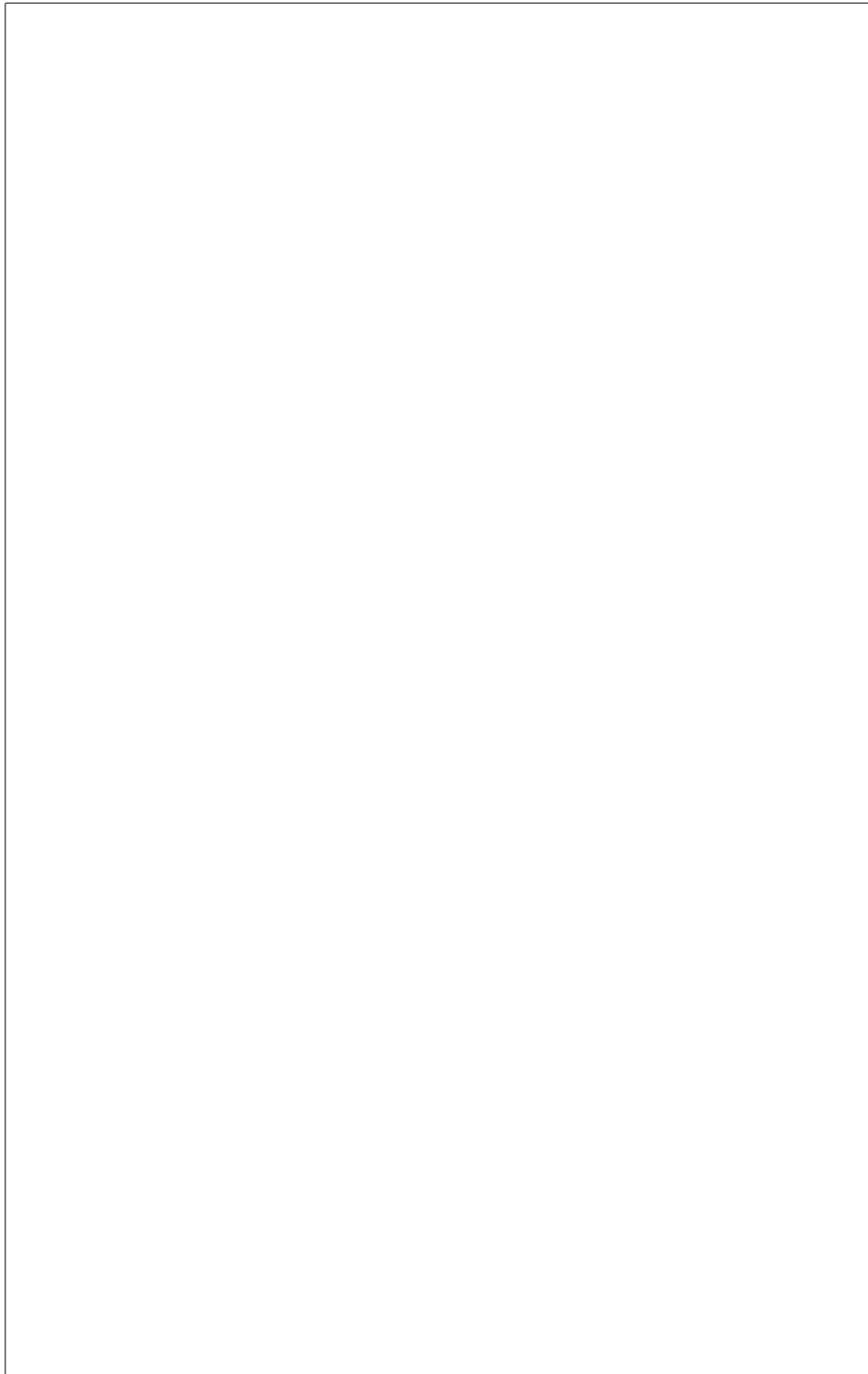
Influence of Tea Packing Design towards Consumer Buying Behavior

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The tea sector has potential to contribute considerably to economic development of Sri Lanka. The production and manufacturing of black tea is of higher importance in this regard. Moreover, in a competitive market arena, the way the product is presented to the customer is also noteworthy. For instance, black tea inner cartons are offered to consumer in many forms and it should be presented in attractive forms to catch the consumer favor to the product. The study was done for find the effect of selected packaging attributes (Color, Size, Material, Image) on the consumer buying behavior and find the relationship between social economic factors of the consumer and the tea inner carton buying behavior. 300 consumers who purchase tea with inner cartons in the Colombo district were taken for the study. Appropriate supermarkets were selected using Judgmental sampling technique while consumers were taken using convenient sampling technique. Primary data were collected by administrated structured questionnaire among the respondents in the sample. Conjoint analysis was performed to rank the importance of the packaging attributes and to find the best combination of attribute levels. Accordingly, the consumers prefer image and color of the packaging to size and material of the packaging while the most preferred combination of packaging attribute was dark color, large size package with traditional image and artificial material. Most of the consumers prefer green, blue, yellow, black and red color inner cartons respectively. Research study recommends that manufactures should focus on the image of the package more than other attributes while giving more emphasis in producing inner cartons having dark color, large size package with traditional image and artificial material.

Keywords: Packaging, Black Tea Inner Cartons, Consumer Buying Behavior, Conjoint Analysis



Environmental Studies

- Environmental Science, Laws and Regulations
- Forestry and Biodiversity
- Geochemistry and Water Chemistry
- Green Technology and Cleaner Production
- Water/Wastewater Treatment and Solid Waste Management

Assessing the Suitability of Groundwater for Drinking Purpose in Paddanichupuliyankulam, Veppankulam and Nelukkulam in Vavuniya Divisional Secretariat Division

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The groundwater is the primary source for drinking purposes in Vavuniya, which is located in northern part of Sri Lanka. Agricultural over application of Nitrogen fertilizers and rapid urbanization are the main causes for the contamination of drinking water supplies. 50 borehole wells located in Veppankulam, Nelukkulam and Paddanichupuliyankulam in Vavuniya Divisional Secretariat Division were assessed for selected physio-chemical parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness, Calcium, Magnesium, Nitrate (as NO₃⁻) and Phosphate. The objective of this study was to assess the suitability of groundwater for drinking purpose based on the Sri Lanka Standards for potable water of SLS 614: 2013. In this study pH, EC and TDS were measured on the field, the Ultraviolet Spectrophotometric Screening Method was used for the detection of Nitrate and Phosphate concentrations, and Calcium and Magnesium were analyzed using Atomic Absorption Spectrophotometer. Nitrate, EC, TDS, Total Hardness, Calcium and Magnesium exceeded the maximum permissible levels in 70%, 96%, 42%, 80%, 53% and 100% of wells, respectively and the values varied in the ranges of 2.1 – 222 mg L⁻¹, 462 – 8240 µS cm⁻¹, 323 - 7480 mg L⁻¹, 172 - 1408 mg L⁻¹, 56 - 419 mg L⁻¹, and 114 - 989 mg L⁻¹, respectively. Phosphate concentrations were below the maximum permissible level in all the wells and varied from 0.01 to 0.68 mg L⁻¹. The pH was within the standard range in all the wells and varied from 6.97 to 8.35.

Keywords: Water quality analysis, Groundwater, Potable water, Total hardness

Effects of Rainfall on Plant Survival in Restored and Unrestored Pine Stands in Lower Hanthana, Sri Lanka

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Restoration is crucial to assist the recovery of degraded, damaged or destroyed ecosystems to promote biodiversity and ecosystem services. This study was conducted to identify the relationship between rainfall and plant establishment in an unrestored (UP) and a restored (RP) *Pinus caribaea* Morelet plantation, in lower Hantana, Sri Lanka. In RP, partial thinning of pines followed by enrichment planting of four broad-leaved tree species and total thinning of pines have been initiated. In both sites fifteen plots (5 m x 5 m) and within each of them three subplots (1 m x 1 m) were demarcated randomly. The number of leaves in plants, height, and diameter at breast height (DBH) in two sites were obtained (seedlings in sub plots and saplings and trees in plots). Effects of rainfall on the species density and survival of plant species in the two sites were investigated. Data were categorized as seedling (< 50 cm), saplings group I (50 - 129 cm in height), saplings group II (129 - 300 in height) and trees (> 300 cm in height). The rainfall data for the study period was obtained from the Meteorology Department, Sri Lanka. Data were analyzed using non-parametric statistical techniques using the SPSS statistical software. When comparing the establishment of woody plant species in the two sites, more species were recorded in the restored site for all categories except for saplings group II. However many plants died within the 6 months of the study period, due to various factors including herbivory damage and over dominance of *Alstonia macrophylla*. The mortality decreased with the increased rainfall in restored site than the unrestored site. According to Spearman's correlations coefficient of seedlings, the restored site has more powerful negative relationship between rainfall and mortality while mortality comparison with rainfall data shows that when rainfall is high, mortality of trees is tending to be low.

Keywords: Mortality, Rainfall, Restored, Unrestored, Woody Plant Species

Development of Electrochemical Method to Remove Nitrogenous Compounds from Prawn Industry Wastewater

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The prawn-farm industry is one of the fastest growing export-oriented industries in Sri Lanka. Wastewater originating from prawn-farms contains an excessive amount of nutrients that becomes a serious environmental issue. Currently, there is no proper wastewater treatment method to remove nitrogenous compounds in Sri Lanka. Thus, the study aimed to develop an electrochemical method to remove nitrogenous compounds from simulated prawn-farm wastewater. Further, this method investigated the effect of control factors such as pH, retention time, current, and surface area of the electrodes using Taguchi method which identifies proper control factors to obtain the optimum results in the removal of nitrogenous compounds by using carbon and aluminum electrodes with KCl salt bridge. Results indicate that with carbon electrodes the maximum (50%) removal efficiency was obtained in 16 hours constant retention time and changing pH, DC, and surface area, respectively, about 4, 350 mA at 22.4 V, and 10 cm². Our results are comparable to the results obtained with Taguchi method where the optimum level was obtained under following conditions where pH = 4, DC = 450 mA at 22.4 V, retention time = 16 hours, and surface area = 40 cm². In aluminum electrodes the maximum (54%) removal efficiency was obtained by changing retention time, pH, DC, and surface area with controlling parameters of 4 hours, 2, 450 mA at 22.4 V, and 10 cm², respectively. Results are comparable to results obtained with Taguchi method where optimum level have obtained under following conditions where pH = 2, DC = 250 mA at 6.8 V, retention time = 4 hours, and surface area = 40 cm². Therefore, the results concluded that aluminum electrodes are better than carbon electrodes to remove nitrogenous compounds even though carbon electrodes can be used due to its low cost, simplicity, and easily renewable surface. The electrochemical method could be a potential method to remove nitrogenous compounds due to its high efficiency, low cost and ease in handling.

Keywords: Electrochemical method, Nitrogenous compounds, Prawn industry's wastewater, Taguchi method.

Ecosystem Carbon Sequestration of Different Land-uses of the Lowland Wet Zone: A Case Study from Waga Area, Kalutara District, Sri Lanka

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This study examines plant above-ground carbon and soil carbon stocks of different land-use types with the same climate and geology in Waga area i.e., natural forests (NF), home gardens (HG), coconut plantations (CP), pine and Araucaria mixed plantation forest (PAP), rubber plantation (RP), rambutan plantation (RAP), pineapple plantation (PP) and tea plantation (TP). Five representative sampling sites viz., 20 m × 20 m were selected in each land-use for floristic survey and to make composite soil core sampling (20 samples mixed together) up to a 30 cm depth. Plant parameters, such as DBH, height and physicochemical properties of soil samples were evaluated. The normalized difference vegetation index (NDVI) was calculated using 2017 Landsat 8 image at 30 m spatial resolution, which was acquired during leaf-on season (i.e. mid January to mid March), to recognize the vegetation health. The study revealed ecosystem carbon and soil C densities in the order NF (625 and 52 t C ha⁻¹), PAP (290 and 38 t C ha⁻¹), HG (199 and 21 t C ha⁻¹), RP (188 and 17 t C ha⁻¹), CP (167 and 25 t C ha⁻¹), RAP (167 and 28 t C ha⁻¹), PP (40 and 38 t C ha⁻¹) and TP (15 and 15 t C ha⁻¹), respectively. NDVI values of the land-uses were RP (0.623), HG (0.618), NF (0.615), CP (0.611), PP (0.592), TP (0.576), RAP (0.562), and PAP (0.556). The highest soil moisture accumulation was reported in NF (17.7%) and RP (16.38%). Soil pH values were mainly acidic (< 5) for all land-uses. High total soil N concentrations were observed in both NF (0.18%) and PAP (0.14%). Higher amounts of soil nitrate were recorded in RAP (15.55 µg g⁻¹ soil), NF (11.45 µg g⁻¹ soil) and PP (9.32 µg g⁻¹ soil). Soil total P concentrations were relatively low in NF (0.041%), PAP (0.042%) and RP (0.045%), and it is an obvious fact for tropical land-uses with perennial vegetation. This study revealed that the land-use types, such as NF, PAP, HG and RP were good carbon reserves in tropical lowland wet zone of Sri Lanka. Further investigations on micro carbon cycles of each land-use are recommended for better understanding of ecosystem carbon footprint.

Keywords: Ecosystem carbon, Land-use types, Low land wet zone, Waga

Investigation of the Effectiveness of Salt Barrage in Jaffna Peninsula (5th Phase)

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To improve the quality and quantity of water resources in Jaffna peninsula, a barrage has been constructed converting the Upparu lagoon into a fresh water lake. Upparu lagoon with its increased fresh water volume is expected to recharge the underground storage and act as an additional surface storage desalinating the lands fringing the lagoon making them suitable for cultivation. Several previous studies have investigated the effectiveness of the barrage focusing on the water quality of different parts of the land bordering the lagoon. This research focuses on the area from the fringe of the lagoon into the land extending for 2 km perpendicular including Nallur, Kopay and Chavakachcheri D.S Divisions to evaluate the effectiveness of the barrage by delineating salt water intrusion patterns. Sixty-one wells were selected in a profile perpendicular to the fringe of the Upparu and Jaffna lagoons to measure in situ electrical conductivity (EC) and salinity in both wet and dry seasons. Out of 61 wells, thirty groundwater samples were selected for analysis of sodium and chloride. The EC of groundwater varies between $571 \mu\text{S cm}^{-1}$ and $20,370 \mu\text{S cm}^{-1}$ in wet season and between $991 \mu\text{S cm}^{-1}$ and $20,620 \mu\text{S cm}^{-1}$ in dry season. Salinity varies between 0.2% and 12.15% in wet season and between 0.45% and 11.3% in dry season. Chloride concentrations vary between 46.15 mg L^{-1} and $5,183 \text{ mg L}^{-1}$ in wet season and between 170.4 mg L^{-1} and $5,467 \text{ mg L}^{-1}$ in dry season. Sodium concentrations vary between 22.8 mg L^{-1} and $6,259.4 \text{ mg L}^{-1}$ in wet season and between 8.7 mg L^{-1} and $4,470 \text{ mg L}^{-1}$ in dry season. Groundwater quality along the fringe of the Upparu lagoon far from the barrage is of good quality compared to the groundwater close to the barrage in both seasons. Even though the effectiveness of the barrage is less during both seasons due to insufficient run-off and seepage, analysis of past five year continuous data set reveals that the salinity of the groundwater in the fringe of the lagoon has reduced to moderate levels. If the barrage works properly as at the initial stages of its construction, the groundwater in the fringe of the lagoon will become fresh water in near future. However, further continuation of this research would deliver a much better result.

Keywords: Groundwater, Upparu lagoon, Barrage, Electrical conductivity, Salinity

Assessment of Ground Water Salinity in Upparu Lagoon Area in Jaffna with Respect to Salt Water Intrusion

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Groundwater is the only source of fresh water that is directly consumed by most inhabitants in Jaffna. However, salinity in ground water has become a serious problem in Jaffna Peninsula and affected to deteriorate the water quality. Further it has been noted that lagoons may be directly responsible for the increased salinity of abandoned agricultural lands in the area. Therefore, this study assessed the extent of the saltwater intrusion in Upparu lagoon which is a major water resource in the Jaffna Peninsula and nearby areas. In this study, 196 sampling points (132 wells in the east bank and 64 wells in the west bank of the lagoon) were selected by using GIS grid net method. Samples were collected along the banks of the lagoon at 1 km intervals and at each selected point, 4 samples were taken; inside the lagoon, 100m, 200m and 500 m away from the lagoon during the time period from August to November 2016. Electrical Conductivity (EC) and pH were tested to find the salinity and alkalinity of water samples. Salinity and pH distribution maps were prepared according the drinking and irrigation water quality standards by using GIS Arc map software. The average EC values in September at the lagoon and at 100 m, 200 m, and 500 m away from the lagoon were 22.44 mS cm^{-1} , 8.47 mS cm^{-1} , 5.32 mS cm^{-1} , 3.60 mS cm^{-1} while in November those were 24.60 mS cm^{-1} , 12.63 mS cm^{-1} , 7.45 mS cm^{-1} and 4.94 mS cm^{-1} , respectively. Salinity level of groundwater increased during the dry season due to low rainfall, high temperature with high wind speed and therefore, water in the lagoon may not be suitable for irrigation during dry season. The pH of water in both lagoon and the wells was considerably high. pH in well water, 500 m away from the lagoon, is within the recommended level for drinking. Based on the results, it can be concluded that water in lagoon is not suitable for drinking and irrigation. Saltwater intrusion was increased and groundwater is contaminated with saltwater in dry periods due to the lateral seepage of salt water in Upparu lagoon area. However, well water can be used for drinking and agricultural activities if the distance from the lagoon to wells is increased.

Keywords: Groundwater, Lateral seepage, Salinity intrusion, Upparu lagoon

Conversion of Waste Polypropylene into Hydrocarbon Fuel – Analysis of the Effect of Set Temperature on Reaction Time and Liquid Yield

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Plastic waste management is a serious environmental issue. The methods available to date such as incineration, land filling etc., are cost intensive. Attention is thus being given to new recycling methods which are more environmentally attractive. Pyrolysis is one such promising method for the treatment of mixed and contaminated plastic wastes. In pyrolysis, plastics are thermally degraded to produce liquid hydrocarbons. Pyrolysis of waste plastics was investigated in a reactor system which consists of a semi batch reactor, a condenser and a liquid-gas separator. Developed reactor system is capable of converting waste plastics (polyethylene, polypropylene and polystyrene) into hydrocarbon fuel at a maximum conversion rate of 99%. Liquid yield and gas yield at optimum conditions are 66% and 31% respectively. Liquid fuel obtained by the process was found to consist of light and middle distillates in the range of C₅ to C₁₂ hydrocarbons with higher concentrations of C₇, C₈ and C₉ fractions. Non-condensable gas obtained was chemically equivalent to the LP (liquid petroleum) gas. Polypropylene waste samples of 3000 g by weight were used for the experiments carried out to investigate the effects of set temperature on reaction time and liquid yield. The reaction time was found to decrease from 390 min to 115 min and the liquid yield was found to decrease from 68.2% to 39.2%, when the set temperature of the reactor increases from 375 °C to 475 °C. The solid residue left in the reactor was also observed to be decreased from 19.1% to 0.4%, during the experiments. Low set temperatures such as 400, 375 °C were found to drastically increase solid residue amount and reaction time at an approximately same liquid yield. High set temperatures such as 450, 475 °C were found to decrease liquid yield and reaction time at an approximately same solid residue amount. Waste plastic pyrolysis process is affected by many process parameters such as pressure, batch size, set temperature, heating rate, reactor design etc. Optimized process parameters lead to obtain high liquid yield at a minimum input energy in a comparatively small reaction time.

Keywords: Liquid yield, Pyrolysis, Reaction time, Set temperature, Waste polypropylene

General Characteristics of Wastewater and Effectiveness of Existing Treatment Methods in Hospitals with Special Reference to Uva Province

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Hospital wastewater has gained a significant attention due to release of untreated toxic chemicals and pathogens to the environment. Although, there are some treatment facilities in hospitals, most of the wastes are partially or untreated before releasing to the environment. This study thus focuses to asses and gives suggestions to improve an existing treatment plant for better function and performance and investigate a hospital that does not have a treatment plant to give suggestions. Wastewaters from Badulla hospital (n=5) and Bibile hospital (n=4) were collected weekly over a period of three weeks (total n=27) where physical (n=5), chemical (n=12) and biological (n=1) parameters were measured. The water quality after the trickling filter in Badulla hospital shows a clear drop for Five-Day Biochemical Oxygen Demand (BOD₅), Total Suspended Solids and pH. The BOD₅, Chemical Oxygen Demand, Total Suspended Solids and PO₄³⁻ of the waters ranged between 21-108 mg L⁻¹, 130-290 mg L⁻¹, 290-904 mg L⁻¹ and 11.84-16.39 mg L⁻¹ respectively and are much higher than Central Environmental Authority standards in Sri Lanka. There were no microbes detected after the Ultraviolet (UV) plant and perhaps due to heavy use of Chlorine in spite of the UV treatment. In Bibile hospital, all discharged water outlets are open to the environment. The BOD₅, PO₄³⁻ and NO₃⁻ of discharged water varies within 8-98 mg L⁻¹, 3.77-8.16 mg L⁻¹ and 0.80-14.60 mg L⁻¹ and are much higher than accepted standards. The treatment plant at Badulla hospital is unsatisfactory to meet the requirements of the accepted standards. Thus, the treatment process of the trickling filter needs improvements in where the rock particles have to be replaced with rock particles in a varying size order. The results indicate that a treatment plant is required for the Bibile hospital with immediate effect.

Keywords: Hospital effluent, Wastewater, Treatment plant, Environment

Investigate The Suitability of Gold Fish (*Carassius auratus*) Effluent as a Nutrient Source in Recirculating Aquaponic Systems

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Aquaponics is a bio-integrated system of aquaculture where wastes produced by farmed fish are utilized for plant growth. The research aimed to probe the suitability of gold fish effluent to be used as a source of hydroponic nutrient for the growth of *Ipomea aquatica* (water spinach) plants. Circular aquariums of about 0.2 cubic meters and 1.05 square meters area with 20 liters of water in each were established and gold fish (*Carassius auratus*) were introduced at a rate of 6 /aquarium as an aquaculture system. *Ipomea aquatica* were used as a hydroponic system, planted at a rate of 25 plants per plot kept above the aquariums to form aquaponic system. Two aquaponic replicates were made along with a control set up that lack hydroponic system. Water quality parameters of the effluent and vegetative parameters of water spinach were measured on a weekly basis for eight weeks from November to December, 2016. Water quality parameters (TS, TSS, TDS, pH, EC, DO) of effluent utilized by the hydroponic plants were analyzed statistically using paired t-test over the control set up. Correlation between the mean vegetative growth (plant height, stem circumference) and water quality parameters were analyzed with Pearson's correlation, simple linear regression and ANOVA using Minitab 17 statistical package. Pearson's correlation between TS and height ($r = 0.946$, $p = 0.000$), TS and circumference ($r = 0.935$, $p = 0.001$) showed a strong positive correlation between the variables. Significant positive linear correlation was observed between TS and plant height ($r = +0.895$), TDS and height ($r = +0.834$) as well as TSS and height ($r = +0.884$). Similarly, significant positive linear correlation was observed between TS -circumference ($r = +0.874$), TDS -circumference ($r = +0.833$) and between TSS -circumference (+0.834). Significant difference in treatment and control was observed in EC ($p = 0.000$), TS ($p = 0.001$), and DO ($p = 0.000$) but not in pH ($p = 0.339$). As a result, this analysis revealed that the nutrients were absorbed by the plant from the effluent efficiently. This suggested that the gold fish effluent could be used as a source of hydroponic nutrient solution.

Keywords: Aquaponics, Hydroponics, Gold fish, Effluent

Public Perception and Management Implications of Invasive Flora in Vavuniya District, Northern Sri Lanka

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Invasive alien species (IAS) due to their competitiveness is threatening the existence of native species in diverse ecosystems world over. The objective of this study is to determine distribution of invasive flora, assess the intensity of distribution, public perception and implications regarding the management of invasive flora in all Grama Niladari Divisions of Vavuniya district. Sampling sites were selected based on the intensity of IAS distribution. Semi structured questionnaire survey was conducted for the total of 120 respondents to measure the level of awareness and willingness towards the management of invasive flora. Based on reconnaissance Survey *Parthenium hysterophorus*, *Lantana camara*, *Muntingia calabura*, *Leucaena leucocephala*, *Typha angustifolia*, *Salvinia molesta*, *Panicum maximum* and *Eichhornia crassipes* were the most abundant invasive flora distributed over the study area. According to the questionnaire survey 69 % of respondents were recorded with the awareness of invasive flora and remaining respondents were without awareness on invasive flora. Though respondents were lacking with knowledge on ecological risks of invasive flora they make use of invasive flora for many ways (shade cattle feed, firewood, etc.). *Lantana camara* (72%) and *Parthenium hysterophorus* (46%) were frequently recorded as weeds closer to human settlements and in agricultural lands. *Eichhornia crassipes* (34%) interferes in fishing activities in inland water bodies whereas rest of invasive flora was without interference to their activities. Hence the research revealed that even though the study area had a considerable distribution of invasive flora, communities lacked awareness on the ecological impacts. Therefore it necessitates the community awareness programs on invasive flora and their ecological risks as the successful management initiative and thereby betterment of ecosystems health by enhancement of the abundance of native plant species diversity.

Keywords: Invasive alien species, Perception, Implications, Ecosystem health

Comparative Life Cycle Analysis of Environmental Impact from Micro and Small Scale Cassava Chip Production Using Raw Cassava Roots

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Cassava chips are produced from fresh cassava root and the market for chips has increased over recent years. The aims of the analysis were to assess the environmental impact of cassava chips manufacturing and to identify the hotspots in the life cycle of cassava chips manufacturing. Three separate but interrelated components: inventory analysis, impact assessment and interpretations were performed for the cassava chips life cycle using SimaPro software 8.4.0.0 faculty version. Inventory data were collected through the use of structured questionnaires and personal communication. Data were collected on cassava farming, chips manufacturing, packaging, transportation and waste management. The scenario combining machinery use, LPgas and polythene showed higher environmental impact than the scenario combining no machinery use, LP gas and polythene. Higher contribution was associated with the electricity used in machineries. Cassava cultivation and cassava chips processing stages contributed to a higher impact on the environment and transportation of raw cassava root, raw material and cassava chips contributed to a lesser impact on the environment. The impact categories most affected by cassava cultivation were stratospheric ozone depletion 78.2%, Human non-carcinogenic toxicity 67.1%, land use 68.6% and mineral resource scarcity 76.4%. The impact categories most affected by cassava chips processing were fine particulate matter formation 80.7%, human carcinogenic toxicity 99.5%, terrestrial acidification 78.2%, marine ecotoxicity 75%, freshwater ecotoxicity 83.8%, fossil resource scarcity 84.9% and ozone formation 80%. No machinery use in cassava chips processing stage contributed to lesser environmental impact compared to the machinery use. Transportation of raw cassava root, raw material and cassava chips contributed to lesser impact on the environment. Cassava cultivation and cassava chips processing stages contributed a higher impact on the environment.

Keywords: Cassava chips, Life cycle assessment, Environmental impacts, Micro and small scale production

Efficiency Comparison of Three Types of Constructed Wetlands for Treating Reverse Osmosis Rejects

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Reverse osmosis is a water purification technology that uses a semipermeable membrane under pressure to remove particulate and dissolved contaminants mainly pathogenic microorganisms, organic compounds, hardness and heavy metals. Use of this technology has increased tremendously to treat ground water in the Chronic kidney disease of unknown etiology prevalent areas in Sri Lanka in recent years. However, the need to treat reverse osmosis rejects (concentrated residue stream of reverse osmosis process) before releasing to the environment has not received much concern yet. Constructed wetland is one economical technique to treat reverse osmosis rejects. In this study efficiency of three different types of constructed wetlands were analysed. Three constructed wetlands were prepared, first one (CW1) only with soil, second one (CW2) with plantation of *Schcenoplectus grossus* (Thunhiriya) on the same soil and the third one (CW3) without soil with *Water Hyacinth* (Japan Jabara), an aquatic plant. The wetlands were created at a hydraulic retention time of 4 days with dimensions of 0.6 m × 0.3 m × 0.2 m. Removal efficiency of eleven parameters including concentration of nitrate, total alkalinity, total dissolved solids, total hardness, electrical conductivity, pH and heavy metals such as calcium, copper, manganese, magnesium, and cadmium were evaluated in all three wetlands. Results showed that all three types of wetlands have considerable efficiency in removing selected parameters, but CW2 was more prominent in removing the selected parameters except for magnesium, nitrate and electrical conductivity. Removal efficiencies of those three parameters were slightly lower in CW2 than CW1, and the reason could be carrying of nutrients to the CW2 at the plantation step. According to the results, it is possible to conclude that a constructed wetland including soil and a plant is more efficient in the treatment of wastewater than a wetland which contains only soil or an aquatic plant.

Keywords: Reverse osmosis reject, Constructed wetlands, Chronic kidney disease, Wastewater treatment

Socio-economic Risk Assessment of Soil Erosion Integrating GIS to Universal Soil Loss Equation; A Case Study from Nillambe Catchment, Kandy

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Soil erosion is a widespread problem in Nillambe catchment which accommodates a population that is mainly based on agriculture. Consequently, it is important to identify the socio-economic risk in the area in order to carryout necessary mitigation measures to minimize the potential risk. This study attempts to categorize socio-economic risk levels of soil erosion. Based on Universal Soil Loss Equation (USLE), geo-spatial input data representing rainfall, soils, land slopes and land use were used to model soil erosion hazard. A selected set of socio-economic vulnerability and coping capacity indicator variables were spatially modeled based on AHP (Analytical Hierarchical Process) and the outcomes of hazard, vulnerability and coping capacity measurements were further modeled using GIS based Disaster Risk Equation to obtain the socio-economic risk index for Nillambe catchment. The study revealed that approximately 25% of the catchment is in moderate to extremely high socio-economic risk to soil erosion. Furthermore, it indicates that the majority of such lands are covered with moderately managed tea and a slope greater than 10% (slope of the catchment varies between 0 - 36 degrees) with a moderately high rainfall erosivity level between 16 - 27. The maps identifying the socio-economic vulnerability, coping capacity and the risk levels to soil erosion can be utilized to identify areas with different vulnerabilities and coping capacities to promote necessary mitigation actions and strengthen socio-economic capacities of the community involved which would eventually minimize the socio-economic risk for soil erosion in the area.

Keywords: Soil erosion; Socio-economic risk, Socio-economic vulnerability, Universal Soil Loss Equation, Socio-economic capacity, GIS mapping, Analytical Hierarchical Process

A Comparative Study on Water Vapour Permeability of Surface Treated Paperboards with Keratin and Gammalu (*Pterocarpus marsupium*) Latex

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Chicken processing industries produce a high amount of feathers as a wastage, which cause disposal problems. Chicken feathers contain a high percentage of keratin; a protein, which shows good resistance towards water. Gammalu latex is a naturally available resource in Sri Lanka, which has high barrier properties. Extracted keratin and Gammalu latex can be applied as a coating on the surface of paperboards for biodegradable packages in order to improve the barrier properties against water vapour permeability, while preventing the environment pollution caused by thermoplastic polymers. Thus, the present studies mainly focused on the extraction of keratin from chicken feathers and develop a coating to paperboards, and compare the properties of that with a coating made of Gammalu latex. Pre-treated chicken feathers were subjected to a feather dissolving, protein precipitation, protein purification and film preparation process. Paperboard (0.25 g cm⁻²) coated with 2% (v/v) Glycerine with Keratin and 2% (v/v) Glycerine with Gammalu latex were used as treated samples. Non-coated paperboards used as the control sample. All samples were stored in a climatic chamber at controlled environment. Water vapour permeability was evaluated under constant temperature (35°C) and relative humidity (65%) for three weeks. Data were analyzed using two-way ANOVA technique in Minitab 17. Results showed significant deference ($P < 0.05$) amongst the treated samples while keratin showed least water vapour permeability followed by Gammalu latex coated paperboards. This study revealed that keratin coated paperboards could be used as an effective packaging material with low water vapour permeability.

Keywords: Chicken feathers, Keratin, Gammalu latex, Water vapour permeability, Paperboards

Integrated Wastewater Treatment Using Water Hyacinth (*Eichhornia crassipes*) and Blue Swimming Crab (*Portunus pelagicus*) Shell Waste

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Natural compounds and biotic structures are used as low cost, eco-friendly methods to treat industrial wastewater by phytoremediation and adsorption/biosorption. Objective of this study was to assess applicability of readily available blue swimming crab (*P. pelagicus*) shell waste and water hyacinth (*E. crassipes*) for removing of heavy metals, organic and inorganic pollutants from wastewater. Integrated waste water systems (IWWS) with 10 different treatments of crab shell powder + water hyacinth (Shell powder as dry weight + water hyacinth as wet weight basis: 2 g & 100 g/ 2 g & 200 g/4 g & 100 g/4 g & 200 g/6 g & 100 g/6 g & 200 g/8 g & 100 g/8 g & 200 g/10 g & 100 g/10 g & 200 g) were subjected to analyse efficiency of each treatment. Efficacy of improved rate of Dissolved oxygen, removal capacity of COD, pH, TS, TDS and PO₄³⁻ was tested in each treatment for 6-day retention period. Removal capacity of Cr, Cd and Cu levels was assessed in each treatment for 4-day contact period. According to results, both blue swimming crab shell powder levels and water hyacinth weight significantly affect on water quality improvement ($p < 0.05$). pH in all treated systems improved at 7.0, indicating optimum levels. The 4 g of crab shell powder with 200 g of water hyacinth recorded highest DO (4.1 ± 0.16), while removal rate of COD (95%), TS (72%), TDS (61%) and PO₄³⁻ (65 - 55% for 1 - 3ppm of PO₄³⁻ levels) were most effective at same treatment. Integrated system with 4 g crab shell +200 g water hyacinth had 92 - 78%, 86 - 77% and 96 - 86% of maximum removal efficiency for Cr, Cu and Cd respectively indicating suitability of crab shell and water hyacinth for IWWS. Metal adsorption capacity depends on adsorbent dosage, pH level, metal ion charge, initial heavy metal concentration, and ionic radius of metal. This study implies novel approach in wastewater treatment as a cost effective, environmentally acceptable method, while controlling freshwater invasive alien species load and value addition to crab shell residues.

Keywords: Phytoremediation, Biosorption, Adsorption rate, Heavy metals, Eco-friendly Wastewater Treatment Systems

A Study on Toxicity Effect of Mancozeb Fungicide Residual on Zebrafish (*Danio rerio*) Embryo

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Mancozeb fungicide which belongs to ethelene bisdithiocarbamates (EBDCs) chemical group causes potential hazard to human and environment. Considerable amount of this pesticide leaches through soil, air and accumulate in aquatic environment. The fungicide breaks down into ethylenethiourea (ETU) within two days and residuals remain in the aquatic environment. In this study, the effect of Mancozeb residuals on zebrafish embryo was performed according to OECD guideline and investigating the lethal end points, median lethal concentrations (LC_{50}) and morphological deformities at different concentrations. Range finding test was carried out initially, using different concentrations to determine the test concentration for toxicity. The embryo toxicity test for Mancozeb residual was performed over four days period according using 16-cell stage fertilized zebrafish embryos. Ten test concentrations (5, 2.5, 1.25, 0.64, 0.32, 0.16, 0.08, 0.04, 0.02 and 0.01) mg L⁻¹ Mancozeb residual was tested on 60 embryos pre-treatment. Lethality rate and morphological abnormalities were recorded at 24, 48, 72 and 96 hours post fertilization (hpf). LC_{50} for 24, 48, 72 and 96 hours of exposure to Mancozeb residual was determined as 1.4, 1.15, 1.15, 1.15 mg L⁻¹ respectively. A significant difference was observed between Mancozeb residual and control group ($P < 0.05$). Coagulation of the embryo, non-detachment from the tail bud, lack of heartbeat and lack of somite formation were observed as lethal end points. Yolk sac and pericardial edema, degeneration of tail region, malformation of head and heart, retarded growth, twisted tail, shrinkage of chorion and spinal curvature were observed as morphological deformities. This study demonstrated that Mancozeb residual at 1.4 mg L⁻¹ was lethal at 24 hpf level and 1.15 mg L⁻¹ was lethal at 48, 72 and 96 hpf. The results indicated that Mancozeb residuals affect zebrafish (*Danio rerio*) embryo indicating its potential to cause environmental toxicity.

Keywords: Pesticide, Median lethal concentration, Fungicide, Environment, Zebrafish

Genetic Variation of Growth and Reproductive Parameters of *Jatropha curcas* in a Progeny Trial at Anapallama (IM2) in Sri Lanka

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Jatropha curcas is used for biodiesel production as an alternative for fossil fuel. Genetic variability among seed sources of Sri Lankan *Jatropha* population was studied for tree diameter at 10 cm height, tree height, and number of branches, fruits and flowers per tree, in a field trial which was established at Anapallama Wellawaya in 2009. The trial consisted of 60 open pollinated families from 13 seed sources. Those families were allocated in a row column design with 4 replicates, each family represented by 5 trees row plot. The results indicate significant differences ($p < 0.05$) among seed sources for survival, base diameter, number of branches, fruits and further indicate significant differences among families within seed sources for the tree basal diameter, number of branches, flowers and fruits. Progeny of seeds from Polonnaruwa, Hambanthota and Badulla performed better in tree base diameter and number of branches and number of flowers. Tree diameter (5.9 cm) was highest in the progeny of seeds from Hambanthota, whereas those from Badulla showed highest number of branches (16/tree) and highest number of flowers (27/tree). Maximum survival (100%) was recorded in the seed sources of Matara and Embilipitiya, and the least (80%) was from Anuradhapura seed source. Individual tree narrow sense heritability estimates for number of flowers, fruits, branches and base diameter were 0.34, 0.8, 0.78, and 0.59 respectively. There were strong positive correlations between number of branches and fruit production; and the tree diameter and fruit production. Hundred individual trees selected using an index based on number of branches and number of fruits per tree (economic weights 1 and 2 respectively) reveal that diverse distribution across the seed sources (50% Matara, 30% Hambantota and 20% Kurunegala) as well as within seed sources. Superior genotypes selected from this breeding population can be used for future improvement and for commercial plantations establishment.

Keywords: *Jatropha curcas*, genetic variation, heritability, correlation, selection

Removal of Excessive F⁻, Mg²⁺ and Ca²⁺ in Groundwater by Electrolysis

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Groundwater contamination in North Central Province, Sri Lanka by excessive fluoride (F⁻), magnesium (Mg²⁺) and calcium (Ca²⁺) causes many negative health effects to the consumers. Though many technologies are available to remove F⁻, Mg²⁺ and Ca²⁺, installation and maintenance cost, power consumption, expertise knowledge, output water quality and the water rejection have become bottle necks on providing the safe water. Electrolysis has proven as a cost effective method. Therefore, in this study, electrolysis was investigated to remove F⁻, Mg²⁺ and Ca²⁺ ions. As an electrolysis reactor, a Polyvinyl Chloride material made rectangular box, which was separated from a clay membrane was utilized by employing platinum and stainless steel electrodes. Electrolysis was performed by varying Coulombs (Ampere × second ÷ Liters) per Liter (C L⁻¹) for groundwater samples collected from North Central Province. During the electrolysis, contaminants were removed via forming a white colored precipitation in the cathode bath and transportation by coulomb forces towards the anode bath. The total water recovery by the system was 50%. Analytical results showed that significant amount of hardness species (Ca²⁺ and Mg²⁺), HCO₃⁻ and F⁻ can be removed. The precipitation could be a mixture of CaCO₃, MgCO₃ and Mg(OH)₂ which formed by reacting HCO₃⁻ and OH⁻ ions with Ca²⁺ and Mg²⁺. Fluoride could be removed via co-precipitation with Magnesium hydroxide. Moreover it was identified that current supplied has a positive effect on hardness species and F⁻ removal. The maximum removal percentage was 71.6% for the Mg²⁺ at 1000 C L⁻¹. The Ca²⁺ and F⁻ removal observed were up to 94.45% and 39.79% respectively for the 1000 C L⁻¹. There was no significant effect on removal percentages by the initial F⁻ concentration, but the higher the initial Mg²⁺ and Ca²⁺ concentrations, the higher the removals of Mg²⁺, Ca²⁺ and F⁻. Accordingly, household scale treatment system was designed and proposed.

Keywords: Fluoride, Magnesium, Calcium, Electrolysis, Coulomb per liter

Use of Laterite Soil as a Filter Material to Remove Copper from Aqueous Solution

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Elevated levels of heavy metals in drinking water are found to have severe impacts on human health. Therefore, effective treatment method is of prime importance. Several techniques are available to remove heavy metals from water. However, all those methods are not cost effective and viable to the environment. Hence, it is important to study alternatives from natural resources. Laterite is a low cost novel adsorbent available in the country. Thus, the aim of the present research is to study the possibility for the use of activated laterite to filter copper from aqueous solution. In the experimental design, acid activated, thermal activated and raw laterite with 2 mm grain size has been used for the adsorbent trials. Experiment was conducted for 15 days continuously and copper removal efficiency was calculated. In addition pH, Oxidation Reduction Potential, Electrical Conductivity and Total Dissolved Solids of filtrates were studied to investigate process of treatment. Results indicate the average Cu removal efficiencies of acid activated, thermal activated and raw laterite is 89%, 98% and 98% respectively for an aqueous solution with 10 ml min⁻¹ flow rate and 2 ppm initial copper concentration. After 15 days, acid activated laterite system has shown higher pH reduction and most of the samples were in pH below 6.5. Other two systems have shown pH within 6.5 - 8.5. Acid activated laterite system has shown positive Oxidation Reduction Potential values and other two systems have shown negative values at the beginning and change to positive values. Both Electrical Conductivity and Total Dissolved Solids curves showed upward trend with time for all three systems. According to the performance of the materials it can be concluded that laterite as an ideal material for removal of copper. Conversely, due to the high cost of activation, raw laterite can be considered as the best filter material for the removal of copper from an aqueous solution.

Keywords: Laterite, Filter, Activation, Cost

Identifying Leachate Plumes Using Geophysical Methods: A Case Study from Open Municipal Solid Waste Dumpsite in Badulla

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Badulla dumpsite is one of the major open municipal dumpsites in Sri Lanka. However the dumpsite has not been constructed according to the modern engineering techniques and it has no liner to prevent seepage of leachate. Therefore leachate pockets can be built up in the subsurface and they can flow directly to a nearby surface water body (Badulu oya) through surface and subsurface channels, due to elevation difference. Therefore mapping leachate plumes and their flow paths have high interest in the environmental management and prevention of surface water pollution. Hence in this study leachate flow paths were delineated by using resistivity imaging with controlled inversion parameters and magnetic mapping techniques. The geophysical findings of the leachate characters, were supplemented with physico-chemical parameter analysis of collected leachate samples from solid waste dumpsite and leachate drainage channel. Leachate plumes were demarcated by 2D resistivity technique, and a unique correlation was established between ground magnetic results and resistivity imaging. 3D resistivity contour plot synthesized by 2D resistivity imaging profiles, confirms that leachate plumes and their flow paths are confined to near surface, almost throughout the dumping area. Moreover high electric conductivity values of leachate produce unique signature in resistivity image. Chemical parameters such as biochemical oxygen demand, chemical oxygen demand and phosphate are above the tolerance limits for the discharge of industrial wastewater into inland surface waters. This study reveals the appearance of subsurface leachate plumes in Badulla dump site and their flow paths. It is recommended to build a retaining wall in the identified direction of leachate flow path down to the depth of bedrock in order to prevent seepage of leachate to Badulu oya and accumulated leachates should be treated prior to discharge.

Keywords: Geophysical methods, 2D and 3D resistivity, Magnetic method, Leachate plume delineation, Physico-chemical analysis

Identification of Near Surface Water Flow Path in Kanniya Hot Water Spring

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Although Sri Lanka is not located in an active volcanic region or in the vicinity of an active plate margin, the country possesses unexplored geothermal resources with potential for development as a source of renewable energy. As the present trend for geothermal prospects of low-enthalpy metamorphic terrains become a focus overriding conventional magmatic provenances, Sri Lanka is well placed to explore the same. Prospects for low to medium temperature geothermal resources can be expected to spread across the hot springs belt of Sri Lanka. Low to medium temperature geothermal resources have direct applications in food processing, fruit drying, refrigeration and recreational activities. Delineating the source characters of prospective geothermal fields in geological perspectives would be the initial step towards addressing this untapped energy source. Thorough geological mapping along with geophysical applications would pave the way for such source characterization. Geochemical analysis further provides necessary clues on the potential of the source, its provenance and temperatures. Among many geothermal fields that are scattered in the SE to eastern region of the island, Kanniya site was selected for this study. Objective of this study was to identify the near surface water flow path in Kanniya hot water spring which is one of the major hot spring fields located in Sri Lanka near Trincomalee. One-Dimensional and Two-Dimensional resistivity survey and magnetic survey were used for subsurface layer mapping of the area and the results were synchronized with the elevation model. The results showed that the flow path is in Northeast - Southwest direction line receiving from beneath a quartz hump. According to the topography of the area, water flow is towards the sea in Northeast direction. Therefore, it is possible to conclude that the near surface water flow path in Kanniya hot water spring is towards the Northeast direction. Presumably the quartz layer acts as a conduit for such flow, due to its high permeability character.

Keywords: Geothermal resources, Hot spring, Subsurface water flow

Analysis of Slope Stability on Road Cut Slopes; a Case Study at Badulla-Bibile Road and a Cost-Effective Proposal for Future Road Cut Slope Studies

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Sri Lanka is frequently affected by hydro meteorological disasters, one of which is slope failure triggered by unusual intense rainfall. Post-disaster inspections reveal the lack of preliminary investigations being carried out on cut slope failures. The first objective, which was a slope stability analysis on proposed cut slopes of Badulla-Bibile road was designed in a three-fold methodology including Preliminary Study, Field Investigation and Laboratory Investigations. Laboratory investigation consisted of Sieve analysis, Liquid limit, Direct Shear and simple pour pile method. The data were interpreted with reference to slope geometry and soil strength. Geometrical interpretation identified that 32.5% of natural and 73.3% of cut slope failures were possible. The soil analysis interpreted using Unified Soil Classification System reveals that silty gravel, Lean Clay, Silt, Silty Sand, Clayey Sand soil types were present. All these soils were known to be cohesion-less and changing the slope angle was identified to be the ideal mitigation. The second objective was to understand the importance of preliminary study in future road cut slope. This proposed method includes geometrical and soil study. Geometrical study is done with three criteria considering the slope angle, slip angle, friction angle, strike of slip and strike slope. The soil analyses are performed using Unified soil classification system considering the Sieve analysis and Liquid limit test. Identified properties of the soil were modeled in Slope W software to check the factor of safety. This method to find the soil properties is cost effective and less time consuming than direct Shear method. This study has considered direct shear as a conventional method and interpreted for a location. Both results were coinciding, and a conclusion can be drawn that the proposed cost effective basic method is economical which can be used as a preliminary study in future road projects in Sri Lanka.

Keywords: Slope stability, Slope geometry, Mitigation, Strike of slip, Slope failure

Hardness Removal Using Graphite-based Nano Materials

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Water hardness creates substantial issues both in health sector and in industry. In regulatory agencies hardness in drinking water is often categorized as a secondary contaminant in that its regulation is not mandatory. However, high hard waters are not palatable. The hardness in the water is defined as the presence of di- and trivalent cations. However the removal of hardness from water is no easy task. Ion exchange resins were commonly used to control drinking water hardness which creates reject water enriched with monovalent cations. The methods based on sorption offers several advantages as such they are economical and do not require high technology. Further most of the adsorbents are readily available. The major limitation of the method is its efficiency. This project aimed at determining developing substrate to remove divalent cations from drinking water using nano Grapheneoxide (GO). GO was synthesized from natural vein graphite of Sri Lanka. Grapheneoxide (GO) was synthesized using the modified Hummer's method. Results showed that the suitable pH for calcium removal was pH 10 but there is a Calcium removal below pH 8 (pH 5.5 to 7) and the optimal concentration was 50 ppm. Equilibrium isotherms have been analyzed using Langmuir and Freundlich isotherm models. The adsorption data were fitted well in Langmuir isotherm than Freundlich isotherm for GO. GO was characterized using Scanning Electron Microscope (SEM), Energy Dispersive X-ray Spectrometry (EDS), Fourier Transform Infrared Spectroscopy (FT-IR) analysis and X-ray Diffraction (XRD) and the results were in good agreement with the literature. Calcium adsorption isotherms were also prepared to assess its applicability for water industry.

Keywords: Water hardness, Drinking water, Graphite, Grapheneoxide, Nano material

Rhizosphere Microbial Activity of *Crotalaria retusa* L. Grown in Soil Contaminated with Used Lubricating Oil

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Contamination of soil with used lubricating oil (ULO) has become one of the major environmental issues worldwide. ULO contains highly hazardous chemicals such as phenols, benzenes, heavy metals and polycyclic aromatic hydrocarbons. Therefore, ULO contamination may negatively affect the overall soil quality and biota. Phytoremediation is a green technological approach which uses plants to remove organic and inorganic pollutants from the environment. Rhizosphere microbial activity plays a vital role in the phytoremediation. The aim of the present study is to evaluate the microbial activity in the rhizosphere of *Crotalaria retusa* L. grown on contaminated soils with ULO. A pot experiment was conducted using contamination levels of 5,000 (T1), 10,000 (T2), 15,000 (T3), 20,000 (T4), 25,000 (T5) and 30,000 (T6) mg kg⁻¹ ULO and uncontaminated control. A randomized block design (RBD) was employed with four replicates per treatment and control. Total microbial activity (TMA) was determined by using fluorescein diacetate hydrolysis (FDA) method and ULO content was determined by using gravimetric method in the soils taken from the rhizosphere in every 30 day interval during 90 days of experimental time. The calculated percentage biodegradation of ULO at the end of the experimental time was 52.2%, 43.8%, 35.6%, 32.2%, 25.2% and 22% for T1, T2, T3, T4, T5 and T6 ULO treatments, respectively. TMA was 20.22, 18.05, 16.81, 15.63, 13.94, 11.59 and 10.59 fluorescein µg ml⁻¹ for unplanted control and T1, T2, T3, T4, T5 and T6 ULO treatments, respectively. According to the results, rhizosphere microbial activity showed a contamination level dependent decrease and a time dependent increase. Further, correlation analysis indicated a highly significant ($p < 0.001$) positive correlation ($r = 0.975$) between the percentage biodegradation and the TMA. Therefore, overall results highlight the applicability of the rhizosphere microbial activity as an indicator to assess the biodegradation of ULO.

Keywords: Percentage biodegradation, Total rhizosphere microbial activity, Used lubricating oil

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Assessment of the Plant Growth Performances of Vertical Green Walls Developed with Different Plant Types in a Tropical Climate

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Planting on roofs and walls seems to be a modern and swiftly developing strategy towards sustainable environmental constructions. Covering building with vegetation enhance the city environment in terms of contributing to urban biodiversity, growing thermal comfort by buffering building temperature and mitigation of the Urban Heat Island (UHI). The study observed the significance of urban vegetation cover with the objectives of selecting suitable plant types for selected medium on vertical green wall panel by investigating the different plant physiological parameters. Fabrications of green wall panels were done in the premises of Department of Civil Engineering, University of Moratuwa by using timber frames (60 × 30cm) filled with coir dust growing medium for 2.5 cm thickness and fixed with wire mesh. Few holes at the bottom of the panel was prepared to facilitate water drainage. Each panel was irrigated three times per week with 0.5 liter of water per each panel. Nutrient solution prepared by dissolving 0.5 g of Albert's mixture in 500 ml of water for each panel and applied two times per week. Experimental design was Completely Randomized Design (CRD) with 3 replicates from each plant species. The nine plant species (treatments) were placed in green wall panel. Each panel (replicates) held eight plants of each species. *Desmodium triflorum*, *Roheo spathacea*, *Centella asiatica*, *Axonopus fissifoliu*, *Axonopus compressus*, *Elusine indica*, *Dieffenbachiae spp*, *Tectaria spp*, *Bigonia spp* were the selected plant species for the study. Plant health was rated for all plants using a 3 point scale. 1 = thriving, 2 = alive, but with signs of pest, disease or other stresses, 3 = dead. Plant height and leaf area were measured along with visual assessments of plant development stages and pest/disease incidence. *Roheo spathacea*, *Elusine indica*, *Axonopus fissifolius* displayed the greatest survival (100%) and coverage on an extensive green wall. Increment of Leaf Area Index of nine species over the eight weeks was significantly different ($P < 0.05$) among each species. Highest LAI obtained from *Roheo spathacea* (3.99) followed by *Axonopus compressus* (0.99), *Elusine indica* (0.76), *Axonopus fissifolius* (0.44,) over the trial period. In terms of actual performance, *Roheo spathacea*, *Elusine indica*, *Axonopus fissifolius* displayed the greatest survival and coverage on an extensive green wall.

Keywords: LAI, Mean temperature difference, Plant physiological parameters, UHI, Vertical green wall

Seedling Composition and Relative Growth in Dieback-affected Tropical Montane Cloud Forest in Horton Plains National Park, Sri Lanka

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This study evaluates the composition and growth of naturally grown tree seedlings in dieback affected forests in Horton Plains National Park. Forty plots (plot size: 1 m²) were established under disturbed (20 plots) and relatively undisturbed forests (20 plots). Seedlings were tagged and root collar diameter and height of tagged seedlings were measured in 03 month intervals for a year, while recording new recruits. A total of 373 seedlings representing 21 species and 16 plant families including Lauraceae (19.1%), Rubiaceae (16.7%), Symplocaceae (16.4%), Euphorbiaceae (15.6%), Elaeocarpaceae (11.3%) and Aquifoliaceae (5.1%) were recorded. Frequently encountered seedlings were *Neolitsea fuscata* (15.9%), *Glochidion pycnocarpum* (15.6%), *Elaeocarpus glandulifer* (10.2%), *Symplocos* sp. (16.4%), *Ilex walkeri* (5.1%), *Actinodaphne speciosa* (3%), and *Syzygium* sp. (3.2%). Mean height increment rate (cm month⁻¹) was greatest in *Sarcococca brevifolia* (0.5 ± 0.08), in disturbed condition and in undisturbed condition it was greatest in *E. glandulifer* (0.4 ± 0.06). Mean height increment rates were not significantly different ($p > 0.05$) in *A. speciosa*, *N. fuscata*, *Syzygium* sp., *Symplocos* sp. and *Meliosma simplicifolia* in both conditions. In disturbed condition, mean root collar diameter increment rates (mm month⁻¹) of the most abundant species were *G. pycnocarpum* (0.03 ± 0.01) and *Symplocos* sp. (0.02 ± 0.00) while in undisturbed condition, it was *N. fuscata* (0.03 ± 0.01) and *Symplocos* sp. (0.04 ± 0.01). Mean root collar diameter increment rates of the *Syzygium* sp., *Symplocos* sp., *N. fuscata*, *I. walkeri*, and *A. speciosa* were not significantly different ($p > 0.05$) in both conditions, however significantly higher in both *S. brevifolia* and *Lasianthus* sp ($p > 0.05$) in disturbed condition. Knowledge generated from this study provides baseline information on growth performance of seedlings of tropical montane forests and that can support for the assistant restoration of dieback affected sites in the future.

Study was supported by NARP grant: NARP/16/UWU/SCT/01

Keywords: Montane forest, Seedling height, Root collar diameter, Horton Plains

Effect of Some Selected Plant Species in Ameliorating Indoor CO₂ Concentration

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In view of increasing migration from rural to urban areas and inadequacy of suitable accommodation in towns, many people and students in urban areas live in highly congested, ill-ventilated and ill-lit abodes. Such conditions have resulted in deterioration of indoor air quality, including increased concentration of CO₂ which have posed issues such as Sick Building Syndrome (SBS), reduced productivity and undue fatigue. Therefore, studies were carried out to evaluate the effectiveness of some selected CAM plant species, namely *Zamioculcas zamiifolia*, *Sansevieria trifasciata* and *Kalanchoe spp.*, in improving indoor air quality. Plants of comparable age and size of the said species were selected and placed in air-tight containers (4500 cm³) one each in 3 replicates. CO₂ gas (0.1 ml) of 1000 ± 250 ppm was injected into each container and gas samples were collected at the beginning of the experiment (7.00 hours) and at four hourly intervals 11.00, 15.00 and 17.00 hours and were analyzed for CO₂ concentration by gas chromatography using a capillary column. Inter-specific variation in CO₂ absorption was evident which was highest in *Kalanchoe spp.* (176.76 ppm.g⁻¹.hr⁻¹) followed by *Zamioculcas zamiifolia* (94.94 ppm.g⁻¹.hr⁻¹) and *Sansevieria trifasciata* (43.16 ppm.g⁻¹.hr⁻¹). Preliminary studies showed a considerable interspecific variation in reducing CO₂ concentration in indoor spaces. Therefore, there are prospects for improving indoor air quality of particularly congested and ill-ventilated abodes using plants effective in absorbing elevated CO₂ concentration.

Keywords: Carbon dioxide, Indoor air quality, Inter-specific variation, *Kalanchoe spp.*, *Sansevieria trifasciata*, *Zamioculcas zamiifolia*,

Baseline Survey of Sediments from Galle Harbor Basin

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Galle Harbor has been operating as one major economic harbor in Sri Lanka since 1873. Long-term contamination of sediments due to harbor operations may pose a great threat to marine biota. Baseline assessment of sediment quality is important to record the sediment state. The aim of the study was to investigate the sediment quality of Galle Harbor basin. Thirteen sediment samples were collected from Galle Harbor with three replicates, covering both inner and outer harbor areas. Air dried samples were sieved using mechanical sieve set and grain size distribution curves were plotted, followed by particle size analysis and coefficient of uniformity (C_u) and coefficient of curvature (C_c) were calculated. Samples were digested in Kjeldhal digestion system and Pb, Ni, Cu, Zn concentrations were determined using Atomic Absorption Spectrometer. The concentration of heavy metals was assessed against the Background Assessment Concentrations (BACs) and Effects Range Low/Effects Range Median (ERL and ERM) concentrations. Sediment organic matter content was determined by using loss on ignition (LOI) method according to the CRIMP protocol. According to the results, all samples were composed of a major portion of silt, very fine sand and fine sand. Sediment particle in all samples, were poorly graded ($C_u < 4$ and $C_c \sim 1$). Zn was the most prominent trace metal in majority of sampling stations. Except Ni in some stations, metals did not exceed the Effective Range Median concentration. Sediment organic matter percentage was not significantly ($P > 0.05$) varied between inner harbor and outer environments and it ranged between $1.6 \pm 0.3\%$ to $41.0 \pm 2.8\%$. According to the standards of US EPA, all sediment samples were in intermediate to high organic carbon levels. Overall results highlighted that the marine environment in Galle Harbor basin is exposed to low and moderate contamination levels of assessed metals and intermediate to high organic matter.

Keywords: Sediments, metal, Organic matter, Galle Harbor

Quantitative Assessment of Microplastics in Surface Water of West Coast – off Colombo, Sri Lanka

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Contamination of water with plastic litter including microplastics is a serious environmental issue. This study addressed morphological identification and quantification of microplastics (1–5 mm) with spatial variability in surface waters of 7 sites; Uswetakeiyawa, Kerawalapitiya, Dikowita, Portcity, Kollupitiya, Bambalapitiya and Wellawatta along west coast - off Colombo during August–November 2017. Marine floating litter was collected, by towing a manta net, mesh size of 300 µm and microplastics were recovered from samples using visual observation. Microplastics were confirmed by hot needle test and categorized into 4 classes based on color: black, white, colored and transparent. Sorted plastics were quantified as number and weight. Total microplastic density does not significantly change with geographical location, as distribution of microplastics has been affected by oceanic waves and winds ($p > 0.05$). Rough sea state causes mixing of surface microplastics, and altering distribution pattern over the sites during sampling period. Overall mean density of microplastics was $0.33 \pm 0.13 \text{ mg m}^{-3}$ and $0.39 \pm 0.05 \text{ No m}^{-3}$ by weight and number of items respectively. Density of white colored microplastics significantly varied spatially, due to site-specific anthropogenic activities ($p < 0.05$). Highest number of white microplastics accumulated in water samples of Uswetakeiyawa ($0.35 \pm 0.06 \text{ No m}^{-3}$), by land based sources of tourism and recreational activities. According to results, all study sites are affected by plastic pollution and cause significant health risk on coastal biota. Microplastic contamination level in surface waters acts as a key indicator on high pollution level in west coast. Site specific management measures are suggested to mitigate microplastic pollution. Frequent estimations of microplastic density in surface water are recommended throughout year in west coast of Sri Lanka. This study provides baseline information on microplastics level in surface water of west coast.

Keywords: Microplastic density, Spatial variation, Surface coastal water, West coast, Plastic pollution

Analyzing Seasonal Variation of Water Quality Parameters of Kelani River

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Raw water quality of a surface water body directly affects the purification process and the final water quality of drinking water. When considering Sri Lanka, the Kelani River plays a vital role in fulfilling people's water necessities, as it provides water for more than 80% of the population of the capital city, Colombo. The current study focuses on the Kelani River in order to identify the models of variation of raw water quality parameters and to investigate patterns and trends of parameter variation. The main objective was to forecast the variation of water quality parameters with special reference to the Kelani River. The water quality was analyzed with different parameters including pH, Turbidity, Electrical Conductivity, Total *Coliform* and *Escherichia coli*, and data gathered for five years (2012 - 2017) at five different intakes. Analysis was carried out by R studio software. Time Series techniques were used to perform the tests, and all decisions were made under p-value of 0.05. ARIMA and SARIMA models were used to identify the best fitting model for the variation of quality parameters with time. Results were forecasted for a 6 month time period using the above fitted models. Based on obtained results, the seasonality of the water quality parameters changed from one intake to another. When analyzing the pH, Ambathale and Biyagama showed seasonality while other three intakes showed non seasonality. Electrical Conductivity had a seasonal variation at Biyagama and Pugoda intakes, while *Escherichia coli* showed seasonality for Ambathale intake only. Frequent long-term monitoring of physicochemical parameters of surface water resources is vital for the better management of water resources as well as aquatic habitats and the environment. Based on the results of this study, a better prior understanding about the behavior of raw water quality parameters can be obtained, and this prior understanding can be used to manage the water purification process and final water quality.

Keywords: Kelani River, Water Quality, Time Series Analysis, ARIMA, SARIMA

Study on the Treating Ability of Palmyrah Seed Shell Based Activated Charcoal in Newly Designed Domestic Water Filter

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Activated charcoal is commonly used as a good source for removing contaminants and impurities, sediment, volatile organic compounds, taste and odor from wastewater through chemical adsorption. This study investigates the ability of activated charcoal produced from Palmyrah seed shell using a newly designed domestic level filter. Dried and same aged Palmyrah seed shells were collected randomly from Chavakacheri area in Jaffna District and activated charcoal was produced following carbonization, activation and pyrolyzation processes. A domestic level filter having stone layer, sand layer and activated charcoal layer was designed. Two filter models were designed placing the activated charcoal layer from Palmyrah based activated charcoal (D1) and commercially available activated charcoal (D2) separately. Then wastewater samples were randomly collected from three different sources; laboratory, industry and abandoned well. About 10 L of wastewater sample was passed randomly 3 times through each charcoal filter slowly. 13 Physio-chemical parameters of water samples were checked before and after treating them in D1 and D2 separately. The results revealed that, wastewater obtained from both industry and abandoned well have been treated sufficiently by D1 for 6 parameters, while by D2 for only 3 parameters. Both D1 and D2 have equally performed for 4 parameters. In case of wastewater obtained from laboratory, D1 has performed well for 6 parameters and D2 for 5 parameters. Both D1 and D2 have similarly performed for 2 parameters. Therefore, it can be concluded that, the newly developed domestic level water filter with Palmyrah based activated charcoal (D1) has performed better than the filter with commercially available activated charcoal (D2) for the tested wastewater samples obtained from laboratory, industry and abandoned well.

Keywords: Commercially available activated charcoal, Newly designed domestic water filter, Palmyrah based activated charcoal, Physio-chemical parameters, Wastewater treatment

Use of Spectral Signature Characteristics to Differentiate Mangrove Species

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Mangroves are woody, highly specialized plants ranging from shrubs to tall trees which play a major role in environmental protection in coastal ecosystems. Past studies reveal that spectral characteristics of plants at different wavelengths are characterized by their biochemical (carotenoid, water content, chlorophyll, nitrogen) and anatomical (leaf inter and intra cellular structure) variations. This research aims at finding spectral signatures of six selected mangrove species in Sri Lanka, namely; *Acanthus ilicifolius*, *Bruguiera gymnorhiza*, *Bruguiera sexangula*, *Lumnitzera racemosa*, *Rhizophora* and *Sonneratia caseolaris*. A hand held Spectroradiometer which is in the range of 320 - 1100 nm (1 nm bandwidth) was used to collect the spectral signature measurements. Ten measurements were taken from each mangrove species followed by a reference measurement, under ambient light, temperature and other environmental conditions. Erroneous data as well as experimental errors were eliminated in all the spectral reflectance curves. Eleven vegetation indices; blue green pigment index (BGI), blue red pigment index (BRI), greenness index (GI), greenness vegetation index (GV), curvature index (LIC), carotenoid reflectance index (CRI), modified chlorophyll absorption ratio index (MCAR), modified vegetation stress ratio (MVSR), normalized pigment chlorophyll index (NPCI), photochemical reflectance index (PRI) and simple ratio (SR4) were selected and calculated. Average of each vegetation index for each mangrove species were obtained and t-tests were performed. Out of the studied indices, four vegetation indices; GVI, MVSR, PRI and BGI can be effectively used to differentiate the six mangrove species as they were statistically highly significant with p-value less than 0.0001. Moreover, the study reveals that the reflectance wavelength region of 450 - 720 nm can be used to separate the six mangrove species effectively.

Keywords: Mangrove, Spectral signatures, Vegetation index, Spectroradiometer

Spatial and Temporal Variation of Temperature Trends in Last Century of Sri Lanka

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The climate of Sri Lanka is characterized as tropical monsoonal. Temperature is one of the main elements in the tropical climate. Spatial differences observed in air temperature over Sri Lanka are mainly due to altitude, rather than latitude. The mean annual temperatures in Sri Lanka manifest largely homogeneous temperatures in the lowlands and rapidly decrease with altitude towards the Central Highlands. The mean annual temperature varies from 27 °C in the Coastal Lowlands to 16 °C at Nuwaraeliya (1900 m) in the Central Highlands. The objective of this study was to examine the spatial variation of temperature trends of Sri Lanka in the last century. The study was based on mean annual temperature data for the period from 1916 to 2015 at 15 meteorological stations distributed all over the island. The data were obtained from the Department of Meteorology, Colombo. The temperature trends over the last 100-year period were estimated using the Linear Regression analysis. The Mann-Kendall statistical test was applied to identify significant or non-significant monotonic trends. Spatial interpolation was done to prepare the temperature trend map for whole Sri Lanka using Radial Basis Functions Method in ArcGIS 10.2.

The results revealed that, the trends of mean annual temperatures have been increasing in all meteorological stations. Out of the 15 stations, 13 displayed statistically significant ($P < 0.0001$) increasing trends. The rate of the increment annual temperature for the 1916 - 2015 period was in the order of 0.009 °C per year (0.9 °C per century) in Sri Lanka. The highest increasing trends were noticed in and around Anuradhapura, i.e. 0.016 °C per year. Two other increasing trends were noticed in two clusters, one in Nuwaraeliya in the Central Highlands and another in Colombo in Western Coastal Lowlands. Mean annual temperature increment was higher in Dry Zone (0.01 °C per year) than that of the other two zones, i.e. Wet and Intermediate. The trend value of Intermediate Zone was 0.009 °C per year and the Wet Zone value was 0.008 °C per year. Reasons for the increase of temperature in Sri Lanka can possibly be the impact of global warming and the influences from El-Niño phenomena. Observed increasing trends of temperature can negatively impact on the human activities and natural environmental processes of Sri Lanka.

Keywords: Temperature, Trend, Variation, Significant, Interpolation

Increased Reactive Oxygen Species Induced by Toxic Heavy Metals as an Initiator of CKDu

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For more than two decades, many people in the North Central Province of Sri Lanka are affected by chronic kidney disease of uncertain etiology (CKDu). The main risk factors of this disease are identified as heavy metals (arsenic, cadmium and lead), pesticide exposure, heat stress and dehydration, fluoride content and hardness of water. To identify molecular mechanisms of renal injury by these factors, we carried out a comprehensive literature survey. According to literature, heavy metals like arsenic initiate toxicity through generation of excessive Reactive oxygen species via two mechanisms. The first mechanism is inducing enzyme complexes to increase reactive oxygen species formation. The second mechanism is via inhibiting antioxidant enzymes. To take an insight into which mechanism has the highest impact, we regenerated an existing mathematical model of redox system in the body. Since experimental data show an increase of superoxide level with heavy metal exposure, we increased superoxide concentration ten times in the simulation. Further, to simulate the inhibition of enzymes, enzyme levels were decreased ten times. Both changes increased reactive oxygen species levels such as hydroxyl ion and lipid peroxidation. In addition, increasing the superoxide level showed high impact rather than decreasing the antioxidant enzymes levels. The reason for increase of superoxide could be the ability of heavy metals to interact in activation of enzyme complexes such as NADPH oxidase, mitochondrial transport chain enzyme complexes I and III. The reason for depletion of antioxidants like Glutathione and antioxidant enzymes such as Superoxide dismutase and Catalase would be the ability of heavy metals to complex with thiol groups in these molecules. The outcome of both mechanisms was an accumulation of higher amount of reactive oxygen species inside the cell. These reactive oxygen species induced oxidative stress activates cellular pathways which lead to cellular toxicity.

Keywords: Heavy metals, Mathematical modeling, Reactive oxygen species

Physico-Chemical and Bacteriological Quality of Reverse Osmosis Water in Vavuniya District

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Vavuniya district is situated in Northern Province of Sri Lanka. The groundwater is the main drinking water source which has been under serious threat with the intensive resettlement and infrastructure development after the civil war and extensive application of fertilizer. Reverse Osmosis (RO) technique is widely used to convert the contaminated groundwater to drinking water. This study was designed to evaluate the physico-chemical and bacteriological qualities of RO water consumed by general public and to compare test results with SLS and WHO recommendation. Ninety (90) samples were collected in precleaned poly propylene bottles and all the testing was based on APHA and SLS method. Test Results reveal Turbidity was below SLS limit of 2 NTU which ensures efficient removal of undesired solids from groundwater. pH was in the range of 4.83 - 8.87 and 31 samples were below the 6.5 which is acidic in nature and facilitate releasing toxic metals from storage tank. EC and TDS ranges and their mean values were 4 - 257 $\mu\text{S cm}^{-1}$, 10 - 167 mg L⁻¹, 79 $\mu\text{S cm}^{-2}$ and 52.7 mg L⁻¹ respectively. TDS of 93.3% samples were below 100 mg L⁻¹ which was recommended as minimum limit for demineralized water by WHO. Total Hardness was in the range of 8 - 136 mg L⁻¹ and maximum and median of Calcium was 22 mg L⁻¹, 3 mg L⁻¹ respectively and 44.4% of the sample were below the LOD of 0.8 mg L⁻¹. Chloride level was in the range of 6 - 62 mg L⁻¹. Maximum level of Fluoride was 0.83 mg L⁻¹ with the median of 0.16 mg L⁻¹. Range and median of Nitrate and Phosphate was < 0.001 - 42.971, 4.565 mg L⁻¹, < 0.01 - 0.7 and 0.15 mg L⁻¹ respectively. Six samples were contaminated by Total Coliform which is an indication of the poor sanitary conditions and it can be due to post contamination in the storage tank. E-Coli was not reported in any of the samples. The results showed that RO technique can be used to purify the contaminated groundwater but mineral content of the filtered water was very low and can be considered as partially demineralized water. RO water does not provide a useful contribution to daily dietary intake and it is highly suitable for low mineral diets rather than sources for necessary daily mineral intake. It is recommended to re-mineralize the RO water before consumption and RO effluent water with high TDS should not be disposed back to ground as it will further damage the aquifer.

Keywords: Reverse Osmosis, Physio- Chemical, Groundwater

Avifauna at Warathenna-Hakkinda Declared Environmental Protection Area (EPA) in Kandy, Sri Lanka

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Sri Lanka has vast diversity and endemicity of both flora and fauna. The Mahaweli River is the longest river and it originates from the central highlands and flows through the wet, intermediate and dry zones of the country. It helps sustain a rich biological diversity. However, large extents along the river are yet to be explored for its rich biodiversity. One such area along the Mahaweli River at Gatambe, Warathenna in the Kandy District appears to harbor a rich biodiversity and hence recently declared as an Environmental Protection Area (EPA). The present study was carried out to investigate and prepare a comprehensive checklist of the avifauna in this declared EPA which may be used for future conservation efforts. The study was carried out from June 2016 to May 2017 along an approximately 2 km stretch of the Mahaweli River in the declared EPA starting from the Gatambe main bridge ($7^{\circ} 27'21.3''N$, $80^{\circ} 6'04.63''E$) to Dodangwela Suspension Bridge ($7^{\circ} 28'79.15''N$, $80^{\circ} 6'08.63''E$). Field sampling was carried out once a week during the study period in the declared EPA and sampling was conducted to encompass all habitat types. A point count method was carried out along 100 m transect to identify the birds and a maximum of 30 minutes was spent at each point. Birds were identified using direct observations with the aid of a 10×42 binocular and through birdcalls. Bird guides were used to confirm the identifications. A total of 74 bird species belonging to 61 genera were encountered from the study site. Among these, seven species were endemic while seven were migratory. Five percent of the birds recorded were raptors and most of them were canopy and sub canopy dwellers associated with riverine forests and islands. Most of the birds encountered use this area as their roosting and nesting areas. According to the National Red List (2012), 62 of the species recorded during the study are categorized as "Least Concerned", two species as "Vulnerable" (Sri Lanka wood pigeon, Sri Lanka Hill mynah), three as "Near Threatened" (Oriental dwarf kingfisher, Cinnamon Bittern and Black crown night heron), one as "Endangered" (Alpine swift) and another as "Critically Endangered" (Rock Pigeon) in their natural habitats. According to the Global Conservation Status, 72 of the species recorded during the study are categorized as "Least Concerned" while one species as "Vulnerable" (Sri Lanka wood pigeon) and one as "Near Threatened" (Sri Lanka Hill mynah). These habitats along the Mahaweli River at Warathenna appear to aid in sustaining a rich bird community so future conservation of this declared EPA will help create a safe haven for the avifauna.

Keywords: Avifauna, Mahaweli River, Diversity, River islands, Environmental Protection Area

Spatial and Temporal Variation of Flood Affected People in Ratnapura District

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The flood is one of the hydro-meteorological disasters frequently occurred in the Ratnapura District. The Ratnapura District has 3275 km² in land. The highest land cover is occupied by the Kalu Ganga Basin. Kalu Ganga is the second largest river basin in Sri Lanka which receives the high amount of rainfall and volume of river discharge. Due to its hydrological and topographical characteristics, people in the lower plain suffer from frequent floods. The aim of this study is to identify the spatial and temporal variation in relation to People Affected (PA) by Flood in the Ratnapura District. The analysis was mainly based on publicly available data obtained from the Disaster Management Centre (DMC) and District Secretarial Office in Ratnapura for the period from 1987 to 2016. ArcGIS 10.2 techniques were used to create the Choropleth Maps, and the Excel software was used for data analysis and interpretation. A larger number of people are affected in the northwestern quarter of the District and it was high in Ratnapura DSD out of total 17. The other cluster has been identified in Elapatha, Kuruwita, Kiriella, Nivithigala, Pelmadulla and Ayagama DSD. These flood areas are located towards the lower plain in Kalu Ganga Basin and are heavily populated when compared with the other areas of the District. DSDs in the Eastern part of the District have a lower number of PA by flood. 76% of the people have been affected by floods during the southwest monsoon season. The month of May is identified as the peak month in term of PA. This peak has a direct correlation with the climatic seasons in Sri Lanka. The number of people affected by flood in the Ratnapura District has been increased by 137,224 (about 47%) in the recent period of 2002 - 2016 compared to 1987 - 2001. The reason for the increase of PA by Flood in Ratnapura District was identified as the increases of improper land use practices, irrigation management issues, extreme and high intensity of rainfall. This situation will negatively affect the socio-economic condition of the society and water discharge processes of the entire Basin.

Keywords: Spatial, Temporal, Variation, Flood, Affected People

Environmental Risk Assessment of Water Basin in Capital City Area of Sri Lanka

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Metropolitan city Colombo can be polluted by many ways. This study was addressed to analyze canal/lake sediment and water samples in selected locations within the Colombo basin to assess the possible environmental risks and challenges of people in those areas. Sampling was carried out only between 8.00 a.m. to 12.00 noon in order to arrest the similar conditions in terms of tidal variations. A grab sampler was used to collect sediment samples at the bottom surface and water samples were collected from the upper 12 inches of the surface. Sulfate, Chloride and heavy metals of sediment samples and pH, Conductivity, COD, BOD, Heavy Metal, Total & Fecal Coliforms and Oil and Grease content of water samples were analyzed in accordance with BS 1377: 1990 and APHA (2005). Heavy metal content varied as for cadmium in the range of 0.4 to 8.3 mg kg⁻¹, chromium 20.1 to 72.8 mg kg⁻¹, lead 30.2 to 805.3 mg kg⁻¹, arsenic 0 to 3.1 mg kg⁻¹ and mercury 0.7 to 3.0 mg kg⁻¹. Sulfate content of sediment varied within the range of 50 to 439 mg kg⁻¹. Chloride content of sediments was from 4 to 48 mg kg⁻¹. The pH varied in between 7 to 8.5 and mostly pH was 7.6. Conductivity was distributed within 11.1 to 539 μ s cm⁻¹. BOD levels were in the range of 9 to 20. COD values were in between 14 to 60 ppm. Oil and Grease content was somewhat high and it was at 7.3 - 296.8 ppm. Total Coliforms was 230000 to 5400000 MPN per100 ml. Fecal Coliforms was in between 130000 to 490000 MPN per100 ml. From the above studies, we conclude Beira Lake has the highest risk for pollution and Madiwela East Lake reported to be at lesser risk with respect to chemicals and microorganism. All measurements indicated that all sampling locations are badly contaminated with fecal matter and hence it will have the considerable adverse impact on human health.

Keywords: Water, Sediment, Risk Assessment, COD, BOD.

Thermal Ecology of an Endemic Sri Lankan Kangaroo Lizard (*Otocryptis wiegmanni*) under Wild and Captive Conditions

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Thermal ecology of Sri Lankan endemic agamid lizard species is poorly known, but vital for their conservation. This study examined the thermal ecology of *Otocryptis wiegmanni* both under wild and captive conditions. External body temperature (T_b), corresponding environmental temperature (T_e), sex and behaviour of 121 lizards were recorded. In captivity T_b and T_e were recorded at one hour time intervals within 24 hours for 10 days. For the wild condition, T_b and T_e were randomly collected both in day and night time. In the wild, T_b was significantly lower than T_e ($p > 0.05$) and mean difference was -1.59 °C. There is a positive correlation between T_b and T_e ($r = 0.816$, $p < 0.05$). The best fit regression line is $T_b = 5.86 + 0.695T_e$ ($R^2 = 66.6\%$). Regression coefficient (0.695) is significant ($p < 0.05$). Although in captivity, T_b was significantly lower than T_e ($p > 0.05$) and mean difference was -0.91 °C. T_b and T_e shows strong positive correlation ($r = 0.914$, $p < 0.05$). Best fit regression line is $T_b = 1.95 + 0.886T_e$ ($R^2 = 83.6\%$). Regression coefficient (0.886) is significant ($p < 0.05$). Moreover in both wild and captive conditions, T_b of males and females were not significantly different. Regression coefficients of both wild and captivity differ from the theoretical value of zero required for thermoregulation verify that *O. wiegmanni* is a *thermoconformity* species. The T_b for this population ranged between 20 - 26.5 °C. We never observed *O. wiegmanni* showing obvious basking behaviour, may be a reason for having a lower T_b than T_e. Activities such as territorial and courtship display, mating, egg laying, and feeding occurred during daytime while they are dormant at night and mostly perch above ground. Moreover, *O. wiegmanni* is adept at tracking environmental temperature by selecting appropriate thermal microhabitats to maintain their body temperature within the optimal level. This study provides a basis and emphasizes the necessity of in-depth thermal ecological studies on Sri Lankan agamids.

Keywords: *Otocryptis wiegmanni*, Sri Lanka, Lizard, Thermal ecology, Body temperature

Evaluation of Rain Drop Project Introduced for Chronic Kidney Disease Uncertain Etiology (CKDu) Patients in Ginnoruwa, Mahiyanganaya

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CKDu is a serious medical problem in the Dry Zone of Sri Lanka. There is an increasing trend for kidney patients in Ginnoruwa GN division of Mahiyanganaya in the recent past. Badulupura is one of the villages in this division where high prevalence of CKDu has been recorded. Since fresh water supply is limited to this area, a Rain Drop Project was introduced in 2015 for CKDu affected families. The project had supported families with 5000-liter water tanks and other utilities. This study has been conducted to assess the outcome of this activity after a period of one-year. The main objective of this study was to reveal the perception of patients on drinking of rain water in terms of the changes of symptoms and future expectations of the patients. A questionnaire based survey, direct observations, and focused group interview with doctors, villagers, and hydrologists were performed to gather primary data and information. Of the respondents, 92% were living in this area for more than 30 years and 72% were paddy farmers. 40% of patients have mentioned that they believe unsafe water is one of the reasons of CKDu. Before the project only 32% patients knew that the rain water is suitable for drinking purposes. Prior to this project, patient used well water for daily consumption and among them 64% used filter or boiled water before consumption while 36% used well water without any purification. 60% patients had the perception that the rain water is natural and it will indirectly supports to control their CKDu. The study also revealed that some symptoms of CKDu patients like burning sensation of urine have been decreased significantly after drinking rain water. 64% patients stated that before the project they used well water and had the symptoms of dark color of their urine and after the project when they use rain drop water the urine color has been changed to pale. At present, 100% of the patients use rain water for drinking purposes. Most of the villagers agreed that this project is useful and successful. Families should be encouraged to use the rain water for their daily consumption which also one of the adaptation practices for the water scarcity in the study area. Providing of good quality water for one year period is not sufficient to assess any biochemical improvement of renal function. It is necessary to conduct future assessment on this issue to come for the concrete indication.

Keywords: Rain Drop Project, Chronic Kidney Disease, Uncertain Etiology, Rain Water, Symptoms

Rainfall Variations in Kandy District of Sri Lanka

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Rainfall of Sri Lanka is of multiple origins, including monsoonal, convectional and depression. In the rainfall calendar of Sri Lanka, four rainfall seasons have been recognized. They are the First Inter-Monsoon (FIM), South West Monsoon (SWM), Second Inter-Monsoon (SIM) and North East Monsoon (NEM). Rainfall variability over space and time must be regarded as the most significant aspect of the monsoon climate over Sri Lanka. The main objective of this study was to identify the spatial distribution of annual and seasonal rainfall in Kandy District (KD). The monthly rainfall data have been collected from 19 rainfall stations in KD from 2005 to 2014. The data were obtained from the Department of Meteorology and other relevant institutions. Spatial interpolation was done to prepare the isohyet maps for KD using Radial Basis Functions Method in ArcGIS 10.2. The analysis shows that the highest annual average rainfall (5,660 mm) has been recorded at Galamuduna Estate in Dolosbage, and the lowest is recorded at Kundasale (1,594 mm) during the study period. From 2001 to 2014 the Galamuduna annual average rainfall was 5,176 mm. According to the seasonal rainfall, during the FIM period (March-April) the rainfall varies from 700 mm (Craighead Estate) to 241 mm (Minipe). Rainfall during SWM period (May to September) varied from 3,436 mm at Galamuduna to 174 mm at Minipe. The southwestern windward side received the highest rainfall while the Eastern leeward side received the lowest during SWM season. The Galamuduna Estate is situated in highest rainfall region of Wet Zone Up-Country of Sri Lanka. The SIM period (October to November) showed most evenly distributed rainfall over the Kandy District. During the NEM period in December to February, the highest rainfall was recorded in the Eastern side of the KD. The highest rainfall (700 mm–1,000 mm) is recorded in and around Minipe station during this season. Kandy Plateau area received a lower rainfall in the NEM season. The study revealed that the annual and seasonal distribution of rainfall over Kandy District has considerable differences. Based on the annual average rainfall, the wettest place of the Kandy District was the Galamuduna Estate and the driest places were recorded as Kundasale and Minipe. The month of June was recorded as the wettest month (777 mm) in Galamuduna and the same month, Minipe (5 mm) was noticed as the driest during the study period.

Keywords: Rainfall, Isohyet map, Interpolation, Windward side, Leeward side

Study on Utility of *Crassostrea madrasensis* Oyster Shells for Water Quality Improvement: An Alternative for Wastewater Treatment

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Oyster shell is a waste residue in sea food industry, thus waste accumulation can be minimized by reusing shells in environmental applications. Most biogenic structures act as adsorbents and biofilters in wastewater treatment. This study focuses on analysis of the potential use of *C. madrasensis* Oyster shells for removal of contaminants. Removal efficiency of heavy metals (Cu/Cd/Cr) and other physicochemical parameters in wastewater were tested in 7 treatments (different levels of thermally treated crushed oyster shells: 5 g, 7 g, 9 g, 10 g, 11 g, 13 g and 15 g) for 24 hrs contact period. As results revealed, heavy metal adsorption capacity significantly changed with initial heavy metal levels and adsorbent masses ($p < 0.05$). Wastewater treated with 9g of shell powder had most efficient heavy metal removal rates for Cu (94.50 - 99.88%) and Cr (95.68 - 97.70%), while 99.16 - 99.64% of highest Cd removal rate was for wastewater treated with 11g of oyster shells. Chitin in thermally activated shells make strong adsorption capacity, thus Oyster shells act as an effective biofilter in removal of heavy metals in wastewater. Average DO increased to maximum 37.73%, while highest removal efficiency of COD was 54.80% for 15 g of shell powder after 24hrs contact period. Initial PO_4^{3-} concentration significantly decreased with increased shell powder amount ($p < 0.05$) by flocculation of phosphorous with CaO in shells during 24hrs retention period. Highest phosphate removal capacity (85.9 - 56.2%) was found to be at 15 g of shell powder, indicating potential of application in eutrophicated water. Final pH was found to be increased to 6.5 - 8.5 which is optimum pH range for aquatic life. 24 hrs is the adequate contact period to equilibrate the reactions between adsorbent and waste water, hence preventing further releasing of chemicals of shells into treated water. This study reveals potential use of *C. madrasensis* Oyster shells for wastewater treatments as a low cost, environmental friendly alternative method.

Keywords: Bio-filter, Adsorption Capacity, Physicochemical properties, Wastewater treatment, Oyster shells

Geophysical Techniques and Geochemical Analysis for Identification of Potable Groundwater – A Case study from Morawewa Area

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Appropriate accessibility to drinking water is a major concern throughout the world. Having access to safe drinking water leads to improvements in health of communities while achieving local (SLS) and international (WHO) Standards, which is a basic measuring-yard of the development of a nation. Dry-zone of Sri Lanka has recently suffered due to lack of drinking water availability and this trend is set to be climbed for damaging heights, as time passes. This study was carried out selecting Morawewa as a sample area, which is situated in the North Central part of Sri Lanka and adjoining the Trincomalee district, bounded by latitude $8^{\circ} 35' 0''$ - $8^{\circ} 38' 0''$ North and the longitude of $80^{\circ} 50' 0''$ - $81^{\circ} 04' 0''$ East. The present study aims to detect the groundwater potential in Morawewa area of Trincomalee District, Sri Lanka using electrical measurement and geochemical analytical methods. Electric resistivity data interpretation was carried out by using Schlumberger configuration with electrode spacing (AB/2) of 100 m distance. The resistivity curves were analyzed with curve matching techniques along with the help of RESIST Software. The results of quantitative interpretation of geophysical data indicated that the layer system having minimum of two layers to a maximum of three layers in the area and the maximum depth to the bedrock was 17.9 m. Hence based on the range of resistivity values and graph trending, the weathered and fractured zones were interpreted. The contacts between certain saturated and dry formation zones having different resistivity values were identified from the interpreted resistivity curve and the range of resistivity value. Moreover, geochemical analysis revealed phosphate contamination in the dug well water samples.

Keywords: Geophysical survey, Schlumberger, 1-Dresistivity survey, VES, Groundwater explorations, Morawewa , Trincomalee , Sri Lanka

Assessment of Groundwater Contamination at Jaffna Municipal Council Solid Waste Dumping Site

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Groundwater is the major natural water resource in the Jaffna Peninsula, and it is used for domestic, agricultural and industrial purposes. Disposal of solid waste is increasingly affecting the quality of the limited groundwater resources of this part of the country. This study investigates the groundwater quality around the Kaakkaithivu landfill site in Jaffna in order to assess the impact of leachate percolating into the underlying aquifer. Groundwater samples were collected from fifty dug wells. Various physicochemical parameters including pH, Temperature, Electrical Conductivity (EC), Total Dissolved Solids (TDS), nitrate (NO_3^-), phosphate (PO_4^{3-}), heavy metals (Cu, Cd, and Cr) and bacteriological contamination were measured. Their spatial distribution patterns were plotted using ArcGIS software 9.0 - 9.1. The results show that, groundwater of the study area was found to be heavily polluted with Cd. EC, TDS and E- Coli levels are excessively high comparing SLS standards. NO_3^- and Cr concentrations in 20% of the wells exceed the maximum acceptable levels. It can be concluded that Kaakkaithivu landfill is leading to significant groundwater contamination. Therefore, separation of solid waste method could be an alternative method to solve the landfill leachate issue.

Keywords: Groundwater pollution, Heavy metals, Leachate, Landfill.

Geochemical Characteristics of Geothermal and Non-geothermal Water at Wahawa Field in Sri Lanka

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Hydrogeochemistry of the geothermal and non-geothermal water is highly related to geology in Wahawa geothermal field. The objective of this study is to accumulate all existing geochemical and isotopic data into the water in the Wahawa area, in high grade metamorphic terrain of Sri Lanka. In this study, the Cl⁻-SO₄²⁻-HCO₃⁻, and Na-K-Mg ternary diagrams, stable isotopes were used to characterize the water and estimate the subsurface temperature using AqQA computer code. Twenty two water samples were analyzed. Geochemistry of geothermal water is separate from that of non-geothermal water. Higher contents of Na, K, Cl, F, Br, NO₂⁻, NO₃⁻, PO₄³⁻, SO₄²⁻, and Total Dissolved Solids in geothermal water are most likely due to the dissolution of feldspar, mica, and sulfide minerals in the granitic and dolerite rocks. Similarly, lower values of Mg, Fe, Cu and Zn suggest less ferromagnesian minerals in the basement. The classification based on major ions reveals a Na-K-SO₄ type of geothermal water for Wahawa. Non-geothermal water is dominated by the Na-Ca-SO₄. The water was classified, mixing processes studied and the origin and movement towards the water determined. From the ternary plots, the waters can be classified as groundwater, geothermal water and a combination of the two, with the geochemical diagram which plots close to mature water. The plots also suggest that all the water originates from old systems. In overall, the chemical compositions of geothermal water in this area are determined by the interface between the groundwater (meteoric waters of current hydrological cycle) and the rock environment. The procedure may depend on pH, mineralization, the rate of other ions and temperature. Most of the geothermal water seems to have equilibrated with respect to specific minerals. Geothermal waters in Wahawa are formed by mixing.

Keywords: Hydrogeochemistry, Geothermal water, Ferromagnesian, Mineralization, High grade metamorphic terrain.

Diurnal Behavioral Patterns and Substrate Use of Endemic Endangered Frog *Fejervarya greenii* in Horton Plains National Park (HPNP)

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With the objective of providing important data through studying diurnal behavioral patterns and substrate use for the conservation of endemic endangered frog *Fejervarya greenii* the study was conducted in and around five lentic waterbodies in HPNP for three consecutive days per month from January to December 2016. Time periods were selected as 06:00 hrs – 09:00 hrs, 09:00 hrs - 12:00 hrs, 12:00 hrs - 15:00 hrs, 15:00 hrs - 18:00 hrs and 18:00 hrs - 20:00 hrs. Possible substrate types were recorded as submerged plant cover, bare water cover, short plants and shrubs cover, grass cover, decaying plant matter and leaf litter cover, sand, mud, gravel and rocks. Locomotion, feeding, resting, refuge use, alert, calling, courtship and swimming were identified as distinct behaviors of *F. greenii*. The behavior of both mature and immature individuals were recorded in 30 second intervals for 20 minutes in each time period. The utilized substrate in each behavioral pattern was recorded. Individuals tend to rest between 06:00 hrs - 09:00 hrs. They were moderately active during 09:00 hrs - 12:00 hrs and mature individuals used to call most of the time. *F. greenii* was mostly inactive during the time period of 12:00 hrs - 15:00 hrs. They tend to rest, call and exhibit courtship behaviors during 15:00 hrs - 18:00 hrs. They were most active during 18:00 hrs - 20:00 hrs. Each distinct behavior was recorded in submerged plant cover. Swimming was restricted to bare water cover. Calling and courtship behaviors were restricted to submerged plant substrate. Gravel and rocks were not utilized. Relatively inactive behavior during the time period of 12:00 hrs - 15:00 hrs was probably a behavioral adaptation to avoid high desiccation during this hottest time. Calling and courtship behaviors were observed in each month which indicates that this species breeds continuously throughout the year. This study identifies the submerged plant cover associated with lentic water bodies as the breeding habitat of this endangered frog population.

Keywords: *Fejervarya greenii*, Horton Plains National Park, Behavior, Substrate Use

Fabrication of Supersand for Water Purification

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Fluoride is an essential constituent for both human and animal health that depends on concentration in the medium. The sand is conventionally used in water treatment plants to control water turbidity. This project is aimed at improving its performance using a chemical modification to remove other water contaminants as well. Thus improved substrate is designated as "Super sand". Super sand has proven to be a better adsorbent for the removal of certain heavy metals and dyes from water. Among several treatment technologies applied for fluoride removal, adsorption process has been explored widely and offers satisfactory results especially with mineral-based and/or surface modified adsorbents. Graphene Oxide was synthesized using the modified Hummer's method. Super sand was synthesized by heating a mixture of sand and graphene oxide/deionized water in an oven for two hours. The process was repeated five times for multiple coating. Graphene oxide and super sand were characterized using Scanning Electron Microscope (SEM), Energy Dispersive X-ray Spectrometry (EDS), Fourier Transform Infrared Spectroscopy (FT-IR) analysis and X-Ray Diffraction (XRD). The applicability of the synthesized material in the water industry for fluoride removal was studied utilizing sand, GO-sand and GO multiple coated sand at varying pH conditions. These results are to be confirmed by conducting further scientific studies.

Keywords: Fluoride, Graphene oxide, Super Sand, Normal Filter Sand, GO-Sand Coating 01, GO-Sand Coating 05

Relations of Municipal Solid Waste Generation and Composition to Socio-Economic Factors of Households

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There is a lack of knowledge about solid waste generation and composition, especially in rural areas because these types of studies were conducted mainly in cities. This leaves the relevant authorities with inadequate information to plan efficient solid waste management. The objective of the study is to determine the quantity of solid waste generation, composition and relationship to socio-economic factors. This study was carried out at Kolavil-01 (Gramha Niladhari Division-16) of Alayadivembu Pradeshiya Sabha, Ampara district. Questionnaire survey covered hundred households and data were analyzed using Microsoft Excel and Statistical Package for Social Sciences. The results revealed that the total household waste generation was ranging from 0.35 kg day^{-1} to 3.41 kg day^{-1} with an average of 1.67 kg day^{-1} . The average amount of household's biodegradable, plastic, polyethylene, metal and glass wastes were 1.37 kg day^{-1} , 0.07 kg day^{-1} , 0.03 kg day^{-1} , 0.13 kg day^{-1} and 0.06 kg day^{-1} respectively. Generation of biodegradable waste was higher than the other wastes while the generation of polyethylene waste was lower. In addition, biodegradable waste contributed nearly 82.54% (by weight) of the total waste generation while plastic, polyethylene, metals contributed 4.04%, 1.87%, 7.72%, 3.84% respectively. Further, it was proved statistically that the household solid waste generation had positive correlation with family income and family size while it had non - significant negative correlation with age and significant negative correlation with education level and occupation of family head.

Keywords: Socio-economic, Municipal, Solid waste

Optimization of Pre-Treatment Process of Iron Removal from Groundwater

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The presence of iron is one of the major issues experienced by groundwater consumers. The rural water treatment plant located at Bolagala area in Kandy treats water mainly for iron removal. The available half treatment process of this plant removes 83.20 - 93.06 % iron from natural water. As the raw water iron concentration is high, the removal percentage is not adequate to bring the iron concentration down to the recommended standards (SLS 614: 2013). The study was carried out to optimize the existing pre-treatment process with the purpose of bringing the treated water iron concentration under 0.3 mg/l. Two oxidation processes a) Aeration b) Chlorination were experimented to select an optimum oxidant. Aeration was tested for different time periods. 6 min aeration time showed approximately 50% removal of dissolved iron concentration. Chlorination was tested for different doses. 5 ppm chlorine dose was effective in 99% removal of the dissolved iron. The final dissolved iron (DI) concentration reached 0.03 mg/l which is ten times lower than recommended level. The plant pre-treatment step should include a chlorination step with aeration to achieve the optimum removal of dissolved iron in raw water.

Keywords: Aeration, Chlorination, Groundwater, Iron removal, Oxidation

Identification of Perception and Adaptation to Climatic Change by the Tea (*camellia sinensis*) Small-holders in Rathnapura District

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As all other agricultural crops, tea cultivation also cannot escape from the consequences of climate change. In Sri Lankan context, majority of tea production is by smallholders and thus tea smallholders' perception on climate change and possible adaptations to it are crucial for the future of the tea industry of Sri Lanka. Therefore, this study attempted to identify the major factors influencing the perception and the adaptation to climate change among tea smallholders over 5 tea inspector ranges in Rathnapura District. The simple random sampling technique was used for data collection. The interviews were conducted with 160 smallholders and those were analyzed using Two Step Heckman's probit model. First, whether smallholders perceiving the climate change and then responding to those changes through the adaptation were considered in the two steps of the model. The results revealed that, the majority of smallholders in Rathnapura District have perceived the changes in climate. Farmers' perception on climate change was significantly related to the gender, crop type (mono cropping), and education level, awareness of the weather forecast and frequency of usage of communication channels. These factors were positively affected to the perception and use of print media as communication channel has decreased the perception level of smallholders. According to their responses, factors affecting the level of adaptation to the climate change were yield, land extent, labor use and temperature change. Further, yield and temperature changes have positive impact on use of adaptation measures by smallholders. Also land extent and family labor involvement have negatively affected to adapt the climate change. According to the findings, by strengthening the awareness programs, weather forecast and extension services can uplift the perception of the climate change and the use of adaption measures by tea smallholders.

Keywords: Adaptation, Climate change, Perception, Smallholders, Tea cultivation

Degradation of Cellulose and Pectin in Organic Wastes by Selected Fungal Strains

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Solid waste management is becoming more complicated due to rise in population, industrialization and changes in life styles. In nature, microbial diversity exhibits wide range of activity, association and interaction with each other and with their environment. Microbes releasing pectinolytic and cellulolytic enzymes are playing a major role in degradation and decomposition of organic compounds. This study aimed to investigate the degradation of cellulose and pectin in organic waste by fungi. A total of 10 fungal species were isolated from waste samples collected from municipal waste dump near Vincent Dias stadium in Badulla. Pectinolytic and cellulolytic activity of isolates were tested by standard plate assays and best strains to degrade cellulose and pectin were selected (F3, F6A, F6B, F8 and F10). Selected fungal species were inoculated to particles (> 1 cm diameter) of corn cobs, banana peduncle and jack fruit axis and incubated under laboratory conditions. Weight loss percentage (WL %), sugar production and Fourier Transform Infrared (FTIR) spectroscopy data were gathered from samples within 5 days interval for 50 days. Experiment was conducted by following complete randomized design with three replicates. The highest weight loss percentage was obtained in F10 treated corn cobs sample (WL% = 1.3). Weight loss percentages and sugar analysis values with respect to the time started to be static after 45 days. It may be due to the fact that the microbial growth has entered a stationary phase since available nutrients have decreased in the medium. According to the FTIR data, the F3 and F6B treated corn cob samples and F8 treated banana peduncle samples had significantly high ($p \leq 0.05$) absorbance in polysaccharide window ($900 - 1200 \text{ cm}^{-1}$) at the fifth day of incubation. In conclusion, all fungi stains used in the study have the ability to degrade organic waste efficiently.

Keywords: Cellulose, Pectin, Organic waste, Fungi

Development of Micro-Propagation Protocol for *Aponogeton dassanayakei*

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Aponogeton is a genus of freshwater aquatic plants and there are five *Aponogeton* species native to Sri Lanka with three endemic members. They have a high demand as an ornamental aquarium plant, food source and medicinal herb. Due to these reasons over exploitation of plants from natural habitats is common with poor attention on conservation. *Aponogeton dassanayakei* is a newly identified *Aponogeton* species from Sri Lanka. This study was carried out to develop a micro-propagation protocol for newly identified *Aponogeton dassanayakei*. Treatments included full strength Murashige and Skoog (MS) solid basal media supplemented with combinations of 6-benzylaminopurine (BAP) (0.00, 1.00, 2.00 mg L⁻¹) with 0.10 mg L⁻¹ Indole-3-acetic acid (IAA) and without IAA for both shoot initiation and multiplication in seed culture. Ten replicates obtained per each treatment. During shoot initiation seed germination rate, seedling height and number of leaves per seedling were taken as the response variables and shoot multiplication stage plant height and number of leaves were considered. Application of hormones showed significant effect ($p < 0.05$) on both number of leaves and seedling height but not on seed germination rate in shoot initiation. Hormones supplemented in solid media during shoot multiplication were shown significance difference ($p < 0.05$) in plant height but not in number of leaves. According to the study, MS medium supplemented 1.00 mg L⁻¹ BAP is the best for shoot initiation. MS medium containing 2.00 mg L⁻¹ BAP is best for shoot multiplication. The study demonstrated that micro-propagation could be useful for large scale propagation of *Aponogeton dassanayakei* while conserving the plant in natural habitat.

Keywords: *Aponogeton dassanayakei*, Micro propagation, Murashige and Skoog medium, 6-benzylaminopurine, Indole-3-acetic acid

Germination Characteristics of Rhizomes of *Panicum maximum* in Coconut Plantations of Sri Lanka

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Panicum maximum is a major weed in the coconut lands and many of the bare lands. Being an invasive and aggressive weed, other than high seed production capacity, germination of rhizomes has a major role for its continuity as a perennial weed. If germination is controlled, it would ultimately result in growth suppression and control of the weed for some extent. Experiment was therefore conducted to investigate the impact of air drying of rhizomes of *P. maximum* on reduction of moisture, total carbohydrate percentage and finally the germination at the CRI, Lunuwila, Sri Lanka. A bulk of uniformly grown plants of *P. maximum* was uprooted from a coconut land and grouped into 8 treatments based on three factors such as presence/absence of soil with roots, presence/absence of leaves, split/unsplit bush condition. Rhizomes were air dried for 0 to 12 days at 3 days interval in a plant house. Air drying of rhizomes for more than 3 days reduced the moisture content, total carbohydrates and germination of rhizomes. Initial moisture content of 75.4 % reduced to the lowest of 6.4% when drying for 12 days in *P. maximum* without soil, with leaves treatments. Initial carbohydrate content also reduced from 0.17% to 0.03% when drying for 12 days in *P. maximum* without soil, without leaves treatments. Germination was totally inhibited when air drying for more than 9 days in all treatments and further *P. maximum* without soil, with leaves treatments recorded 16 - 20% germination. Most effective agronomic practice to control *P. maximum* was the removal of the soil attached to the root system after uprooting and laying for air drying for 6-9 days, where soil is no in contact with roots.

Keywords: Air drying, Germination of rhizomes, Moisture content, *Panicum maximum*, Total carbohydrates

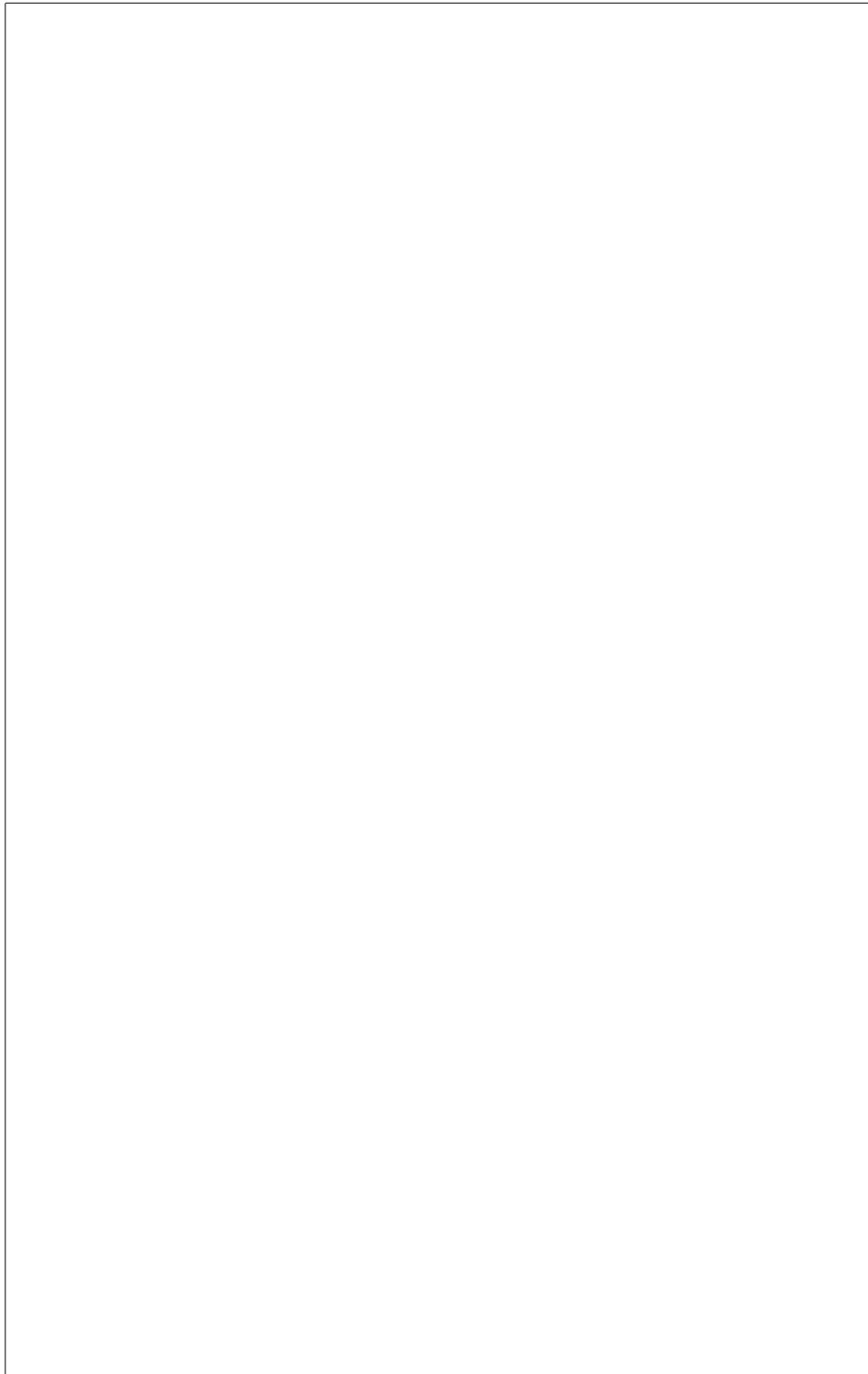
Environmental Valuation of Dunhinda Falls

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The environmental valuation for natural assets in Sri Lanka is very important now a days because presently natural resources are being destroyed. It can provide lots of arguments about protecting natural resources. Dunhinda Falls is one of the main natural resource of the country which is located in Badulla District. As main foreign and local visitors attracted to this place it is important to calculate total economic value of the Dunhinda Falls. Travel Cost Method (TCM) was used to evaluate the economic value of Dunhinda Falls. The objective of Travel Cost Method was to identify the net value of the Dunhinda Falls and identify the people's requirements regarding the water fall. A total of 30 respondents from the visitors who are from different provinces to this fall, were interviewed using structured questionnaire. By using these answers the number of visitors from each provinces per year were calculated, and total visitors per year was gained. The estimated value for Dunhinda Falls for 2017 was worth LKR 7,743,892 (Sri Lankan Rupees). By applying the model, derived from the study can be used to assess the economic value by travel cost method of natural water falls in this region. It can be suggested to responsible persons to take correct actions to protect the valuable resource and take best actions to attract foreign and local people. It will help to increase foreign exchange and increase the living standards of people who live near Dunhinda Falls.

Keywords: Dunhinda Falls, Economic value, Travel Cost Method



Food Science and Technology

- Food Microbiology
- Food Chemistry
- New Product Development
- Dairy, Meat, Fish and Egg Technology
- Cereal, Grain, Fruit, Vegetable, Spice and related Product Processing Technology
- Beverage Technology
- Food Safety and Quality

Identification of Possible Microbial Contamination Points and Sources in Commercial Tea Blending Process Factory in Kelaniya

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Exporting quality deteriorated tea will degrade the brand reputation of “Ceylon tea”. Rejecting tea at point of export will result a loss of international tea market. Objective was to determine the major contamination sources during black tea blending processing in tea blending factory in Kelaniya, Sri Lanka. Nine control points including 06 swab collecting points (packing materials, blending floor, employees’ hands, 3 stainless steel equipment used) and 03 tea samples (raw material feeding point, conveyor belt, bag feeding point) have been examined for the enumeration of total aerobic mesophilic bacteria, *Coliforms*, *Escherichia coli*, yeast and mould and *Salmonella*. Microbial count of raw and blended black tea was benchmarked with SLS black tea standards followed by Sri Lanka tea board. Microbial count of raw black tea and blended black tea for total aerobic bacteria and yeast and mould were $\log 12.2122 \pm 0.6232$ cfu /g, $\log 13.3636 \pm 0.8751$ cfu /g and $\log 11.9699 \pm 0.7404$ cfu/g, $\log 12.0755 \pm 0.8751$ cfu/g respectively and exceeded the acceptable level according to the Sri Lanka tea board. Employees’ hands and blending floor were positive for *E.coli* and *Salmonella* tests indicating that high possibility to contaminate Black tea blending process through faecal matter. Control point examination identified, raw material as the primary contamination and personnel hands and blending floor as the secondary contamination sources. High microbial count of blending floor may be due to shoes of visitors and supervisors walking across the floor. In conclusion, there is a requirement to initiate GMP for primary tea processing to select black tea with low initial microbial counts to the plant. Initiation of proper hygiene conditions with sufficient sanitary applications is necessary to eliminate remaining particles from initial blending to minimize cross contaminations.

Keywords: Black tea, Microbial contamination, SLS standards

Variation of Antioxidant Activity of Traditional Rice Due to Gamma Irradiation

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Many traditional rice varieties are very high in nutritional value and reported to have medicinal properties, but can be experienced quality degradation due to many reasons. Irradiation is one of the best technologies that can be used in food preservation very effectively. This study was carried out to investigate the effect of gamma irradiation on antioxidant properties of ten different, commonly available traditional rice varieties of Sri Lanka. The varieties including Suwandel, Madathawalu, Kuruluthuda, Pachchaperumal, Kahamala, Rankahawanu, Hichchinangi, Gonabaru, Heenati and Hatadaa were collected from North central province in Sri Lanka. The varieties were irradiated at 5 kGy levels using Cobalt-60 radiation sources at Sri Lanka Gamma Center of the Atomic Energy Authority of Sri Lanka. The antioxidant activities of these rice varieties were determined by using DPPH method. The free radical scavenging activities of these rice samples were compared with Ascorbic acid and BHT as standard. The highest antioxidant activity of unprocessed raw rice was reported in Hatadaa (93.3%) followed by Hichchinangi (93.2%), Madathawalu (92.5%), Kuruluthuda (92.3%), Heenati (92.0%), Gonabaru (92.0%) and Pachchaperumal (88.2%) with respect to standard BHT (93.5%) and Ascorbic (96.0%). However, Kahamala (46.0%), Suwandel (29.0%) and Rankahawanu (35.3%) showed low antioxidant activity. No significant difference of antioxidant activity was reported in irradiated rice samples. The antioxidant activity of irradiated Hatadaa (92.6%), Hichchinangi (91.7%), Kuruluthuda (92.0%), Heenati (92.0%), Gonabaru (92.6%) were still higher and no significant reduction were recorded. The study concluded that the gamma irradiation process not considerably change the antioxidant activity of Sri Lankan traditional rice varieties.

Keywords: Antioxidant activity, Rice, Gamma irradiation

Evaluation of Anti-Bacterial Activity of Hydrolyzed Ovomucin Using Fish Pattie Produced from Tilapia (*Oreochromis mossambicus*)

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Fish patties contain higher amount of essential nutrients. Ovomucin is an egg white protein and can be used to produce bioactive peptides with various functional properties. This study was conducted to determine the effect of hydrolyzed ovomucin on the survival and growth of *Salmonella* sp. and *Escherichia coli* in vacuum packed fish patties made from Tilapia (*Oreochromis mossambicus*) during storage at -18°C for 28 days. Ovomucin (20 mg/ml) was hydrolyzed with heat inactivation at 100°C for 15 min. Fish patties contained fish (64%), bread crumbs (17%), ice (12%), vegetable oil (4%), salt (2%) and spices. Seven different treatments including ovomucin hydrolysate and curing salt in ratio of 125 ppm: 0 (as positive control), 0:100 ppm (Tr₁), 62.5 ppm: 62.5 ppm (Tr₂), 31.25 ppm: 93.75 ppm (Tr₃), 93.75 ppm: 31.25 ppm (Tr₄), 125 ppm of ovomucin (Tr₅) and no additives (as negative control) were prepared as above mentioned procedure. Samples were cooked at 80°C to reach a core temperature of 72°C and cooled in cold water. Samples containing hydrolysates showed significant (P<0.05) antimicrobial activity compared with negative control. However, the effect of Tr₂ on *Salmonella* growth inhibition was higher than other treatments. Similar effects were found with *E. coli* growth inhibition. The combined antimicrobial effect of curing salt and hydrolyzed ovomucin was higher than using them alone, in both contaminated samples. Generally, all tested food-borne microbes were significantly (P<0.05) affected by adding curing salt and hydrolyzed ovomucin. It can be concluded that antimicrobial activity on foods can be much stronger when incorporated hydrolyzed ovomucin with curing salt. In addition, hydrolyzed ovomucin can be used as a prospective natural replacement of curing salt by 50% which is currently used in processed fish products.

Keywords: Antimicrobial, Fish Pattie, Hydrolyzed ovomucin

Antioxidant Property of Peptides Derived from Ovalbumin Using Protease Enzyme under Different Temperature and pH Conditions

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Ovalbumin is the major and most abundant protein in chicken egg white. Ovalbumin hydrolysates (OVH) have high biological and nutritive value which facilitates the wide use in OVH as dietary supplements and functional foods. The objective of the study was to compare the peptides produced from ovalbumin using protease enzyme with different temperature, time and pH condition and check its' hydrolysates for its antioxidant properties. Ovalbumin was dissolved with 20 mg/mL concentration and hydrolyzed using protease enzyme under different temperature conditions ranging from 37 °C to 50 °C, pH from 6.5 – 8.0 for 0-24 hrs. Level of hydrolyzing was observed with 15% SDS-PAGE gel electrophoresis system and visual observation. Best hydrolysates were evaluated for antioxidant properties using TBARS assay and DPPH Scavenging activity. Based on TBARS assay, all OVH derived under different conditions showed antioxidant property when compare with the oil emulsion ($p < 0.05$). According to the DPPH assay, OVH showed some level (99.37±0.38%, 99.22±3.46%, 98.99±1.24%, 98.97±2.77%, 98.58±2.99%, 98.56±3.39%, 98.54±3.21%) of scavenging activities under conditions of; 37 °C/pH 8.0 (3 hrs); 40 °C/pH 7.0 (12 hrs), 45 °C/pH 6.0 (6 hrs), 8.0 (12 hrs) ; and 50 °C/pH 6.5 (9 hrs), 7.0 (6 hrs), 8.0 (24 hrs). OVH which was produced under 37 °C and pH 8 for 3 hrs had the highest DPPH scavenging activity and was significant difference ($p < 0.05$) among the antioxidant properties observed. In conclusion, TBARS and DPPH values for OVH which were derived under 37 °C and pH 8 for 3hrs conditions have good antioxidant property than the rest. However, applications of these peptides have to be further studied for its' applications in food industry.

Keywords: Ovalbumin hydrolysates, protease, antioxidant property, TBARS

Comparison of Lipid Profile of Smoked Catla (*Catla Catla*) Made Under Different Combustion Conditions

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Fish lipids are considered as one of the major sources of polyunsaturated fatty acids including docosahexaenoic (DHA) and eicosapentaenoic (EPA) acids. Since fish is a highly perishable food item, preservation techniques are needed to keep the quality of fish at a higher level for longer shelf-life. Smoking is one of most popular fish preservation techniques and during which lipid profile of fish may be changed resulting in the reduction of nutritional value of fish. This study was conducted to compare the lipid profile of smoked fish made under different combustion conditions. Medium sized (2-3 kg) male Catla fish (*Catla catla*) were selected from a local reservoir in Ampara district. Fish were brought to the laboratory under chilled conditions and fish fillets were prepared for smoking. Smoking was carried out at 45 °C for 2-4 hours. Mahogany, Paddy straw, Cinnamon and Gliricidea were selected as the combustion materials according to the availability and low cost. Lipid extraction was carried out from the smoked fish samples. The composition of lipid extracts of smoked fish were compared with the lipid extract of raw fish by Gas Chromatography-Mass Spectroscopy method and Thin Layer Chromatography method. The level of unsaturation was compared by calculating iodine, acid, peroxide and saponification values. Smoke was collected from the combustion materials and analyzed using Gas Chromatography-Mass Spectroscopy to determine the composition of the smoke. Results showed that there was a significant difference ($p < 0.05$) in the level of unsaturation between the lipid extracts of the smoked fish and raw fish. According to the chromatogram obtained from Gas Chromatography, there was a significant difference in the predominant fatty acids between the lipid extracts of raw fish and smoked fish. In concluding the results, during the processing of fish, chemical changes occur which change the nutritional value of fish.

Keywords: *Catla catla*, Lipid extraction, Fatty acids, Gas chromatography-mass spectroscopy, Smoke

Utilization of Lycopene from Tomato (*Lycopersicon esculentum L.*) Peel as Natural Antioxidant and Colorant in Stirred Yoghurt

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Tomato peel is a good source of lycopene which can be used as a natural antioxidant agent and colorant in foods. This study investigated use of Tomato Peel Powder (TPP) as an antioxidant agent and a colorant in stirred yoghurt. Tomatoes were washed, immersed in boiling water (1-2 min) and hand peeled. Tomato peel was lyophilized, pulverized and analyzed for Radical Scavenging Activity (RSA) using DPPH (2, 2-diphenyl-1-piclyhydrazyl) method and Total Phenolic Content (TPC) using Folin-ciocalteu reagent assay. Total Carotenoid Yield (TCY), expressed as lycopene in TPP was measured. FTIR (Fourier Transform Infra-Red) and UV-Vis spectrum analysis were done for TPP comparing with extracted lycopene and commercial lycopene. Two batches of stirred yoghurts were prepared by adding lyophilized TPP at level of 0%, 2%, 4%, 6% and 8% (w/w) Before Incubation (BI) and After Incubation (AI). The physiochemical properties, microbial and sensory analysis were conducted to determine the quality of stirred yoghurts. RSA and color of all ten stirred yoghurt samples were investigated at 7 days interval at refrigerated storage for 21 days using DPPH method and colorimeter, respectively. RSA (%) and TPC of TPP were $50.05 \pm 0.66\%$ and 0.38 ± 0.01 mg GAE g⁻¹ extract, respectively. TCY of the TPP was 71.42 ± 0.1 mg kg⁻¹. FTIR and UV-Vis spectrum data confirmed the presence of lycopene in TPP. Significantly higher ($P < 0.05$) overall acceptability was shown by the stirred yoghurt contained (2%) TPP. The highest RSA was shown by the sample contained 8% TPP, AI ($23.07 \pm 0.04\%$) while, the lowest RSA was shown by the control BI ($1.58 \pm 0.03\%$). TPP (8%) added sample showed the highest color value for redness (18.83 ± 0.37). Results revealed that TPP can be successfully incorporated into stirred yoghurt as a natural antioxidant agent and a colorant.

Keywords: Tomato peel, Radical scavenging activity, Total phenolic content, Stirred yoghurt

Development of Reduced Fat, Inulin Incorporated Prebiotic Butter

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Butter is a dairy product with at least 80% fat which contributes to high caloric value of a meal. Health conscious consumers today seek for products with low caloric contents. Inulin is a prebiotic and further can be used as a fat replacer in various food products including ice cream, yoghurt, cheese and cookies. This study was aimed to develop a reduced fat, prebiotic butter incorporating inulin as the fat replacer. Inulin was incorporated into butter in two methods namely as water-based gel and oil-based gel. Water-based inulin gel (40% w/w) was prepared by heating and cooling method, while oil-based inulin gel (40% w/w) was prepared by homogenization method using commercially available olive oil. Soy lecithin was added as the emulsifier in both inulin gels. Butter samples were prepared by incorporating either water-based or oil-based inulin gels to have final inulin concentrations of 4%, 8%, 12%, 16% and 20% (w/w) in butter. No inulin added butter was used as the control. All 11 butter samples were chemically analyzed for fat, moisture and ash contents, peroxide value and free fatty acid value. Organoleptic properties were analyzed using a sensory evaluation with 30 panelists. Sensory evaluation results indicated that 20% oil-based inulin added butter had significantly higher ($P < 0.05$) sensory attributes including, texture, color, aroma, taste, sweetness, mouth feel and overall acceptability compared to all other butter samples. In addition, oil-based inulin added butter samples had significantly lower ($P < 0.05$) peroxide values compared to their counterparts. The fat contents of inulin incorporated all butter samples were significantly ($P < 0.05$) lower compared with the control. Results revealed that 50% of fat in butter can be replaced successfully using 20% water-based inulin gel. This study indicated that inulin can be successfully used as a fat replacer in dairy spreads.

Keywords: Inulin, Fat replacer, Dairy spreads, Olive oil, Butter

Development of Garlic (*Allium sativum L.*) Incorporated Synbiotic Butter

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Today consumers are looking for health beneficial synbiotic food products which contain both prebiotics and probiotics in order to prevent non-communicable diseases. Inulin is a prebiotic naturally and abundantly occurs in Garlic. Synbiotic butter with Garlic should be a new value added product concept to the Sri Lankan market. This study was conducted to develop garlic incorporated synbiotic butter and investigate the effect of garlic incorporation on survival of *Bifidobacterium animalis* subspecies *lactis* (Bb12) probiotic strain during long term refrigerated storage. Lyophilized garlic powder (LGP) was prepared using garlic bulbs and analyzed for its chemical composition. FTIR analysis was done for LGP and commercial chicory inulin to identify the presence of inulin. LGP was incorporated into butter at levels of 0%, 2%, 4%, 8% and 10% (w/w), while 5% (w/w) commercial chicory inulin incorporated butter was used as positive control. *B. animalis* 6% (v/v) was inoculated to cream (40% fat) before churning to ensure final count of $>10^6$ cfu/g. Viability of Bifidobacteria during 28 days of storage at 6°C was assessed at 7 day intervals. Bifidobacteria enumeration was carried out by pour plating on MRS media supplemented with 0.05% L-cysteine followed by anaerobic incubation. Sensory characteristics, proximate analysis, physico-chemical and microbiological parameters were analyzed in all six butter samples. FT-IR spectrums confirmed the presence of inulin in LGP. The highest scores in the sensory assessment were obtained by 10% garlic powder incorporated butter. Results of chemical (pH, titratable acidity, peroxide value) and microbiology analysis (*E. coli* count) were not deviated from SLS specifications for butter. In all samples viability of Bifidobacteria was increased up to 14 days of storage, and then reduced during 28 days of shelf life. The Bifidobacteria count (cfu/g) was increased with increasing garlic percentage compared to negative control sample (0% garlic), indicating that the prebiotic compounds in garlic such as inulin may have enhanced the growth of probiotic bacteria. The results concluded that garlic can be successfully used as a prebiotic source in synbiotic butter.

Keywords: *Bifidobacteria*, Bb12, Synbiotic, Butter

Characterization of Potentially Industrial, Important Lactic Acid Bacteria (LAB) Isolated From Goat Milk

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Goat milk is proven as nutritious, easily digestible, alternative milk for human consumption, containing diverse lactic acid bacteria (LAB) with various functionalities. The aim of this study was to isolate and characterize industrially beneficial lactic acid bacteria present in goat milk for future food applications. In this study 100 bacterial isolates were obtained (by culturing on MRS agar) from 20 fresh goat milk samples which were directly collected from goat farms in Colombo area. Among the 100 isolates, 44 isolates were gram positive and 29 isolates were confirmed as LAB by presumptive identification tests (gram positive, catalase negative, non-motile and non-endospore formers. Haemolytic test was performed to ensure safety for human consumption and 40% non-haemolytic organisms were selected for further investigations (2 rods and 6 cocci). Identification to species level was done based on morphological, physiological and biochemical characteristics following the Bergeys manual. The pool of isolates were identified as *Lactobacillus pentosus*, *Lactobacillus plantarum*, *Streptococcus thermophilus*, *Streptococcus bovis*, *Lactococcus lactis* and *Enterococcus faecium*. All the isolated LAB species were able to coagulate the skimmed milk within 24 hours by lactic acid production (pH 4.8 to 5.9). All isolates survived under high (45 °C) and low (15 °C) temperatures exhibiting the abilities to survive under industrial fermentation and refrigeration conditions. Isolates were tolerant to different NaCl concentrations (2%, 4%, 6.5%) and pH levels (1.5, 3, 9) as well. *Lactobacillus pentosus* (33 mg L⁻¹) and *Streptococcus thermophilus* (14 mg L⁻¹) were the best lactic acid producers indicated by quantified lactic acid concentration from High Performance Liquid Chromatography. Therefore, the LAB isolated from goats milk could be considered as potentially beneficial organisms for future food fermentations.

Keywords: *Lactobacillus*, *Lactococcus*, High performance Liquid Chromatography, Lactic acid

Development and Assessment of Sensory, Physicochemical and Phytochemical Properties of a Soursop (*Annona muricata L.*) Jam

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There is a great potential for soursop (*Annona muricata L.*) value-added products due to its proven influence on human health. Fruit jam is a preservation technique with a mixture of fruit pulp, sugar, pectin and citric acid. This study was focused to develop a soursop jam and assess its sensory, physicochemical and phytochemical properties. Soursop jam was prepared according to Sri Lankan standard specification for jams, jellies and marmalades by using a general recipe for fruit jam. Proximate composition of the final product was determined. Microbiological analysis including total plate count and yeast and mold count were done up to two months of storage at room temperature. Sensory evaluation was done using nine point hedonic scale. Physicochemical properties including total soluble solids, titratable acidity, pH and ascorbic acid content were determined during the storage period. Total polyphenol content was determined by Folin-Ciocalteu method and antioxidant activity of soursop jam was assessed using DPPH assay and ABTS assay. Sensory data were analyzed using MINITAB 17 statistical software by Kruskal-Wallis test and physicochemical and phytochemical data were analyzed by one way ANOVA test with 95% confidence level. Soursop jam contained 69.58% carbohydrate, 29.46% moisture, 0.4% ash, 0.29% crude protein and 0.27% fat. Microbial counts were less than the standard maximum limits. Total soluble solids, titratable acidity and pH were not significantly changed ($P>0.05$) during the storage period. Ascorbic acid content, total polyphenol content and antioxidant activity were significantly decreased ($P <0.05$) during the storage period. Sensory evaluation revealed that only texture of soursop jam was significantly changed ($P<0.05$) during the storage period. In conclusion, soursop jam is an ideal way of adding value to the underutilized soursop fruit with retained antioxidant properties.

Keywords: Fruit jam, Quality parameters, Soursop, Value-added product

Evaluation of Combined Antimicrobial activity of Leaf Extracts of *Psidium guajava* and *Moringa oleifera* against *Staphylococcus aureus*

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The combined effect of diverse plant extracts on microorganisms is a highly effective, new approach in modern pharmaceutical industry due to its excessive capability in treatment of serious infectious diseases caused by multidrug resistant bacteria. The purpose of this study is to determine the synergistic effect of *Psidium guajava* and *Moringa oleifera* against *Staphylococcus aureus*. In this study leaves extracts of *P. guajava* and *M. oleifera* plants were tested in different concentrations individually and in different volume combinations (1:1, 2:1, 1:2) against *S. aureus*. Healthy plants leaves were selected, washed, dried and were grounded into a fine powder. Each plant material was extracted in a Soxhlet using methanol. Different dilutions of the resulting crude extracts were prepared separately to give final concentration in the range of 100, 80, 60, 40, and 20 mg mL⁻¹ using methanol as the solvent. The two extracts of the same concentration were mixed in three different combination (volume) ratios (1:1, 2:1, and 1:2) to obtain solutions with a final volume of 30 mL. Agar-well diffusion method was used to investigate the synergistic antimicrobial activity. Resulting inhibition zones were compared with the commercially available antibiotic, Ofloxacin. The minimum inhibitory concentration 80% were 7.91 and 24.45 mg mL⁻¹ respectively for *P. guajava* and *M. oleifera*. According to the results, antibiotic showed significantly high mean inhibitory zone diameter compared to different concentrations of extracts. With the increment of the concentration, the inhibition value increased except for the values obtained for combinations at concentration 20 mg mL⁻¹. The acquired data concluded that the synergistic antimicrobial effect of these two plants was less effective than their individual activity at high concentrations. However, the results revealed that at low concentration of 20 mg mL⁻¹, the synergistic antimicrobial effect of *P. guajava* and *M. oleifera* was increased for the volume ratios of 2:1 and 1:1(v/v) which shows the antimicrobial potential of combined leaf extract.

Keywords: Antimicrobial, Medicinal plants, Plant extracts, Synergistic

Effect of Starter Culture and Type of Milk on Textural and Functional Properties of Mozzarella Cheese

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Mozzarella is a pasta filata type cheese which has unique textural and functional properties but has less popularity in Sri Lanka. This study was conducted to investigate the effect of starter culture and type of milk on textural and functional properties of Mozzarella cheese. Cheeses were made with commercially available single strain culture of *Streptococcus thermophilus* or mixed strain culture of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus* using buffalo milk and cow milk as different milk types. Four cheeses were produced namely single strain-cow milk (SSCM), single strain-buffalo milk (SSBM), mixed strain-cow milk (MSCM) and mixed strain-buffalo milk (MSBM). All cheese samples were evaluated for meltability using the Schreiber test and hardness using the texture analyzer. Cheeses were analyzed for chemical composition (moisture, protein, fat, and ash content), color and yield. Organoleptic properties of cheeses were evaluated using sensory evaluation. Results revealed that, chemical composition of mozzarella cheese were significantly affected ($P < 0.05$) by both, starter culture and type of milk. SSBM cheese had highest fat (24.5%) and ash (5.5%) contents while MSCM cheese had highest moisture content (57.8%) and MSBM cheese had highest protein content (26.3%). Sensory evaluation results revealed that the MSBM cheese had received significantly higher ($P < 0.05$) score for all sensory attributes. The yield and color were significantly affected ($P < 0.05$) by the type of milk but not by type of culture. However meltability and hardness were significantly affected ($P < 0.05$) by starter culture and type of milk. Results indicated that MSBM cheeses had best textural and functional qualities compared to other cheeses. This is apparently due to unique chemical composition of buffalo milk and high proteolysis of mixed strain culture. In conclusion both, starter culture and type of milk had great effect on quality of mozzarella cheese.

Keywords: Mozzarella cheese, Buffalo milk, Cow milk, Starter culture, Meltability

Application of Crude Extract of Gelatin from Tilapia (*Oreochromis mossambicus*) Skin as an Edible Coat for Tomatoes (*Solanum lycopersicum* var. *padma*)

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Edible coating is an effective method to maintain fruit quality and minimize the post-harvest losses especially in soft skinned fruits. Tomatoes at harvested maturity are more prone to physical impacts during transportation increasing the post-harvest losses. Over the years gelatin has been commonly used as an edible coating due to its barrier properties. Tilapia fish skin as a by-product from inland fisheries is a good source of gelatin. Thus, the present study was focused on application of gelatin based edible coating extracted from tilapia skin for tomatoes. Locally available tilapia skins were used to extract crude gelatin and treated with 5% (v/v) glycerol and applied for tomatoes by brushing at turning stage under room temperature. Non coated tomatoes were used as the control. Both coated and non-coated tomatoes were stored at room temperature for 25 days of storage in opened polyvinyl boxes. During storage, samples were evaluated for pH, weight loss, color (L^* , a^* , b^*), titratable acidity, total soluble solids, hardness and sensory attributes at 3-day intervals. Weight loss, color, total soluble solids, titratable acidity and hardness of coated tomatoes showed significant differences ($p < 0.05$) than those of non-coated tomatoes. However, pH and titratable acidity were not significant ($p > 0.05$) between treatments. Sensory analysis was done by 30 untrained panelists and results revealed that the use of edible coating positively influenced on overall acceptability of coated tomatoes until 24th day whereas non coated tomatoes had an unacceptable quality at 18th day. In conclusion, application of crude extract of gelatin on tomatoes showed delayed ripening with acceptable quality parameters for 24 days at room temperature.

Keywords: Gelatin, Edible coating, Tomato, Tilapia skin

Physico-chemical Characterization of Cookies Enriched with Sugarcane Bagasse Fibers

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Sugarcane cultivation and sugar development processes are mainly located in the Uva Province of Sri Lanka. Sugarcane bagasse is a by-product of sugarcane processing and riches in insoluble dietary fibers. Sugarcane stems are crushed in the treacle, jaggery, and sugar industries to obtain the juice and the remaining plant residues called bagasse. The objective of this study was to develop cookies enriched with sugarcane bagasse fibers as a fiber source with no added sugar. Bagasse (with or without peel) were collected from a jaggery manufacturing plant and they were dried, grinded, and sieved to obtain bagasse powders (moisture content, 3%). The fiber content (%) of bagasse powders with and without peel were 12.43 ± 0.30 and 8.61 ± 0.38 , respectively. Furthermore, the bagasse with peel contained the highest total phenolic content ($1270 \pm 3.36 \mu\text{g GAE/g}$) than bagasse without peel ($721 \mu\text{g GAE/g}$). In addition, water holding capacities of with peel and without peel bagasse were 485.9 ± 29.1 and $804.06 \pm 1.78 \text{ g/100 g}$, respectively. These two types of bagasse powders at 0 (control), 5 and 10 % (w/w) ratios were enriched to develop five types of cookies. According to the sensory evaluation, the 5% bagasse with peel cookies showed the highest overall acceptability than other bagasse enriched cookies but lesser overall acceptability than the control. Moreover, 5% with peel bagasse cookies significantly differ from without peel bagasse cookies in overall acceptability. Collectively, this study suggested the potential application and value-addition of sugarcane bagasse in cookies manufacturing.

Keywords: Sugarcane, Bagasse, By-products, Health foods, Value-addition

Progressive Freeze Concentration of Fruit Juices and Yield Improvement by Partial Ice Melting

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Progressive freeze concentration (PFC) is a novel freeze concentration method which replaces the conventional Suspension freeze concentration (SFC) which requires a higher capital cost. The applications of the PFC are limited since still it is a developing technology and has lower yield than SFC. The research study has been done to concentrate pineapple, watermelon and tomato juices by PFC after producing clear juices by blending the fruit and filtering the blended juice with a muslin cloth. The yield of the process was increased by performing partial ice melting process. During the formation of ice crystals in the PFC, the solute particles can be entrapped between the boundaries of the ice crystals. The initial melted fraction provides juice with higher brix value. The freezing point of samples were -0.5 °C, -0.6 °C and -0.9 °C respectively, for tomato, watermelon and pineapple. Pineapple, watermelon and tomatoes juices were concentrated up to brix values of 14.8° 12.2° and 6.1° respectively without losing organoleptic characteristics of the original juices from initial brix values of 12.2°, 8.3° and 3.2°. The partial ice melting method was used to improve the yield of concentrated product. By recovering the initial melted ice fraction, the yield percentage of the PFC product could be increased. In this study, the yield was increased up to 80% for all fruit juice samples by recovering 20-30 ml of initial melted ice fractions.

Keywords: Progressive freeze concentration (PFC), Suspension Freeze concentration (SFC), Partial ice melting

**Effect of Gamma Irradiation on Histamine Content of Yellowfin Tuna
(*Thunnus albacares*) Fish Muscle**

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Food irradiation is a process that has proven to be successful, due to its high effectiveness in inactivating pathogens without deteriorating product quality. Histamine is a causative agent for scombroid foodborne poisoning which effects on the quality of fish products. Therefore present study was conducted to evaluate the effect of gamma irradiation on histamine content in Yellowfin tuna fish fillets. Fish flesh was treated by Co-60 source at doses of 1, 3, 5, 7 and 10 kGy. Initial determinations were made just after irradiation and second determinations were made after storing control and irradiated samples for 24 hours at room temperature (30 °C). The concentration of histamine was detected by using High Performance Liquid Chromatography (HPLC) method. Total bacterial count (TPC) was performed according to the ISO 4833:2003 standard. The highest increment was detected in control sample after 24 hours of storage period and rate of increment of histamine is 9.97%. After 24 hours of storage, irradiated samples showed 2.40, 2.00, 3.00, 8.69 and 7.31% of increment in histamine at 1, 3, 5, 7 and 10 kGy irradiations respectively. However, no any significant difference found between any treatments. As revealed by results of TPC, highest amounts were found in control samples (3.03×10^5 cfu/g initially and 1.44×10^8 cfu/g after 24 hours storage period). In spite of increment in bacterial count in 1 kGy irradiated sample (7.4×10^5 cfu/g), all other samples were not exceeded the maximum level of acceptance in bacterial count (5×10^5 cfu/g) either after 24 hours of storage. The TPC results showed significant reduction after irradiation and within the storage time respect to the control. The results revealed that the low dose (3 kGy) irradiation can implement for the better safety of Yellowfin tuna fish fillets according to the changes in the histamine content and bacterial count.

Keywords: Yellowfin tuna, Histamine, Scombroid poisoning, Bacterial count

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Development and Quality Evaluation of Ready to Drink Fruit Flavored Whey Beverage

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The major by-product of cheese manufacturing is cheese whey which contains many milk nutrients. Though it has good nutritional properties, it is not used in effective manner in Sri Lanka. Therefore the objective of this study was to develop a fruit flavored whey beverage. A preliminary investigation was carried out with passion fruit, water melon, Indian gooseberry, black plum and governor's plum to check the effect of each fruit on the sensory properties and the stability of the whey-fruit juice mixture. Then the levels of the required additives were tested for the three selected whey-fruit juice mixtures from the preliminary investigation. Three whey beverages were developed and tested for color, sedimentation, odor, taste and overall acceptability using a nine point hedonic scale. Crude protein, titrable acidity, moisture percentage, pH and the total soluble solids (TSS) were analyzed for the most accepted formulation in the sensory evaluation. The preliminary study revealed negative effects of black plum and governor's plum on the development of a whey beverage. 15% of passion fruit, water melon and Indian gooseberry could be blended with 75% of cheese whey while retaining acceptable flavor, color and the stability. 0.3% of citric acid, 0.7% of pectin and 9% of sugar were effective for those formulations. The results of sensory evaluation revealed that there was a significant difference among three tested whey beverages with respect to all tested sensory attributes. The whey beverage flavored with passion fruit was the most accepted formulation which contained 0.47% of crude protein, 0.73% of titrable acidity, 82.03% of moisture and 17.97% of TSS. The pH value was 3.82 at 25°C which showed a decreasing trend, indicating an increase in acidity during storage in glass bottles. Therefore it could be concluded that conversion of cheese whey into passion fruit flavored whey beverage is a good attempt for the value addition of cheese whey for human consumption.

Keywords: Cheese whey, Beverage, Fruit flavored, Ready-to-drink, Value addition

Effect of Storage Conditions to Minimize Contaminants before Packaging of Ceylon Cinnamon Quills (*Cinnamomum zelanicum* Blume)

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Cinnamon is one of the major spice crops in Sri Lanka. Maintenance of the quality of the processed cinnamon is very important in exportation to get a good market value. Microbial and store pest contaminations of processed cinnamon quills make the final product less demanded with high post-harvest losses. This study was conducted to identify the most suitable storage conditions to maintain the export quality of the cinnamon quills without using synthetic chemicals. Collected cinnamon quill samples from the processing center of National Cinnamon Research and Training institute at Palolpitiya were stored at different time durations (0,3,7,14 days) with different combinations of temperature and relative humidity (RH) levels [(15 °C, 45%), (15 °C, 60%), (30 °C, 30%) and (30 °C, 60%)] in a growth chamber. The experiment was conducted as triplicate using 16 treatments. Moisture content (%), store pests per 100g, fungal and bacterial colony per 100g and color of the cinnamon quill samples were measured before applying the treatments and after 3 days, 7 days and 14 days from the treatment. Results revealed that 9.6% of mean moisture level was gained after 14 days, under 30°C temperature and 60% RH and it has taken 3 days to decrease moisture level up to 12% under the treatment of (15 °C, 45%), (30 °C, 30%) and (30 °C, 60%) ($P<0.05$). Under the 30 °C temperature and 30% RH store pests were decreased up to 1 within 3 days while 7 days spent to kill all the store pests. All the store pests were killed after 14 days under the treatment of (30 °C, 30%) (30 °C, 60%) and (15 °C, 60%) ($P<0.05$). Significantly lower fungal and bacterial colonies were observed after 14 days under 15 °C temperature and 60% RH ($P<0.05$). Quill samples under the 15°C temperature and 60% RH showed the best color in colorimeter than the quills of other storage conditions as per the ISO standards. Thus, the expected quality of the cinnamon quills can be gained within 14 days under the 15 °C temperature and 60% RH.

Keywords: Cinnamon quills, Color, Moisture content, Storage conditions, Store pests

Effect of Cow Milk and Goat Milk on Growth and Survival of *Bifidobacterium animalis* in Presence of Bee Honey

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Bifidobacterium animalis is a probiotic bacteria which have been incorporated into fermented dairy products due to their reported health benefits. The fastidious behavior of Bifidobacteria, makes it difficult to obtain legally required counts of probiotic bacteria in a probiotic milk product. This study was conducted to evaluate the effect of cow milk and goat milk on enhancement of growth and survival of *B. animalis* (Bb-12) in the presence of bee honey in a yoghurt beverage. Yoghurt beverages were prepared from cow milk or goat milk using 5% (v/v) single strain Bb-12 starter culture and different concentrations of honey (2, 3 and 5% (v/v)), without adding sugar. Commercial fructooligosaccharides (FOS) (5%) and table sugar (5%) added yoghurts were used as the positive controls while no any sugar or FOS added yoghurts were used as negative controls. All yoghurts were incubated at 37°C for 12 hours. Enumeration of Bb-12 was done by pour plating on MRS agar supplemented with 0.05% L-cysteine-HCl, followed by anaerobic incubation at 37°C for 48 hours. Viability of Bb-12 during 28 days of refrigerated storage at 4 °C, were assessed at 7 day intervals. Sensory evaluation, proximate, chemical and microbial analysis were conducted to determine the suitability and acceptability of the product. Bee honey showed enhanced bifidobacteria growth in both types of milk compared to controls. Growth promotion effect of honey on Bb-12 was maximized at honey concentration of 5% in cow milk and 3% in goat milk. Among them significantly higher ($P<0.05$) growth of Bb-12 was resulted in goat milk compared to cow milk. Survival of Bb-12 was significantly higher in honey added beverages compared to controls up to 14 days of storage (4°C). The pH values of honey incorporated goat milk beverages were significantly lower ($P<0.05$) compared to cow milk incorporated with honey. Overall, the effect of goat milk on growth and survival of Bb-12 was enhanced in presence of honey ($>10^6$ bifidobacteria/g).

Keywords: Goat milk, cow milk, bee honey, bifidobacteria, prebiotic

Impact of Seed Moisture Content on Yield, Antioxidant Activity and Free Fatty Acid Content of Sesame Oil

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This research was undertaken to assist Sri Lankan sesame oil producers to further enhance yield and quality of their products. Oil samples were extracted using a screw expeller, in triplicate, from blackish ($86\pm1\%$) sesame seeds having moisture content (M) of 0.3, 3.3, 3.6, 4.6, 5.1, 6.3, 7.0 and 7.9% on dry basis (db). Oil samples were half filled in clear glass bottles and stored on table top for 4 months. Antioxidant activity (AOA) was determined by quantifying the amount of 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radicals scavenged by phenolic fractions of oil. Free fatty acid in oil (FFA, % as oleic acid) was also determined. Oil yield (Y g oil per 100 g dry weight of seeds) was estimated as $Y = 0.6M^3 - 11.8M^2 + 71.9M - 95.9$ and mean temperature (°C) of oil being extracted as $T = -1.5M^2 + 14.9M + 21.8$ with 99.7% and 90.3% variability in Y and T explained by M, respectively. Maximum Y of 45.0 ± 0.2 and T of 60 ± 3 °C were close to M of 4.6 and 5.1% db, and these values were significantly different from other M values studied. FFA contents of all oil samples studied were well below 3.0 and therefore satisfied the quality standard for FFA of sesame oil. Minimum and maximum FFA contents of 0.8 ± 0.1 and 2.2 ± 0.1 were obtained at M of 4.6 and 7.9% db, respectively, both of which were significantly different from FFA of all other M values studied. No significant differences were observed among AOA of oil samples studied which spanned the range of 0.67 to 0.75 μmol DPPH loss per g oil. It could therefore be concluded that 4.6 to 5.1% db seed moisture contents gave the seeds adequate amount of water to maintain the temperature required to assist in cell wall rapture and in pushing oil out of the seeds and through the voids with ease while preventing plasticization within the seeds. Lowest and the significantly different FFA content obtained suggested that an M of 4.6% db was the best choice for delaying potential oil oxidation leading to rancidity during oil storage.

Keywords: Antioxidant activity, Free Fatty acid (FFA), Seed moisture, Sesame oil, Yield

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Effect of Coagulation Temperature on Yield, Chemical, Sensory and Textural Properties of Buffalo Milk Paneer

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Paneer, popularly known as Indian cottage cheese is prepared by heat and acid coagulation of standardized buffalo milk. The present study was carried out to investigate the effect of different coagulation temperatures on yield, chemical, sensory and textural properties of paneer cheese coagulated with lime juice. Paneer cheese was prepared from whole or skimmed buffalo milk using different coagulation temperatures (70 °C, 80 °C and 90 °C) and lime juice as the coagulant. Relevant milk coagulation temperatures were maintained using a constant temperature water bath, while a constant volume of lime juice (30 mL) with a pH of 2.3 at a temperature of 30 °C was used as the coagulant. Sensory evaluation was done for fresh paneer samples with 30 untrained panelists, using a nine point hedonic scale. Texture of paneer cheese samples were analysed in terms of hardness, cohesiveness and springiness using CT3 texture analyser. Results revealed from completely randomized design indicated that the highest yields of both whole and skimmed paneer were obtained at coagulation temperature of 70 °C. Moisture and protein content of paneer were significantly differed with different coagulation temperatures ($p<0.05$). However, fat and ash content of paneer were not significantly differed with different coagulation temperatures. According to the sensory evaluation, paneer sample prepared at a coagulation temperature of 80 °C had a significantly higher overall acceptability. It was found that hardness and cohesiveness was increased with the coagulation temperature up to 90 °C, whereas springiness increased with the temperature up to 80 °C, and then decreased with the increase in temperature. The study showed that the coagulation temperature had a significant effect on chemical, sensory, and textural properties of paneer.

Keywords: Buffalo milk, Coagulant, Coagulation temperature, Paneer

Effect of Dehydration Temperature on Quality of Virgin Coconut Oil

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Virgin coconut oil/ (VCO) is a product obtained from fresh, mature kernel of the coconut by mechanical or natural means, with or without the use of heat and without undergoing chemical refining, bleaching or deodorizing. Dry processing of VCO is mainly practiced in Sri Lanka. But there is no documented standard temperature for VCO production. Therefore, this study was conducted to determine the effect of dehydration temperature on quality of VCO. Matured fresh coconuts were dehusked and split manually. The seed coat was peeled off, kernels were washed and cut into medium size particles. Those particles were dehydrated at 60 °C, 70 °C and 100 °C separately and drying time, moisture, fat content and free fatty acid content was tested for desiccated coconut (DC). Then DC expelled using the cold press expeller. The extracted VCO was filtered and tested for oil yield, oil recovery, moisture, FFA, color, relative density, fatty acid profile and total phenolic content. The experimental design was complete randomized design (CRD) while the data were analyzed using one way ANOVA with mean comparison through Duncan's multiple range tests at 5% significant level. Drying time, moisture and FFA of DC obtained from different drying temperatures were significantly different ($p<0.05$). Dehydration temperature had no impact on fat content of DC. There were no significant difference ($p>0.05$) among FFA, relative density and oil yield in VCO obtained from all three temperatures. The fatty acid profile had no variation among three different temperatures and lauric acid content ranged from 52.93% to 53.83% in all temperatures. The moisture, color, oil recovery, total phenolic content of VCO samples obtained from different drying temperatures were significantly different($p<0.05$) and overall results indicated that these parameters were changed with the studied dehydration temperatures. Color of oil and oil recovery exhibited better results at 60 °C and 70 °C dehydration temperatures.

Keywords: Dehydration Temperature, Physicochemical Properties, virgin coconut oil

A Study to Enhance the Shelf Life and Postharvest Quality of Tomato (*Solanum lycopersicum L.*) using Aloe Vera Herbal Coating

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Tomatoes have limited marketability owing to its high moisture content and high degree of perishability which leads to extensive postharvest losses. It is estimated that 40-60% of the harvested tomatoes go waste annually. There has been increased usage of Aloe vera gel as a herbal coating for fruits owing to its antimicrobial properties. In this study, the effectiveness of Aloe vera gel coating on the shelf life and quality of tomatoes were investigated. The mature green tomatoes were dipped in the concentrations of 1, 2, 3 and 4% (w/v) Aloe vera gel solutions for 5 min and air-dried for 24 hrs. The coated fruits were stored at 30°C and 90% RH for 30 days along with the uncoated controls. The nutritional properties, sensory acceptance and microbiological studies were carried out for all the treatments. Herbal coating significantly enhanced the firmness and reduced weight loss, delayed changes on total soluble solids and retarded the loss of total acidity compared with uncoated tomatoes. Fruits coated with 2% of Aloe vera gel showed greater retention of ascorbic acid, titratable acidity and total sugars of 11.26 mg%, 0.53% and 12.5% respectively, following 28 days of storage at 30°C. Sensory evaluation was done using 30-trained panelists and the results revealed that the use of the Aloe vera gel coating increased the acceptability of tomatoes. The determining factor of shelf life of tomatoes was the microbial spoilage. The Aloe vera gel coated tomatoes showed reduced number of microbial growth than that of control. The shelf life of tomatoes coated with 1 and 2% of Aloe vera gel increased up to 21 and 28 days respectively, without decay while tomatoes coated with 3 and 4% Aloe vera gel solution showed lower shelf life of 20 and 12 days respectively, with higher percentage decay. The control tomatoes decayed at the end of the 10th day of storage. Therefore, Aloe vera gel solution of 2% could be used as an edible herbal coating to enhance of shelf life of tomatoes.

Key words: Aloe vera gel, Herbal coating, Quality, Shelf life, Tomatoes.

Development and Quality Assessment of Cereal based Complementary Food Enriched with Germinated Green Gram and Carrot Flour

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Malnutrition is a common problem of children in developing countries including Sri Lanka. It affects the child at the most crucial period. Although, a number of convenient cereal formulas are available, they are often too expensive for the poor income people. As a solution to this problem, present study was designed to formulate low cost complementary foods that provide recommended levels of protein, vitamins and minerals for children. The Complementary Food Mixtures (CFM) were prepared from unpolished parboiled red rice (UPRR), germinated green gram (GG) & carrot flour (CF) in the ratios of 100:00:00, 80:10:10, 70:20:10, 60:30:10, 50:40:10 & 40:50:10 respectively. The CFM were subjected to nutritional, organoleptic and microbial analysis to evaluate the suitability for consumption and its' keeping quality. The nutritional analysis of the CFM revealed that the moisture, ash, protein & fiber content increased and fat & vitamin A decreased with the increasing of GG flour from 10 to 50%. There was no total plate counts observed in the formulated CFMs during the storage period. The sensory qualities such as colour, texture, taste, aroma & overall acceptability showed that there were significant differences ($p<0.05$) among the treatments. Based on the quality characteristics, most preferred CFM were selected and stored for 14 weeks at $30\pm1^{\circ}\text{C}$ and 75-80% RH. The storage studies showed that there were declining trend in ash, protein, fiber, fat & vitamin A and an increasing trend in moisture of the CFM. The results indicated that the CFM made with 60% UPRR, 30% GG & 10% CF contained 14.2% protein, 1.6% fiber, 2.06% ash, 1.91% fat, 6.28% moisture & 30.2 mg kg^{-1} vitamin A following 14 weeks of storage. This mixture is found to be superior in the analyzed quality characteristics and could be suitable for consumption up to 14 weeks without any significant changes in the quality.

Keywords: Carrot flour, Complementary food, Germinated green gram, Parboiled red rice

Study on Preparation of Composite Vegetable Squash of Tomato and Pumpkin

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The study was conducted with an objective to develop best formulation of composite squash of tomato and pumpkin by determining the physico-chemical, microbial and sensory qualities. Different proportion of tomato and pumpkin were used to prepare five formulations of composite vegetable squashes viz: T1-100% tomato, T2-100% pumpkin, T3-25% tomato+75% pumpkin, T4- 50% tomato+50% pumpkin and T5- 75% tomato+25% pumpkin. Physico-chemical analysis, sensory evaluation and microbial analysis were conducted to these formulations . Physico-chemical analysis of freshly made formulations of composite vegetable squashes of tomato and pumpkin showed that titrable acidity and ascorbic acid were increased with % of tomato. Total Soluble Solids and Total Sugar were increased with an increased amount of tomato and pumpkin, the pH reduced significantly ($p < 0.05$) with an increase in the concentration of tomato juice. The sensory analysis revealed that there were significant ($p < 0.05$) differences for the organoleptic characters between the formulations. According to Duncan's Multiple Range Test, T4 had shown highest value of rankings in colour, taste, aroma, nature and overall acceptability. Microbial studies showed no microbial colonies in all freshly made composite squash formulations. Based on the results of physio-chemical characteristics, sensory attributes and microbial test, the composite squash of tomato and pumpkin with 50% tomato and 50 % pumpkin was selected as best formulation.

Keywords: Formulation, Composite , Physico-chemical, Microbial, Sensory.

Evaluation of Physicochemical Changes in Un-Boiled Eggs Stored at Different Temperatures

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Eggs are considered as powerhouse of nutrients and also it is very popular food in the world due to its nutritional value. Among that, hard boiled eggs are widely used in ready-to-eat food processing industry. However, storing of hard boiled eggs under refrigeration and freezing conditions lead to some problems including rejection of customer demands due to its textural changes. Objective of this study was to check the effect of storing temperature on textural changes in un-boiled egg white with time. Medium sized brown shell eggs collected from commercial layer farm and stored under room temperature (27 °C), refrigeration (4 °C) and freezing (-18 °C) conditions for 0, 6, 12, 18, 24 and 48 hours. Then the stored eggs were boiled for 100 °C for 15 minutes and egg properties were studied under Fourier Transform Infrared (FTIR) spectroscopy (ALPHA), texture profile analysis using Texture analyzer (CT3), visual observation done by using gemological microscope and color was measured using colorimeter (CR 410 Chromo meter). Sensory qualities of boiled eggs were measured using 30 untrained panelists. According to the results, frozen eggs were showing low acceptance in all organoleptic properties checked ($p<0.05$). Hardness and gumminess of eggs were effected significantly during the storage in frozen eggs from the rest of the treatments ($p<0.05$). FTIR spectrums also confirm that the textural changes in bonds of amide A (3271 cm⁻¹), amide I (1626.2 cm⁻¹), amide II (1539.0 cm⁻¹), C=O stretch of COO- (1397 cm⁻¹), asymmetric PO₂⁻ stretch (1240 cm⁻¹). However, the color of the egg white was not significantly different ($p>0.05$) among treatments. Sensory results revealed that frozen eggs after 12 hours did show low acceptance comparing the rest. As a conclusion storing temperature of un-boiled eggs has an effect on the texture of eggs after boiling.

Keywords: Un-Boiled eggs, FTIR, Temperature, Textural changes, Hardness of egg white

Determination of the Organoleptic Properties of Hydrolyzed Ovalbumin Incorporated Dry Cured Ham

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Ham is one of the most popular cured meat products used all over the world. Potassium and sodium salts of nitrite and nitrate are commonly used as a preservative agent and color enhancer in dry cured ham production. However, high use of these chemicals may lead to health risks. Ovalbumin is the major chicken egg white protein that can be used to produce several bio-active peptides with various functional properties. Objective of this study was to use these peptides as a nitrate replacer in dry cured ham. Dry cured ham was produced incorporating nitrite: ovalbumin hydrolyzates in ratio of 0:0 (no curing salt, as negative control, Tr₁), 0:100 (Tr₂) 125ppm nitrite as positive control, 0:100 (Ovalbumin,Tr₃), 0:100 (Hydrolyzed Ovalbumin,Tr₄), 50:50 (Tr₅), 75:25 (Tr₆) and 25:75 (Tr₇). Ovalbumin was hydrolyzed using pepsin (1, Enzyme: 100 Substrate) at just after incubation at 37°C followed by heat inactivation (15 min/100°C). Prepared ham samples were vacuum packed and stored under freezing condition [-18°C] for further analysis. Sensory analysis was carried out by 30 untrained panelists. Antimicrobial activity was tested for locally isolated *Escherichia coli* and *Salmonella*. Keeping quality was checked with pH and TBARS assay with 03 days intervals up to 40 days. Color of the samples was initially measured using a colorimeter. According to the sensory analysis, there was no significant difference in overall acceptability among the treatments ($p>0.05$). Taste was better in positive control ($p<0.05$). Redness and lightness were significantly different between treatments ($p<0.05$), yellowness of the treatment did not show any difference ($p>0.05$). pH and the level of oxidation were within the acceptable range among the treatments during the storage period. It can be concluded that peptides derived from hydrolyzed ovalbumin can be used as an effective curing salt replacer for dry cured ham.

Keywords: Dry cured ham, Hydrolyzed ovalbumin, Sensory properties, Curing salt

Development of a Fruit Nectar Using Locally Available Willard Mango Variety.

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Utilization of local mango varieties cost effectively for the production of fruit nectar that fulfils the quality standards without using imported frozen-mango pulp has been a challenge for the Sri Lankan major fruit beverage manufacturers. This study developed a consumer acceptable nectar using Willard mango at maturity stage, containing 12-15% total soluble solids. The pulp (25%) and sugar (8%) percentages were selected according to the standards of Sri Lanka Standards Institution and adjusted with a two factor factorial design to identify the optimum level of consumer perception. Two Alternative Forced Choice method was conducted according to ISO 5495:2005(E) standard procedures to identify Just Noticeable Difference (JND) via Weber's Law in both pulp and sugar amounts. Reference nectar samples with 0.065 gml^{-1} , 0.095 gml^{-1} , and 0.125 gml^{-1} sugar concentrations, each containing a series of samples with increasing sugar contents, have provided Weber's constants of 0.154, 0.158, 0.120 respectively. Similarly, for the reference samples that contain nectar pulp concentrations of 0.150 gml^{-1} , 0.200 gml^{-1} , 0.250 gml^{-1} , have provided the Weber's constants of 0.033, 0.035, and 0.025 respectively. Moreover, a sensory analysis was conducted in accordance with the JNDs. As for the continual improvement, Kruskal Wallis Tests were conducted to identify the optimum experimental product from descriptive sensory analysis using semi-trained sensory panels. Sensory attributes, namely, appearance, odour, taste and mouth feel were assessed to improve overall acceptability. Final product was compared with the products of market leaders to improve the consumer acceptance from descriptive sensory analysis. Final Willard mango nectar was analysed for ash, ($0.052 \pm 0.002\%$), crude fat ($0.482 \pm 0.004\%$), crude protein ($1.345 \pm 0.022\%$), crude fibre ($0.392 \pm 0.002\%$), total carbohydrate ($10.899 \pm 0.000\%$), reducing sugar ($0.392 \pm 0.002\%$) on wet basis (w/w%) and for energy (1.254 kcalg^{-1}).

Keywords

Food product development, Mango nectar, Factorial design, Sensory analysis

Identification of the critical control points of a newly established commercial Spray Dried Milk Factory

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Food industries maintain number of quality assurance systems to produce safe and quality product. Among them HACCP focus on food production, storage and distribution monitor system for identification and control of associated health hazards. Study was carried out for identification of critical control points (CCPs) for an newly established spray dried milk factory as an initiation to develop the HACCP plan. Preliminary studies were carried out to identify the processing steps and sample collection points. Samples were collected from all processing steps, raw materials to the final finished products. Hazard analysis and the quality of the product were assessed using microbiological (total plate count and coliform) properties and chemical adulterations. According to the preliminary analysis, total plate count (TPC) of the samples taken from raw milk silos was significantly higher than the standard ($p<0.05$) which range from 6.72 ± 0.65 log cfu ml⁻¹ while coliform results were positive. Adulterations were also positive at this stage in milk. Samples taken after pasteurization (80°C, 15 seconds) and balance tank (before evaporate) were not contaminated from the coliform, but TPC of pasteurized milk vat 4.99 ± 0.43 log cfu/ml and balance tank before evaporator (4.84 ± 0.45 log cfu ml⁻¹) was significantly higher than the standard value ($p<0.05$). However TPC count after the evaporation step (4.08 ± 0.36 log cfu ml⁻¹) and final packed samples (2.68 ± 0.23 log cfu ml⁻¹) were less than the standard value ($p>0.05$) and coliform were negative in both conditions. According to the analysis; raw milk silos, pasteurized milk vats and the balance tank (before evaporator) were identified as the three CCPs and evaporate milk vats and the fluid bed identified as the critical points. Therefore more attention need to be given to control the three CCPs of the process line of spray dried milk factory.

Keywords: Critical control point, Microbial contamination, Hazard analysis, HACCP

Identification and Characterization of Acetic Acid Bacteria Isolated from Sri Lanka

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Acetic acid bacteria (AAB) are a group of Gram-negative aerobic, rod shaped bacteria, important in production of acetic acid, L-sorbose, and gluconic acid. The present work is focused on isolation, identification and characterization of AAB in Sri Lanka, where no previous studies been performed. From various types of fruits and fermented products in Sri Lanka 41 isolates of AAB were obtained, and were identified using different physiological and biochemical methods. All the isolated strains were found to be Gram-negative, rod-shaped and catalase positive. According to the acetate oxidation pattern, 32 of the isolated strains were identified as *Acetobacter*, seven isolates as *Acidomonas* and only two strains were identified as *Gluconobacter* strains. The isolated *Acetobacter* stains were classified in to *A. pomorum* (18 strains), *A. pasteurianus* (7 strains), *A. aceti* (6 strains), and *A. liquefaciens* (1 strain). The two *Gluconobacter* strains were identified as *G. frateurii*. All the isolates showed a good growth at both 30 °C and 37 °C, while few number of *Acetobacter* strains showed their growth at 40 °C, and none of the *Gluconobacter* strains grew at 40 °C. All the *Acetobacter* strains showed a good growth with 10% (v/v) and 4% (v/v) ethanol and acetic acid respectively, at 30 °C. At 37 °C, 75% of the isolates showed a good growth with 10% ethanol, while the rest grew well only up to 3% ethanol, and moderate growth up to 10% ethanol. When consider the acetic acid tolerance, few strains (16%) showed a good growth at 37 °C with 1% acetic acid, while 10% of the isolated strains showed a moderate growth, and rest of the strains showed a very poor growth at 37 °C even with 1% acetic acid. Growth of the isolated strains with 2-4% added acetic acid at 37 °C was very limited, while no growth was observed at 40 °C. In conclusion, variety of AAB were isolated from Sri Lanka that can be used in oxidative fermentation at higher temperatures, and further studies are required.

Keywords: Acetic acid bacteria, *Acetobacteraceae*, *Acetobacter*, *Gluconobactor*, Acetic acid

Development of a Value Added Canned Fish Product Using Rough Trigger Fish (*Canthidermis maculatus*)

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Fishes are one of the excellent nutrient sources for human. Fish canning is used as preservation technique to reduce spoilage. Improper continuous supply of mackerel to produce canned fish is the main problem in canned fish production. Objective of this research was to develop a value added canned fish product using Rough Trigger fish as an alternative to mackerel. Canning was done under commercial conditions in a fish canning company. Trials were carried out to select the best brine concentration and spices added. Another set of trials were done to compare the brine and oil filling. Based on the sensory evaluation the best treatment was selected using the 30 untrained panelists. Taste, color, aroma, texture, mouth feel and overall acceptability were checked. The final product was subjected to keeping quality analysis by determining the pH, level of oxidation and microbial contamination. According to the trials, 2.5% (w/v) brine solution was selected as the best brine percentage. Aroma and color did not show any significant difference among the treatments ($p>0.05$) and texture, mouth feel, taste and overall acceptability had significant difference ($p<0.05$). Similarly 2.5% (w/w) pepper and 0.25% (w/w) cinnamon was selected as the best level of spices to be add in to the final canned fish. According to the sensory data coconut oil was selected as the best oil to be used. *Salmonella* and *E coli* were absent in all treatment. pH of the treatment were ranged from 5.79 ± 0.18 to 6.26 ± 0.18 for 21 days and it was within the acceptable range. Results from TBARS assay showed significantly ($p<0.05$) low oxidation in brine added canned fish than oil immersed canned fish until 21 days. In conclusion, 2.5% (w/v) brine, 2.5% (w/v) pepper and 0.25% (w/v) cinnamon added canned Rough trigger fish can be a good replacer for mackerel canned fish.

Keywords: Rough Trigger fish, Brine Solution, Mackerel, Keeping Quality

Effect of Induced Ripening Agents on Physicochemical Properties of Ambul Banana (*Musa acuminata*, AAB)

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This study is to evaluate effects on induced ripening agents on physicochemical parameters of banana. Freshly harvested green mature banana (*Musa acuminata*, AAB) hands, which were in same maturity stage, were subjected to 1000 ppm ethephon, 1000 ppm acetylene, 20% Ethylene Glycol, Wood smoke and natural ethylene emits from ripened fruits. Physicochemical properties were measured in each treated sample in every 48 hours until the fruits get overripe. Ethepron showed significantly different ($p < 0.05$) L* and a* values in fully yellow stage from others at the same stage. Firmness of the peel and flesh was reduced during ripening where the lowest flesh firmness (31.25 g) was obtained for acetylene and wood smoke treated samples. Hardness of the peel reduced from 1541.45 ± 135 g to $221-334$ g during ripening. Acetylene treated fruits showed the highest moisture percentage in flesh and the lowest in peel at overripe stage comparing to others. Titratable acidity showed increasing pattern through ripening and pH showed decreasing pattern. The highest titratable acidity was recorded in ethephon treated samples while the lowest was recorded in naturally ripened samples at fully yellow stage. pH which was 5.3 ± 0.2 in raw sample was decreased up to 4.2 ± 0.1 in carbide treated samples at fully yellow stage when that in the control sample was 5.1 ± 0.1 . Pulp Total Soluble Solids (TSS) was increased from 0.6 to 5.2-5.5 during ripening and rate of TSS increment was highest in ethephon treated samples. Maximum pulp to peel ratio was obtained in carbide treated fruits while that was lowest in ethephon treated samples. Total sugar content was increased from 0.3 ± 0.04 g/100g of fresh weight to 19.91 ± 0.07 g/100g in natural ripening while it was 10.2-10.6 g/100g in treated samples in fully yellow stage. Starch content showed decreasing trend throughout ripening process where it was reduced from 16.64 ± 1.15 g/100g to $1.22-1.39$ g/100g in fully yellow stage.

Keywords: Artificial ripening agents, banana, physicochemical changes

Formulation of a Natural Flavor Enhancer Based on Glutamic Acid and Study of Sensory Properties

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The main objective of this study was set as formulation of a natural and nutritious flavor enhancer using locally available ingredients with having umami taste as a replacement for Mono Sodium Glutamate (MSG). Mushrooms, Tomatoes, Carrots and Garlic were dehydrated and powdered prior to be used as ingredients. These ingredients were mixed according to Taguchi L8 design by changing the ratios to form eight different formulations. Eight different formulations were evaluated based on seven point hedonic scale. Formulations were added into dhal curry and sensory tests were carried out with dhal and bread. Thirty untrained panelists were contributed in the sensory evaluation and samples were analyzed for Appearance, Taste, Odor, Mouth feel and Overall Acceptability. Results were analyzed using MINITAB 14 for Kruskal Wallis non parametric analysis and Mann-Whitney test. Based on the results of two sensory evaluations, sample 767 formulae (Tomato 2: Mushroom 2: Carrot 1: Garlic 1) and 671 formulae (Tomato 2: Mushroom 1: Carrot 2: Garlic 2) were selected for the third evaluation where Formulae 671 showed the best results. Considering overall results of three sensory evaluations sample 671 was selected for the final product development. Out of all the sample, selected formulae (Tomato 2: Mushroom 1: Carrot 2: Garlic 2) contains the highest level of tomato, carrot and garlic along with the least amount of mushroom compared to other samples. Development of a flavor enhancer using natural ingredients as a substitute for MSG would be a great achievement as far as health and the natural taste of the food is concerned. In conclusion, sensory evaluations for eight different ratios of mixing above ingredients revealed that formulae 671 gave the best composition that could be a good replacer for MSG.

Keywords: Mono Sodium Glutamate, Flavor, Sensory Evaluation

Evaluation of Antioxidant Properties and Total Phenol Content of Bark Exudates of *Lannea coromandelica* & *Mangifera indica* and Its Application as a Functional Fruit Coating

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The bark exudates of *Lannea coromandelica* and *Mangifera indica* are rich sources of health beneficial bioactive compounds. The bark extractions of these plants have been consumed and used in the traditional medicine for centuries. The objective of the present study was to investigate the total phenolic content and antioxidant capacity of the gum exudates of *Lannea coromandelica* and *Mangifera indica* and to evaluate the variation of physicochemical characteristics of a moderate respiratory fruit after applying the waxes. The application of these bark exudates for the food industry to develop a nutraceutical and functional fruit coating is promising. The waxes were prepared by dissolving 6 g of the exudates in 100 mL of water at 60 °C and then evaporating water to get the final volume of the wax to 40 mL. The waxes were further enhanced by adding Neem extract to the waxes. Antioxidant capacity was determined using the free radical 2, 2- diphenyl- 1-picrylhydrazyl (DPPH) method, the total phenolic contents were measured using Folin-Ciocalteu reagent assay. DPPH radical scavenging assay: IC_{50} value for gum exudates of *Lannea coromandelica* was 9.327 ± 0.286 mg of Gallic acid equivalents per mL, IC_{50} value for gum exudates of *Mangifera indica* was 2.375 ± 0.413 mg of Gallic acid equivalents per mL. Total phenolic contents in gum exudates of *Lannea coromandelica* and *Mangifera indica* were 6.49 ± 1.88 ppm and 242.7 ± 34.2 ppm respectively. The gum exudates of *Mangifera indica* contained more antioxidants and phenols when compared to the gum exudates of *Lannea coromandelica*. Therefore, natural bark exudates of these plants can be recommended as a functional coating for low respiratory fruits.

Keywords: *Lannea coromandelica*, *Mangifera indica*, Antioxidant capacity, Total Phenolic Content

Effect of Stage of Maturity on Physicochemical Properties of Jackfruit (*Artocarpus heterophyllus* Lam.) Flesh

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The objective of this study was to investigate the physicochemical changes in different maturity stages of jackfruit (*Artocarpus heterophyllus* Lam.) flesh. Four maturity stages including immature stage 1 and 2, mature stage and fully ripe stage were selected from several jackfruit trees in Western Province, and tested for color (L*, a*, b*, c* and h° values), hardness, moisture content, total soluble solids, pH, titratable acidity, and vitamin C content. Spectrophotometric methods were used to analyze the total starch content and total sugar content (Anthrone method). The results showed that the color parameters varied significantly with maturity and the hardness decreased. The moisture content ranged between 70.94 ± 2.09 - $89.21\pm2.29\%$. Total soluble solids increased with maturity, from $3.4\pm0.7\%$ to $19.6\pm1.1\%$, corresponding to the increase of total sugar content from $3.055\pm0.967\%$ to $25.498\pm0.495\%$. pH increased from the immature stage 1 (5.27 ± 0.15) to the mature stage (6.25 ± 0.06), then decreased during ripening up to 5.76 ± 0.03 . The variation of titratable acidity showed the opposite pattern of pH, with a range of 0.17 ± 0.07 - $0.29\pm0.06\%$. The vitamin C content increased with maturity, ranging between 2.18 ± 0.34 - 8.17 ± 0.39 mg 100g⁻¹. The total starch content increased with maturity from $1.597\pm0.295\%$ to $19.533\pm0.354\%$, but then decreased with ripening up to $6.237\pm1.285\%$. The study concludes that there is a significant difference ($p<0.05$) in physicochemical traits at different maturity stages of jackfruit flesh.

Keywords: *Artocarpus heterophyllus*, Physico-chemical properties

Physicochemical Characteristics of Peanut Butter Fruit (*Bunchosia armenica*) And Possible Application in Food Industry

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Bunchosia armenica or Peanut butter fruit being a member of family Malpighiaceae is a native plant to America. Peanut butter fruits are edible and used for different purposes including medicament. This study was carried out to determine the physicochemical properties of the pulp of the peanut butter fruit and incorporation of it to the food chain as sauce. The proximate composition (moisture, dry matter, crude fiber, crude fat, total ash, minerals and carbohydrates) of flesh of peanut butter fruit were determined by using Association of Analytical Communities (AOAC) methods and pH, titratable acidity, total soluble solids and ascorbic acid were also analyzed. The colour and texture variation of flesh of fruit in six maturity stages were determined. Further the Total Phenolic Content (TPC), antioxidant capacity (free radical 2, 2- diphenyl- 1-picrylhydrazyl (DPPH) method) and reducing power were also analyzed. Percentage of moisture and dry matter content of peanut butter fruit were 74.17% and 25.82% respectively. Crude protein, crude fat, crude fiber, ash and carbohydrates content in 100g of dry matter were 0.32, 3.35, 45.29, 0.87 and 50.16 g respectively. Potassium was the most abundant mineral in flesh of peanut butter fruit, followed by Na, K, Mg, Ca, Zn, Fe and As. Vitamin C content of peanut butter fruit was 9.43 ± 0.13 mg/100 ml. Total polyphenol content of flesh of peanut butter fruit was obtained as a mean of 33.27mg Gallic acid equivalents per L of fruit extract. In DPPH radical scavenging assay, the IC₅₀ value in peanut butter fruit variety was obtained as 13.443 ± 0.29 mg/ml. From the sensory evaluation, sauce with medium sugar content obtained the highest average rank for overall acceptability.

Keywords: Peanut butter fruit, Sauce, Physicochemical

Assessment of Sensory Acceptability of Beetroot (*Beta vulgaris*) incorporated Buttermilk Wine during Storage

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Buttermilk is the by-product produced during butter manufacturing process which contains protein, lactose and minerals in high levels. It has been estimated that the 50% of buttermilk is discarded as a waste product. As an ingredient, buttermilk in product development helps in effective utilization of the by-product. Thus, present study was conducted to develop a wine using buttermilk with incorporation of beetroot (*Beta vulgaris*) and *Saccharomyces cerevisiae*. Preliminary trials were conducted to select best ratio between buttermilk: beetroot with 1:1, 2:1, 3:1 and 4:1. Based on total soluble solids, treatment having 3:1 buttermilk: beetroot ratio was used for further study. Four levels of *Saccharomyces cerevisiae* were used to determine the best level of yeast incorporation to produce the wine. Commercially available wine was used as control. All treatments were evaluated by 30 untrained panelists for color, aroma, mouthfeel, taste and overall acceptability for 42 days of storage. Data from sensory evaluation were analyzed using Friedman non-parametric test using Minitab17®. Based on sensory evaluation at day 21, all treatments showed significant difference ($P<0.05$) with respect to the all sensory attributes while 0.1% *Saccharomyces cerevisiae* incorporated wine showed highest estimated median values for mouthfeel, taste, and overall acceptability; 8.00, 7.86 and 8.38 respectively. Moreover, at day 42, treatments showed significant difference ($P<0.05$) with all attributes while amongst all treatments 0.1% *Saccharomyces cerevisiae* incorporated wine scored highest estimated median values for mouthfeel, taste and overall acceptability; 8.00, 7.94 and 7.86 respectively. Hence, the study revealed that organoleptically acceptable buttermilk wine could be produced using 0.1% *Saccharomyces cerevisiae* incorporation level with 7.0% (v/v) alcohol content.

Keywords: Beetroot, Buttermilk, *Saccharomyces cerevisiae*, Sensory attributes, Wine

Assessment of Physio-Chemical and Sensory Properties of a Value Added Buttermilk Based Beverage Incorporated with Finger millet (*Eleusine coracana*)

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Butter milk is a by-product from butter manufacturing which is a good source of protein, mineral and lactose. During the butter manufacturing process, approximately 50% of total milk used in butter manufacturing is discarded as butter milk. Thus, there is a growing interest in utilization of butter milk as an ingredient in dairy product development. Hence, present study was conducted to develop a value added fermented beverage using butter milk with incorporation of finger millet slurry. Three treatments were used with changing of finger millet slurry as 4%, 6% and 8%. Treatments without incorporation of finger millet slurry served as the control. Treatments were evaluated for pH, Titratable acidity (TA) and sensory attributes using nine point hedonic scale with 30 untrained panelists for 21 days of storage at 4 °C. Data from pH and TA were analyzed using two-way ANOVA, while sensory evaluation data were analyzed using Friedman non-parametric test in Minitab 17®. Based on sensory results, there were no significant difference ($P>0.05$) among treatments in terms of all sensory attributes. However, 4% finger millet slurry incorporated fermented butter milk beverage was selected as the best treatment with respect to taste and overall acceptability which scored high estimated median values of 7.59, 7.50 respectively. TA, pH were showed significant difference ($P<0.05$) amongst treatments, storage and treatment-storage interaction, while the treatments–storage interaction was non significance for pH. Moreover, at day 15, treatments showed significant difference ($P<0.05$) in all attributes while amongst 4% finger millet incorporated butter milk beverage scored highest estimated median values for color, aroma and overall acceptability. Yoghurt beverage with 4% finger millet slurry can be kept for 15 days of storage period at 4 °C without deterioration of quality parameters.

Keywords: Buttermilk, Fermented beverage, Finger millet

Assessment of Sensory Acceptability of Diyamiththa (*Cissampelos pareira*) Leaves Extract Incorporated Lacto-vegetarian Set Yoghurt during Storage

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The addition of stabilizers in dairy industry helps to improve viscosity and texture especially in set yoghurt production. The texture of yoghurt results from a complex interaction between milk proteins, acid and exopolysaccharide produced by starter culture. Gelatin is an animal originated stabilizer used in yoghurt production. Food habits in the world have started to change with an increasing demand for vegetarian food. Diyamiththa (*Cissampelos pareira*), a medicinal plant exhibit a unique gelling properties which could be an alternate for gelatin. Thus, the present study was conducted to assess the organoleptic acceptability of lacto-vegetarian set yoghurt with incorporation of a gel from diyamiththa leaves. Three levels of diyamiththa leaves extract (DLE) were used as treatments, 1%, 2% and 3% while 0.68% gelatin incorporated yoghurt served as the control. Treatments were evaluated by 30 untrained panelists for color, aroma, texture, mouthfeel, taste and overall acceptability (OA) attributes at 7 days interval for 21 days of storage at 4 °C. Data from sensory evaluation were analyzed using Friedman non-parametric test using Minitab 17®. Based on sensory evaluation at day 0 all treatments showed significant difference ($P<0.05$) with respect to all the attributes while 2% DLE incorporated yoghurt showed the highest estimated median values for both taste and OA; 7.50 and 7.78, respectively. Moreover, at day 21 treatments showed significant difference ($P<0.05$) with all attributes while amongst all treatments, 2% DLE incorporated yoghurt scored the highest estimated median values for texture, mouthfeel, taste and OA; 7.50, 7.06, 7.81 and 8.03, respectively. However, after 21 days of storage the organoleptic acceptability was declined particularly with taste and mouthfeel in all treatments. Results revealed that, 2% DLE incorporated set yoghurt can be stored for 21 days at 4 °C without deteriorating organoleptic properties.

Keywords: Diyamiththa leaves extract, Gelatin, Set yoghurt, Stabilizer

Antimicrobial Activity of Turmeric (*Curcuma longa*) Against *Salmonella* Spp and *E. coli* Spp

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The active components of natural herbs and spices contribute to the self-defense against mechanisms infectious organisms and also getting the attention as alternatives for synthetic chemicals due to their inherent antimicrobial nature, which is primarily used in food preparation. Turmeric is a tropical herb, which use to obtain aromatic powder from its mature rhizomes used for various purposes. The research was conducted to evaluate the Turmeric Methanolic Extraction (TME) and Turmeric Powder (TP) against *Salmonella* spp and *E. coli* spp. Dilution series of TME and TP were prepared according to 0.4%, 0.8%, 1.2%, and 1.6% and well diffusion method was conducted. Distilled water served as the negative control while Augmentin® (0.625ppm) served as the positive control. Antimicrobial activity was measured using the diameter of bacterial inhibition zone (DBIZ). TME inhibition for *E-coli* spp were shown significant difference ($P<0.05$) between treatments while 1.2% dilution series (DBIZ of 9.69 ± 0.54 mm) was closely related to positive control (DBIZ of 9.98 ± 1.57 mm). However, TME inhibition for *Salmonella* spp did not show significant difference ($P>0.05$) between treatments. Inhibition of TP inhibition for *E-coli* spp showed significant difference ($P<0.05$) between treatments and the best treatment was 0.8% (DBIZ of 1.84 ± 0.10 mm). Moreover, TP inhibition for *Salmonella* spp showed significant difference ($P<0.05$) between treatments and the best treatment was 1.2% (DBIZ of 2.31 ± 0.08 mm). In conclusion, 1.2% concentration in both TME and TP samples can be selected as the suitable treatment for antimicrobial property by considering the cost effectiveness.

Keywords: Turmeric, *Salmonella* Spp, *E.coli* Spp, Antimicrobial Activity

Determination of Composition and Curcumin analysis of Turmeric Grown in Sri Lanka and India

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Turmeric is a spice, colouring agent and herb which is consumed throughout the world. The main objective of this research was to do a comparative analysis of the composition of 5 different turmeric types. Two Indian market samples were used namely as Indian Pettah (IP) and Indian Matale (IM). Three Sri Lankan Samples were used namely Local Matale (LM) Research Matale (RM) and Homegarden Matale (HM). The research was done at Export Agriculture Research Institute Matale and University of Sri Jayewardenepura. Proximate analysis for all parameters and antioxidant content were quantitatively analyzed while phytochemical content was qualitatively determined. The results show a range of values which indicate the highest and lowest values respectively such as moisture (12.4 -11.33) %, volatile oil (3.3- 1.80), curcumin (5.053-3.5) %, oleoresin (15.87-14.2)% , protein (8.53-7.6)%,total ash (7.7-6.7)%, acid insoluble ash (1.8-1.1)% and fiber (7.9-7.2)%. Total Phenolic content ranged from (627.46-422.68) mg GAE 100g⁻¹ and the DPPH free radical scavenging capacity was (7.7-3.48) µg per ml. The identified phytochemicals were saponin, tannin flavonoids and steroid. Mineral were analyzed using Atomic Absorption Spectroscopy and Na content ranged from (32-35) mg 100g⁻¹, K (1603-2402) mg 100g⁻¹, Fe (32-38) mg 100g⁻¹ and Cu (0.62-0.73) mg 100g⁻¹. Volatile oil of the turmeric rhizome was subjected to Gas Chromatography Mass Spectroscopy and 44 different compounds were identified. Indian samples contained a comparatively high number of volatile compounds. The genetically modified research sample (RM) was recorded with highest values for curcumin and oleoresin. It concludes that there is a significant difference in composition among Indian and local samples.

Keywords: Turmeric, curcumin, oleoresin, Phytochemical, Comparative analysis, Volatile oil, antioxidant

Enhancing Sesame Oil Quality by Heat Treatment

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Heating, in general, destroys quality of edible oils. Since heated sesame oil is rich in antioxidants (AO) such as sesamol, in this research, we tested the hypothesis that quality of sesame oil was preserved during heating. Oil was extracted using a screw expeller from 70:30 black:white sesame seeds. A 2-factor-2-level design of experiment with centre point was used. Factors and levels were temperatures (T) at 70 °C and 180 °C and durations (t) at 1 and 4 hr. Choice of the said levels were governed by no appreciable changes in oil characteristics being detected with oil heated for 1 h at 70 °C (denoted by lowest level, LL) and considerable changes being detected with oil heated for 4 hr at 180 °C (denoted by highest level, HL). Crude oil samples, in duplicate, were oven-heated and centrifuged at 2200 g for 10 min. AO activity was quantified by assessing the 2,2-diphenyl-1-picrylhydrazyl radicals scavenging activity (RSA, in %) of oil samples. Free fatty acid content (FFA, as % oleic acid) was also assessed. Analysis of variance results of estimated interaction models of RSA and FFA revealed that all coefficients were statistically significant ($p < 0.05$) and adjusted R^2 were 94 and 88%, respectively. Anderson-Darling tests revealed that residuals of both models were normally distributed. Said models showed that fitted mean of RSA of sesame oil at HL was 5.8 times the mean at LL and fitted mean of FFA reduced from 1.8 at LL to 0.9 at HL. Increase in RSA of sesame oil with heating may be attributed to the conversion of sesamolin to sesamol, a potent AO. Further experimentation showed that more than 30 hr of heating at 180 °C was required for RSA of sesame oil to start declining, which may be explained by potential destruction of sesamol. Decrease in FFA may be attributed to evaporation of fraction of free fatty acids during heating. It was, therefore, concluded that heating in the parameter space studied enhanced sesame oil quality by raising its AOA and lowering its FFA.

Keywords: Antioxidant activity, Free fatty acid (FFA), Radical scavenging, Sesame oil

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Biochemical Analysis of Underutilized Seaweed *Ulva lactuca* from Matara, Sri Lanka and Its Application in the Development of a Nutribar

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Compared to land based agriculture, ocean farm seems to be more sustainable as it does not required land, fresh water and chemical fertilizers. Therefore cultivation of seaweeds has the ability to grow mammoth amounts of nutrient-rich food for humanoid consumption. The underutilized macro algae *U. lactuca* was manually collected during July, 2017 from Thalaramba coast Matara, Down South; Sri Lanka. Then cleaned seaweeds were subjected to oven drying at 60 °C for 8 h. Proximate composition, minerals from inductively coupled plasma optical emission spectrometry (ICP-OES), swelling capacity (SWC), water holding capacity (WHC) and oil holding capacity (OHC) were evaluated. Finally crude protein contents and radical scavenging activities were investigated for 0, 5 and 10% algal incorporated nutribars. Moisture content of fresh algae was $80.08 \pm 0.61\%$ and dry matter content was $19.92 \pm 0.61\%$. The crude protein content found in green algae was $20.16 \pm 0.16\%$. Iron was the dominant mineral present in *U. lactuca* (363.03 ± 13.54 mg kg⁻¹). Cell wall polysaccharide content obtained was 17.21%. In this study WHC of pulverized *U. lactuca* was about 4.39 g of water per g of dry matter. SWC was 1.00 ± 0.10 mg/g and OHC was 2.22 g/g at room temperature (25 °C). Significantly the highest protein content ($8.55 \pm 0.38\%$) was inspected for 10% algal added nutribar while $7.54 \pm 0.15\%$ for 0% and $7.89 \pm 0.03\%$ for 5% algal added nutribar also the highest radical scavenging activity (34.47%) was observed in 10% *U. lactuca* added nutribar. Therefore incorporation of under-utilized green algae can significantly increase the protein content and antioxidant activity of the nutribar. Moreover it can be used to develop novel healthy and nutritious foods in Sri Lanka.

Keywords: Nutribar, *Ulva lactuca*, Seaweeds, Nutraceuticals, Functional Foods

Comparative Analysis of Physicochemical and Sensory Attributes of Mature and Immature Tumid Venus Clam (*Gafrarium tumidum*) in Different Locations of Jaffna Lagoon, Sri Lanka

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Tumid Venus clam (*Gafrarium tumidum*) is one of the dominant and readily available coastal bivalves consumed by local residents in Jaffna district of Sri Lanka. Scientific data on physicochemical and sensory attributes of this species is however scarce. Therefore, the objective of this study was to determine physicochemical and sensory attributes of Tumid Venus clam in four different sites of Jaffna lagoon at two different maturity stages. Randomly collected 200 clams from each different sites of Jaffna lagoon: Karainagar (9.7481°N, 79.8829°E), Mandaitivu (9.6165°N, 79.9920°E), Kayts (9.6526°N, 79.9081°E) and Navanthurai (9.6687°N, 80.0007°E) were graded into two maturity stages as mature (100 clams ≥ 35 mm in each location) and immature (100 clams < 35 mm in each location) based on the shell length. The composite flesh samples were then subjected to analysis of physicochemical and organoleptic attributes using standard analytical protocols. Results revealed that there was a significant difference in color a^* (redness), b^* (yellowness), L^* (lightness), pH value, water holding capacity, moisture and ash contents with the location as food availability is changed with inhabiting region ($p < 0.05$). However, maturity stage had significant effects only on color a^* , b^* and L^* values and water holding capacity ($p < 0.05$). Based on the sensory evaluation, the appearance and taste of cooked clams were significantly varied with the location and maturity stage due to qualitative & quantitative changes of food items under different environmental conditions and variable nutritional requirements with maturity level ($p < 0.05$). The highest consumer acceptance was recorded for immature bivalve samples from Navanthurai. In conclusion, current study showed the suitability of low cost bivalve resources as a substitute for conventional, expensive seafood sources. Furthermore, location and maturity stage had a significant effect on physicochemical and sensory attributes of Tumid Venus clam.

Keywords: Jaffna lagoon, Physicochemical attributes, Sensory, Tumid Venus Clam

Formation of Edible Casings from Hydrolyzed Ovalbumin

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Edible casings are environmental friendly approach that can be applied on food products to control the deterioration due to oxidation or microbial growth, while enhancing the nutritional attributes. Ovalbumin and its hydrolysate exhibit functional properties to a greater extent and can be used to form an edible casing. Thus, the present study was focused to develop an edible casing using hydrolyzed ovalbumin (HOB) and to assess its physical properties. Firstly, already extracted ovalbumin protein was hydrolyzed using 1% pepsin. The HOB solid was dissolved in distilled water (9 g/ 100 mL) and as the plasticizer either levels of glycerin (Gly) at 20, 30, 40 and 50% (w/w of protein) or sorbitol (SB) at 50 and 60% or lactic acid (LA) at 30, 40, 50 and 60% was added. Then, the pH of the solution was adjusted to 11.25 ± 0.10 and heated up to 45°C for 20 min in water bath. The treated solution was casted into polypropylene covered plates and the films were peeled after 48 hrs at $25 \pm 2^{\circ}\text{C}$. After peeling, the films were subjected to heat treatment at 85°C for 20 min. The films formed using SB at 50 and 60% had a lower elongation and those of made using LA at 30, 40, 50 and 60% which had a higher brittleness. Films formed with Gly at 20% had higher brittleness while Gly at 40 and 50% had lower elongation compared to the Gly at 30%. The hardness of the prepared films was compared according to the different thicknesses as 0.06, 0.08, 0.10 and 0.12 mm. The thicknesses of 0.06 mm and 0.08 mm had higher brittleness and thickness of 0.12 mm had a higher hardness than that of 0.10 mm. In conclusion, Both SB and LA were not suitable in film formation from HOB as plasticizers while the film with 30% Gly and 0.10 mm thickness showed a better film characteristics as an edible casing.

Keywords: Edible casing, Elongation, Glycerin, Hydrolyzed ovalbumin, Tensile strength

Effect of Maturity Level on Quality and Yield of Virgin Coconut Oil (VCO) and White Coconut Oil (WCO)

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The raw material for the production of coconut oil is the kernel obtained from the fruit of *Cocos nucifera L.*. Level of fruit maturity impacts on extraction yield and physicochemical characteristics of the derived oils. The correct maturity level to be used for VCO and WCO extraction is not adequately studied. Therefore, study was conducted to evaluate the effect of 3 maturity levels (fresh 11 months old, fresh 12 months old, fully matured & 3 weeks seasoned coconuts) on extraction yield and physicochemical properties of VCO and WCO. Copra and desiccated coconut obtained from three maturity levels were tested for moisture content, fat content and free fatty acid content. The VCO and WCO obtained were analyzed for moisture content, free fatty acid content, color, relative density, fatty acid profile, total phenolic content, oil yield and oil recovery percentage. Experimental design used was complete randomized design (CRD). The lowest oil extraction yield was observed in fresh eleven month old coconuts. Fresh twelve month old coconuts and fully matured seasoned coconuts produced similar oil yield percentage. There was no significance difference of moisture, color, free fatty acid, relative density, total phenolic content of coconut oil samples from three maturity levels. Maturity levels showed no effect on physicochemical properties of VCO and WCO. Extracted VCO from the three maturity levels showed significance difference among lauric acid percentage. Fully matured seasoned coconuts had the highest lauric acid content (52.32 %). In white coconut oil showed no significant difference in fatty acids composition among three maturity levels. Fresh twelve months old coconut and fully matured seasoned coconut can be used for VCO and WCO production.

Keywords: Maturity level, Physicochemical properties, Virgin coconut oil, White coconut oil, Yield

Influence of Milk Fat and Added Sugar Content on Texture Profile of Set Yoghurts

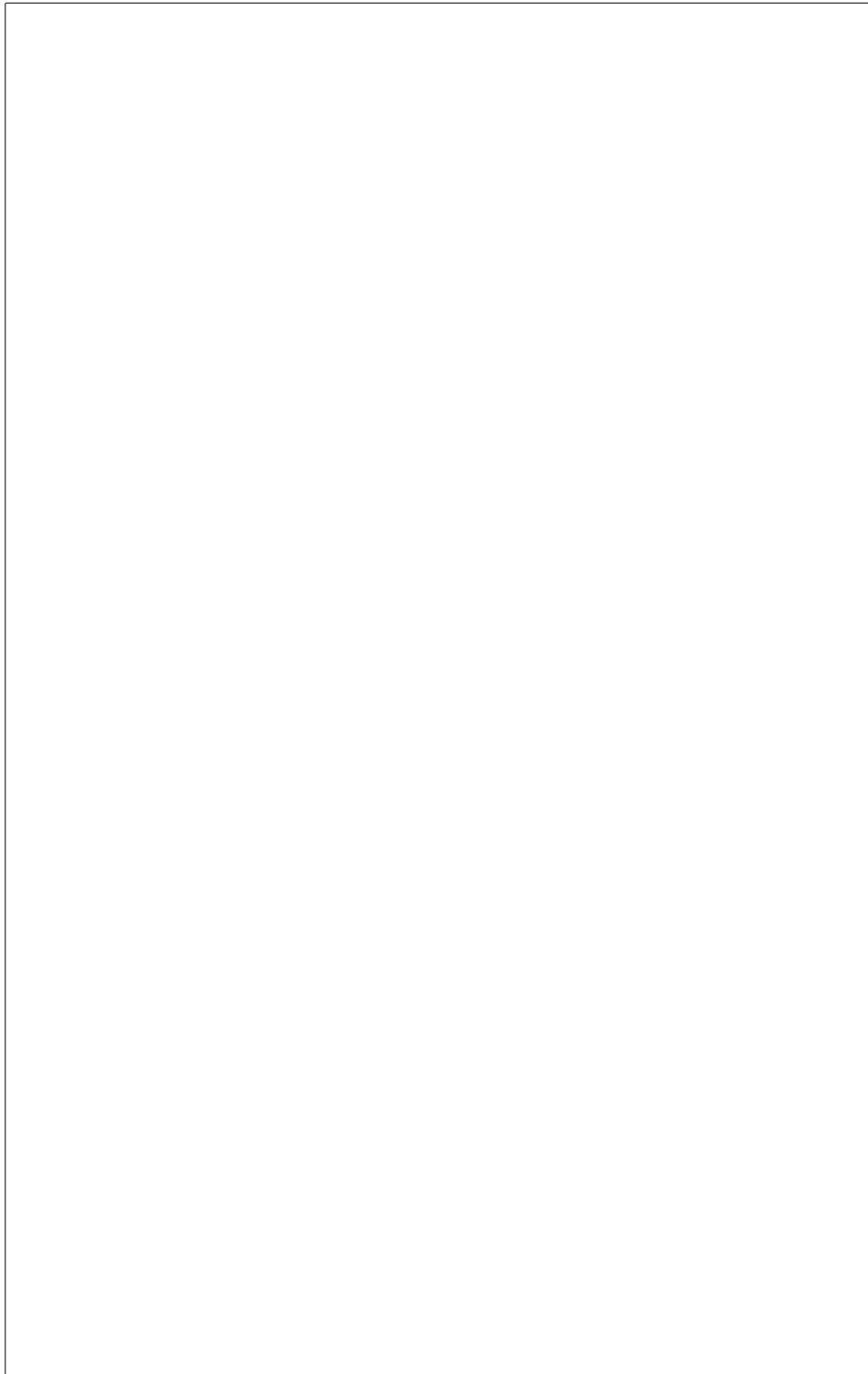
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Developing food products without fat and sugar is an emerging trend as one of the solutions for the increased risk of non-communicable diseases. However, the changes in fat and sugar content may lead to altering the product attributes and directly effect to the consumer preference. Therefore, studying those effects is essential to establish consumer preference for the particular product category. The study is focused on the effect of alteration of milk fat (3.3%, 1.5%, and 0%) and added sugar (7%, 3.5%, and 0%) levels on texture profile of set yoghurts. Tests were performed using a texture analyzer (CT3; Brookfield) with cylindrical probe (38.1 mm diameter) at 20 °C. Each response was tested in triplicates. Results revealed that hardness, adhesiveness, fracturability, gumminess, and chewiness were gradually increased with the fat content. Lowest hardness (107.4 ± 5.97 g), adhesiveness (2.21 ± 0.16 mJ), fracturability (13.7 ± 1.30 g), gumminess (50.93 ± 2.57 g), and chewiness (9.59 ± 0.46 mJ) were observed in set yoghurt made with 0% milk fat and 7% added sugar combination. Cohesiveness and springiness values were not significantly affected by the level of milk fat or added sugar. Whey separation is a predominant defect which is inversely proportional to the milk fat content of yoghurt. Syneresis index of fat and added sugar free yoghurt was high as 43.30 ± 0.46 %. Reduction of fat and added sugar leads to decrease the total solid content of yoghurt may contribute to the syneresis. Texture profile of set yoghurts was largely influenced by the milk fat levels.

Keywords: Fat, Sugar, Texture, Yoghurt, Hardness



Hospitality, Tourism and Event Management

- Tourist Destination Planning and Management
- Tourism Marketing
- Heritage and Intangible Cultural Heritage Management
- Sustainable Tourism Management
- Hospitality Management
- Service Marketing and Management
- Events and Catering Management

Determinants of Tourism Industry Attractiveness: Evidence from Tourism and Hospitality Undergraduates of Public Universities in Sri Lanka

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A person's perception on his vacation is of vital to be effective in any specific circumstance. Tourism industry employment being of extraordinary noteworthy at this intersection in Sri Lanka, the work potential and the genuine emotions on this of its future pioneers is of basic for the accomplishment of quickly developing tourism industry of the nation. Sri Lankan tourism industry needs considerably more manpower to convey great administration for individuals who visit the country. For that the government universities provide degrees identified with hospitality and tourism. Key objectives are, to identify the current status and trends in the tourism industry, examine the factors affect to the perception tourism undergraduates towards the tourism industry and identify the most influencing factors to the attraction of tourism industry. Data was collected utilizing surveys which filled by 60 undergraduates contemplating tourism degrees in government universities. Sample was selected using stratified sampling method. Questionnaire designed by using six dimensions. As indicated by illustrative measurements undergraduates concurred with social, cultural, economic and personal factors and decently conceded to environmental and industry factors. While considering on affection of these factors to the dependent variable; social factors are the most influencing factor and cultural factors are the slightest influencing factor. Despite the fact that early researchers discovered negative perception among tourism graduates towards their career, as per the discoveries of the present examination, they have thought of positive recognitions than negative discernments. It is recommended to improve the understanding of undergraduates on tourism industry and working conditions and attitudes to maintain positive ideas towards tourism industry. Future researches should be focused to take undergraduates from private universities, select students from different groups such as fresher, junior and senior and also implement qualitative approach to analyze data.

Keywords: Industry attractiveness, Perception, Undergraduates, Public universities, Tourism.

Impact of Destination Attributes on Tourists' Purchase Intention towards Shopping Products in Colombo District

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Sri Lanka targets to become one of the highest tourist spending nations in order to increase foreign direct investments & exchange revenues. The unique products in Sri Lanka such as gem kinds Sri Lankan Batik wood carving handicrafts tea spices have to gain value by understanding the most appropriate destination to reach tourists with more purchase intention. Colombo has become a business tourism destination while initiating shopping as a complementary product for travelers with the establishment of MICE triangle. This research was conducted to identify the impact of destination attributes on tourist purchase intention towards shopping products in Colombo. The data has been quantitatively collected from 100 of shopping tourists who answered the structured questionnaires. The findings interpret that destination attributes such as Attraction Accessibility Amenities Available packages Activities Ancillary services are existing in good condition while positively relating with tourists' purchase intention of shopping products. Destination attributes in Colombo illustrate the individually positive impact on tourist purchase intention which was studied as attitude subjective norm and perceived behavior towards shopping products. As per the research findings, Colombo requires the development of destinations attributes specially sight seen events & activities variety of cuisine on offer which majorly affect on tourists when relaxing from shopping and take actions to provide complied tourist guiding services to direct tourist towards local shops. Moreover, the study will guide the shop owners in tourists target markets in line with their products and analyzed destination's attributes which upgrade their revenue targets of selling more of the product to the more demanded tourists rather than pursuing clientele who are not buyers but merely window shoppers.

Keywords: Tourism, Destination attributes, Tourists' purchase intention towards shopping products.

Analysis of Organizational and Environmental Benefits from Sustainable Waste Management Practices in Hotels (with special reference to Kandy District, Sri Lanka)

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Kandy district is a reputed tourists' destination which records the second largest waste generation next to the Colombo district in Sri Lanka. Today the highest business competition has made sustainable waste management as a trend in hospitality organizations' environment. According to the main purpose the study analyzed the organizational & environmental benefits from sustainable hotel waste management practices in Kandy district, Sri Lanka. The study was adopted a descriptive survey research design. Convenience sampling method was used to select the respondents. Data collection instruments included questionnaires targeting the hotel general manager, departmental managers and junior staff. The collected data were coded tabulated and edited with the aid of SPSS electronic statistical package then presented using table, graphs and pie charts to enhance a meaningful description. The data were analyzed using the mixed method including frequencies distribution percentages and means to explain the variable characteristics, while inferential statistics including correlation to determine the variable relationship. As per the research findings, hotels in Kandy have to overcome many challenges to gain organizational and environmental benefits from sustainable waste management practice. Assistance from local government authorities improves the awareness among working staff innovative working environment an appropriate policy framework for hotels are essential to improve the waste management confidently face to critical challenges in order to the growth of sustainability in the hotel industry in Kandy district.

Keywords: Waste management, Sustainable waste management, Organizational & environmental benefits

Planning Eco-friendly Wedding Events (with special reference to event organizers in Colombo district)

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Wedding is a very important event in human life. However, weddings generate a considerable amount of waste to the environment. The remarkable increase of the event specific waste tracking and environmental impact have been discussed in detail in recent studies. Presently, the world trend is to celebrate the weddings in eco-friendly manner. But, the attention for planning eco-friendly weddings is less in published academic literature. Sri Lankan wedding industry showed a few evidences for eco-friendly weddings. Hence, the primary objective of the study is to identify the potential factors that induce the event organizers to practice eco-friendly weddings. The secondary objective is to identify the potential consequences and to identify the best practices of planning eco-friendly weddings in Sri Lanka. Qualitative method and thematic analysis was used to provide a general idea related to the objectives by categorizing the data into fourteen themes. Semi-structured interviews were conducted among the selected event organizers. The study suggests that the inducing factors such as government support and communication should be enhanced and the awareness and consideration should be improved lowering the environmental impact of events. However, it is important to note that in the commercial world, the best approach is to adopt the practices that provide benefits to the businesses, the consumer and the environment.

Keywords: Environmental Impact, Eco-friendly, Events management, Weddings, Sri Lanka

**Potentials of Developing Sri Lanka as an International Wedding
Tourism Destination
(study based on Colombo and Negombo Areas)**

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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. This is a niche market, which has not yet been capitalized and can be developed as a diversified tourism product and a method for minimizing the effect of seasonality. Hence, this study is aimed at identifying the potential of developing Sri Lanka as an international wedding tourism destination. Primary data was collected from 40 foreign wedding couples and 10 Sri Lankan wedding handlers applying judgmental sampling method and interview method for collecting data. Colombo and Negombo areas were the research areas for data collection. Both quantitative and qualitative data analyzing techniques were used. The study found that there is a positive perception among foreign wedding couples about Sri Lanka as a wedding destination. However, the wedding tourism industry has many issues and the challenges in Sri Lanka. The major challenges are the lack of involvement by the government, government rules and the regulations, lack of properties in the industry and lack of sufficient educated and trained staff in the industry. The current situation of wedding tourism industry in Sri Lanka is positive with the new trends like low cost weddings, traditional Sri Lankan weddings, and Indian weddings. The analysis concluded that there is a potential to develop international wedding tourism in Sri Lanka through the existing resources. However, the industry need to realize the real significance of wedding tourism in the Sri Lankan context.

Keywords: New trends, Tourist perception, Wedding tourism, Wedding destination

Modeling Residents' Support for Mega Events: A Partial Least Square Path Model Based on Perceived Event Impacts and Quality of Life

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How to advocate residents' support for mega-events has become a topic of discussion given its complex nature. Conventionally, political and top-down approach has been used where public resources are devoted without much involvement of the public. Hence, bottom-up approaches for mega event management and advocating residents' support has become important both theoretically and empirically. Studies based on need driven approaches are becoming attractive drawing the attention of scientific studies. Maslow's hierarchy of needs has been a central focus in management, motivation and satisfaction studies though its application in residents' support for mega events is less. The central focus of this study is to model the antecedents of resident support for mega events through Maslow's theory of needs. The model proposed integrates residents' perceived event impacts and perceived quality of life in shaping their support for mega events. Olympic Park residential area in Beijing where 2008 summer Olympic Games took place was identified as a fertile ground to test the proposed model. Item generation was supported through analysis of literature where pre-tested scales are applied to capture the key concepts. A self-administered questionnaire was pilot tested and fielded from January to April 2017 and 737 responses were secured for final analysis. Partial Least Square Structural Equation Modeling was performed to test the proposed model and the findings endorsed a strong support for the proposed model. Out of 20 hypotheses originally proposed, 18 were statistically significant and were supported. Higher order needs of the hierarchy such as self-actualization needs show less significance in mega event impacts and residents support towards the same. Comprehensive debates on implications and recommendations were discussed based on the latent variables and individual item loadings which are theoretically and empirically significant in the field of mega event management.

Keywords: Beijing olympic park, Perceived event impacts, Maslow's theory of needs, Quality of life, Support for mega events

A Study of Factors Affecting the Business Success of Tourism Related Small and Medium Enterprises in Sri Lanka (with special reference to Central province)

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Sri Lanka is one of the fastest growing tourist destinations in world. Small and Medium Enterprises (SMEs) occupy a dominant position in Tourism both at global and local level. Currently, Tourism related SMEs are facing various challenges to survive in the market and they should have the ability to adapt to the changes, as Tourism is one of the fastest growing and dynamic industries in Sri Lanka. Considering the importance of SME sector in Tourism, this study strives to identify the factors affecting the business success of Tourism related SMEs in Sri Lanka. Objectives of this research are to identify the demographic profile of Tourism related SME operators, to determine the factors affecting on business success and to identify the most influential factor which is significantly affect the business success of Tourism related SMEs. SME business characteristics, Firm's strategies, Management know how, Products and services, Customer and market, Resource and finance, Government support and External environment were studied as business success factors used to measure the business success. The study was based on primary data collected from a sample of 75 Tourism related SME business operators selected using convenience sampling method. Questionnaire survey method was applied data collection. Descriptive statistics, correlation analysis and regression analysis techniques were used for the data analysis. The results revealed that all the factors studied other than the government support are having positive relationship with the business success, while SME business characteristics was identified as the most significant factor which shows the highest coefficient value of 0.421. Study recommends to Tourism related SMEs to focus on all the affecting factors. Further support from government should be improved in order to acquire more benefits and to overcome the current challenges while ensuring business success of Tourism related SMEs in Sri Lanka.

Keywords: Business success, SMEs, Sri Lanka, Success factors, Tourism

Why Sri Lankans Eat at International Fast Food Outlets? Motivations and Demographics

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An extensive growth of international fast food consumption has been recognized evidencing the influence made on the eating habits of people by their modern lifestyle and the consumption patterns. Although fast food consumption in international outlets is fairly a new food trend in developing countries like Sri Lanka, a considerable growth of international fast food outlets all over the country is apparent. However, there is a dearth of literature on investigating what persuade people to eat at international fast food outlets in Sri Lanka. On these grounds, this empirical study examines consumers' motivations towards the international fast food while investigating the demographic differences of the motivational factors adopting quantitative-dominant mixed method approach. One hundred and eleven usable responds, collected through an on line survey, were analyzed using descriptive statistics to assess the relevancy of 13 identified motivational factors. Leximancer map, developed based on an open-ended question, was also applied to validate the findings. Demographic differences of motivators were also examined using ANOVA, t-test, and CHAID analysis. Results suggest that preferences of companion and taste as the prominent motivators whereas nutritious values and price are least concerned motivators towards the consumption of international fast food. Moreover, the demographic analysis reveals that there is a significant difference between age groups with respect to the motivational factors.

Keyword: International fast food, Motivations, Demographics

Impact of Beach Tourism on the Host Community: Evidence from Arugam Bay Beach in Sri Lanka

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One of the main and foremost attractions of Sri Lanka is its long, sandy beaches which extend all over the island. A wide tourism market has arisen in and around the beaches in Sri Lanka. Arugam Bay beach is one of the ten world's best surfing points. As beach tourism is carried out along the coasts of the island, it influences the region as well as the whole country in many ways as in positive as well as negative. This study focuses on the beach tourism activities at Arugam Bay, its positive and negative impacts on economy, socio culture and environment of the host community. Main objective of this study is to identify the beach tourism activities and to find the kind of impact they have on the host community. Primary data was collected through structured interviews from 30 respondents. Sample comprised from host community, foreign tourists, local tourists and the government officials in Arugam Bay. Analysis was done using thematic analysis which identified 3 main themes i.e. economic impacts, sociocultural impacts and environmental impacts along with several sub themes. Income generation, job creation regional development, cost of living and increasing real estate rates are the main economic impact whilst, living standards, illegal activities, misbehaviors, drug abuse and cultural influence under socio cultural impacts and environmental concern, pollution and overcrowding come under environmental impacts. The results of the study conclude that the beach tourism activities have a positive impact on the economy and the environment of the host community, while the activities negatively affect the socio culture of the host community. This study will contribute for the tourism development with community participation in Arugam Bay.

Keywords: Beach tourism, Arugam Bay, Impact, Host community

Perceived Destination Loyalty of International Millennial Tourists: Evidence from Eco-Tourists in Sri Lanka

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Eco tourism is one of the fastest growing segments in the international tourism market. Presently, Sri Lankan ecotourism sector performs far below its potential. Therefore, Sri Lankan eco-tourism market hasn't considerable demand among travelers. Targeting millennial is one of the strategies to develop eco-tourism. Millennial refers as the individuals who reached adulthood around the turn of the 21st century and Millennial tourists could be identified as one of the largest consumer cohorts in the present market, paying more for sustainability compared with other generations. Equally, the percentage of youth travellers gradually increased with their environmental attitude. The Objectivise of this study are to investigate the relationship between eco-tourism perception and destination loyalty towards eco-tourism, determine the effect of eco-tourism perception and destination loyalty towards eco-tourism and to determine the most influential dimension of eco-tourism perception on destination loyalty towards eco-tourism. Primary data collected from 141 international millennial tourists towards eco-tourism in Ella and Horton plains sourced the analysis. The judgemental sampling technique was used for the study and data was collected through a structured questionnaire. In order to achieve the objectives of this research, descriptive analysis, Pearson correlation analysis, and multiple regression analysis are used. According to the findings, most of the millennial tourists not favoured Sri Lanka as the preferred destination and as an Eco tourism destination. As for recommendations, cleanliness of the destination, effective promotional method, the convergence of facilities, implement the rules and regulations, minimise the entrance cost and increase the quality of the eco-tourism activities and practises of the country could proposed. Further sustainable tourism practices need to be adopted by the Eco tourism destinations to enhance the destination loyalty of Sri Lanka.

Keywords: Destination loyalty, Eco-tourism, Millennial tourists, Perception, Sri Lanka

The Role of Business Events' Brand Personality on Participants' Event Loyalty in Sri Lanka

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Sri Lankan MICE market with thousands of business event attendees has become a booming market representing around 11% of the total visitors to the country. The segment consists of up-market visitors and gained a huge importance to the economy. Therefore event marketing always keeps the pulse on business events' participants and motivations. As a result, event brand personality has gained a great marketing value since it differentiates the specific event from the competition influencing participants' involvement and loyalty. Main objectives of the study were to identify the impact of business events' brand personality on participants' loyalty in Sri Lanka and to identify the mediating role of participants' event involvement on the relationship between business events' brand personality and participants' event loyalty in Sri Lanka. The population includes all the business event attendees of Sri Lanka and the sample of 120 attendees selected from four business events representing the four categories of Meetings, Incentive Travels, Conferences, and Exhibitions. Convenience sampling method adapted and data was gathered using self-administered questionnaires. Data analyzed through descriptive statistics, correlation coefficient analysis, regression and Sobel Test by SPSS software. The results revealed a positive relationship between business events' brand personality on participants' event loyalty when the presence of participants' involvement, with 74.89% of mediating effect. The findings can be implied by the event organizers in improving the participants' event involvement and loyalty. Also it can be implied by marketing managers in improving their brand personality as to enhance the participants' loyalty. The study recommends effective advertising and promotions, consistent branding, creating a less imitable brand personality, event technology engagements and sustainable event practices.

Keywords: Business events, Events' brand personality, Participants' event involvement, Participants' event loyalty

Role of Destination Attributes in Developing Religious Tourism in Anuradhapura; Perspective of Chinese Tourists

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Religion plays a major role in almost all the aspects of human life. The idea of the religious travel almost prevailed from ancient time. Today, the religious tourism has been developed into a much larger and more segmented market. Sri Lanka has a great potential for religious tourism with its cultural heritage. Anuradhapura is one of the ancient capitals of Sri Lanka, designated as a UNESCO World Heritage Site due to its heritage and cultural significance. China is an emerging tourism market in Sri Lanka. Further, China is a multi-religious country where Buddhism takes a significant place. Hence, Religious tourism is one of the niche market in the tourism that can be best developed and promoted in the Sri Lanka, especially for Chinese tourists, that has not yet reaped the benefits from the full potential. Since, destination attributes are critical in any form of tourism to create a successful tourism destination, the main purpose of this study to identify the impact of the destination attributes to develop the religious tourism in Anuradhapura from the perspective of Chinese tourists. A conceptual framework has been developed based on the 6A's in tourism. The study mainly depends on the primary data that has been collected by the author. The convenience sampling method was used to collect the data from the 100 Chinese tourists who visited Anuradhapura. The quantitative research approach with Descriptive statistics, Pearson correlation analysis and the multiple linear regression analysis were used to analyze the data. The results revealed that attractions, amenities, activities and the ancillary services are highly impacting on the religious tourism development in Anuradhapura from the perspective of Chinese tourists. In order to develop the religious tourism in Anuradhapura, 6A's concept can be considered with a proper strategic framework based on the behavior patterns of different nationalities.

Keywords: Religious tourism, Destination attributes, Chinese tourists

**Effect of Authentic Atmospherics in Ethnic Restaurants on Consumer Emotions and Revisit Intension
(special reference to Sri Lankan, Chinese & Indian restaurants in Colombo district)**

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Sri Lankan tourism sector has been identified as one of the key sectors propelling the country's economic growth. The Ethnic food market is one of the fastest growing industries globally. In this respect, this study attempted to explore the effect of authentic atmospherics in ethnic restaurants on consumer emotions and revisit intension. Investigating Sri Lankan, Chinese & Indian Restaurants This study gathered information from 300 guests who visited to ethnic restaurants in Colombo by convenience sampling technique. Further, the data were analyzed through Descriptive analysis, Correlation, Simple Regression. Apart from that, Preacher and Hayes multiple mediation assessment model 06 and Process Model 01 used to assess the mediation effect of emotion. The study found that there is a significant relationship between Authentic Atmosphere and Revisit Intension and Consumer Positive Emotions significantly and partially mediates the relationship between Authentic Atmosphere and Revisit Intension. Further, the finding of this study demonstrates Visitor Attitude significantly moderates in the relationship between Positive Emotions and Authentic Atmosphere. Finally, this study recommends to the ethnic restaurants to develop the authentic Atmosphere further in order to retain the customers.

Keywords: Authenticity, Atmospherics, Emotion, Revisit intention, Ethnic restaurant, Chinese restaurant, Indian restaurants, Sri Lankan restaurants

Study the Impact of Destination Attributes on International Tourist Satisfaction in Uva Province as a Tourist Destination

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Tourist satisfaction has been identified as a key performance indicator in the tourism industry. Uva province is not attracted by many tourists as their tourist destination even with a vast collection of tourist voluminous collection of tourism possibilities. Therefore, it's very critical to investigate the current level of tourist satisfaction and the relationship between destination attributes and tourists perspective in order to gain in-depth understanding of tourist's satisfaction in the Uva province. This study focused on the evaluation of the relationship between destination attributes and tourist satisfaction with special reference to the Uva province. Destination attributes are the independent variable and under that, there were six sub independent variables. Tourist satisfaction was the dependent variable and below that there were two subs dependent variable. There were mainly three objectives based on this research and those to identify the existing level of tourist satisfaction and destination attributes in Uva province, to identify the relationship between destination attributes and tourist's satisfaction and to recognize most significant attributes influence on the satisfaction of tourists in Uva province. A sample 150 tourist was drawn using judgmental sampling. Primary data were collected using self-administrated questionnaire. Data were analyzed by using SPSS. Descriptive statistics, correlation and regression were used to analysis the data to achieve objective of the study. Finding revealed that there is a strong positive relationship with destination attributes and tourist satisfaction. Further finding reveal that destination attraction, accessibility, amenities and ancillary services are significantly influence on tourist satisfaction while available packages and activities are not significantly influence.

Keywords: Destination Attributes, Tourist satisfaction.

**Determinants of Street Food Consumption in Colombo City, Sri Lanka;
Perspective of Foreign Tourists**

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Street food vending is one of the major livelihoods in many countries in the world, specially in developing countries by contributing up to 50 percent of daily diet of urban consumers. Street foods also a noticeable source of attracting tourists to a particular destination as the gastronomic tourism, and culinary tourism. Low level of income earners as well as low-end tourists who are satisfying their needs in the cheapest possible way are highly depend on street food. Consumption of street foods in Sri Lanka also is becoming an increasingly important component of the food market because of strong interaction with the tourism. However, information on street food industry has been found to be greatly lacking in many developing countries. In order to show more light on the street food sector, a study was carried out to recognize the determinant of street food consumption of international tourists in Colombo city, Sri Lanka. The main purpose of this study is to discover the most influencing determinant of street food consumption of international tourists in Colombo city and develop the profile of street food consumers. Sample of 100 international tourists chosen through convenience sampling technique and data were collected through a self-administrated questionnaire. Multiple regression model, identified that out of Economical, Environmental, Socio Cultural, Physical and Psychological factors. Accordingly the Economical factors are the most influencing for the tourist's perspective towards the street food consumption in Colombo city as most of the time, street foods are consumed by the low income earners who are highly sensitive about expenditures. The study recommends that street food industry stakeholders have to concern the pricing and other economical factors in advance to develop the street food industry in Sri Lanka.

Keywords: Street foods, Consumption, Foreign tourists, Food vendors

Socio-Economic Determinants of Wildlife Tourism Affecting on Tourism Service Suppliers- Special Reference to Ruhuna Yala National Park and Horton Plains National Park

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Wildlife tourism had gained much priority recently. Wildlife tourism involves activities that interact with wildlife, mostly in national parks and protected areas. Ruhuna Yala national park and Horton Plains national park are the most popular national parks for wildlife tourism in Sri Lanka. Therefore due to the highest number of tourist arrivals impact on wildlife and environment is negative. Over visitation had laid the foundation for further problems and identifying the factors that will effect on Wildlife tourism is important. Researchers had identified an empirical gap in the context. There are no researches regarding socio-economic determinants of wildlife tourism that effect on tourism service suppliers. The objective of this research study is to identify socio-economic factors of wildlife tourism affecting on tourism service suppliers in the Ruhuna Yala national park and Horton Plains national park. Primary data were gathered through self-administered questionnaire. A sample of 100 tourism service suppliers selected using multi-stage sampling method from both Ruhuna Yala national park and Horton Plains national park through. In order to achieve the objective of this research, the researcher conducted exploratory factor analysis method and found five wildlife tourism factors affect on tourism service suppliers. Reliability of this research study is 0.815. Findings revealed that community health and safety, host community, investment, social cohesion and income distribution are the factors that effect on the tourism service suppliers. Further, based on the factors, researcher recommends maintaining the code of conduct, ensuring the CSR activities by tourism establishments and implement of a health policy, confirmation of fair income distribution and encouraging foreign investments can be used to increase the favorable environment for tourism service suppliers to perform a memorable experience to tourist.

Keywords: Wildlife tourism, Socio-economic factors, Tourism service suppliers, Tourism

The Impacts of Entertainment Events on Host Community with Special Reference to Hikkaduwa

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Sri Lanka has proved to be one of the fastest growing tourist destinations for most type of tourism, especially events tourism. Events are widely recognized to generate many impacts on the host communities and other stakeholders. However the impacts of the events have not been considered in the Sri Lankan context in past few decades. Therefore this research mainly focuses on the entertainment event tourism sector and its impacts on the economy, socio-cultural and environment of the host community. Furthermore, the study identifies the existing strategies for development of host community needs in the research area. The researcher selected 20 event tourism stakeholders who lived in Hikkaduwa area using the convenience sampling method. Semi-structured interviews are conducted to gather the data. Local event organizers, government administrative staff and host community in Hikkaduwa area are interviewed and their views and opinions are used as the basis of the researcher's analysis from which findings and recommendations are derived. Data were analyzed using thematic analysis using NVivo 11 pro software. By using thematic analysis method, infrastructure development, income generation, living standards, illegal activities, cultural influence and waste management were identified as the main themes. A general conclusion is that entertainment events affect host communities positively by constructing a destination image & building community commitment and negatively by illegal activities, disturbances & pollution. Findings of this study recommend to improve the collaboration & networking among stakeholders, increase positive cultural influences and to raise awareness of the host community about event tourism.

Keywords: Event tourism, Entertainment events, Local event organizers, Host community

Socio-Economic and the Environmental Impacts of Developing a Hydropower Plant in Kithulgala Adventure Tour Site (with special reference to adventure activity operators)

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Kithulgala is considered as a premier adventure tourism destination in Sri Lanka due to the White Water Rafting Industry. There are 30 adventure activity operators along the Kelani river who run by typical lifestyle entrepreneurs dedicating considerable time, talent and capital resources to develop the rafting industry. Moreover, 1500 families indirectly gets benefits through job opportunities and the spin-off industries. It is estimated that the tourism industry in Kithulgala generate US \$17.5 million per annum directly for the local economy. However, development of the hydropower plant in Kelani River threatens to destroy the rapids and it negatively effects on rafting. There is hardly any attention given to conduct empirical studies on adventure activity operators in Kithulgala based on the power plant. The qualitative research was conducted through structured interviews, using 15 adventure activity operators in Kithulgala area. Data was collected through convenient sampling by recording the personal interviews, to assess the current situation, economic, social and environmental impacts and to assess their perspective regarding the implementation of the power plant. Thematic analysis method adopted to analyze the transcribed qualitative data. The findings of this study indicates that, the building of the power plant has led to reduce the water level, destroy the rapids of the river, lose the main source of income generation of rafting operators and the villagers, displace the population, damage the houses, environmental pollution and to degenerate the Kithulgala tourist destination. The study suggests, the government should pay more attention on releasing water during the day time, or construct mini hydropower plant below the existing dam that generates 10-12 MW, open up a new track which has 3-4 natural rapids to protect the Kithulgala adventure tourism destination.

Keywords: Adventure tourism, Hydropower plant, Lifestyle entrepreneur, White water rafting

Community Based Tourism and Poverty Alleviation in Sri Lanka: With Special Reference to Monaragala District

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Tourism can make a significant impact on rural communities as the customer comes to the facility or product creating a room for direct selling/engagement for the host communities. Accordingly, community-based tourism emerged as a possible solution to the mass tourism in developing countries, which thus became a strategy for a community organization in order to alleviate poverty. Therefore, this research exploited the opportunities for poverty alleviation through Community Based Tourism in Monaragala district and identified the most influencing challenges for Community Based Tourism. The research adopted the quantitative approach to data analysis, especially using multiple regression analysis. The primary data were gathered by using a self-completion questionnaire. The Sample consisted of 60 respondents engage in Community -based Tourism and 60 respondents did not engaged in Community -based Tourism. The major objective of the study was to identify the potentials for poverty alleviation through Community-based Tourism in Monaragala district. The results of the analysis indicated that, CBT engaged people earn more 10123.03 rupees than CBT not engaged people suggesting that earning capability of the CBT engaged people are higher. Therefore, the study concluded that there is a higher potential for poverty alleviation through Community Based Tourism. The second objective of the study was aimed at identifying the most influencing challenges for CBT in the district. The study found that lack of training, lack of e-commerce, lack of skillful employees as the major challenges in developing community based tourism in Monaragala district.

Keywords: Community based tourism, Poverty, Poverty alleviation

A Study on Labour Turnover Intention of Millennial Employees in Hotel Industry; With Special Reference to Five Star Hotels in Sri Lanka

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Hospitality industry is considered as a highly labour-intensive industry, and labour turnover has been conspicuously recognized as a severe concern within the industry, all around the world. The industry requires more evident to discover the ins and outs to minimize the negative waves of this high rate of labour turnover within the sector. Millennial employees, the future of work force have completely different attitudes, characteristics and behaviors compared to past generations and they have already dominated the human capital in some companies specially hotel sector and fast-growing travel industry. Thus, this study has empirically assessed the labour turnover intention of millennial employees in the hotel industry to provide more inputs to minimize future challenges. Three objectives were stated in order to recognize how job stress, job satisfaction, extended working hours and reward management practices are influencing millennial employees' turnover intention in hotel industry. This study based on three objectives; first, to determine existing situation of determinants, second, to identify the relationship between labour turnover intention and determinants. Finally, to identify the most significant factor which determine labour turnover intention of millennial employees. Data were collected by the researcher from a sample of 136 millennial employees, who were working in a five star hotel at least for 6 months period were selected through convenient sampling techniques and assessed through a self-administrated questionnaire. In order to achieve the objectives, the researcher conducted descriptive analysis, correlation analysis and multiple regression analysis. According to the results, job stress, extended working hours, are positively influenced on the turnover intention of millennial employees in hotel industry where reward management practices and job satisfaction are negatively influenced. The job stress and reward management practices were the most significant elements to control the turnover intention of millennial employees in hotel industry. Further, based on the above variables , researcher recommends that increase in employee satisfaction level, flexible supervision and policies for their work schedule, increase performances through career advancement workshops, training sessions and performance appraisal, providing a safety environment and better facilities with necessary equipment, making opportunities for success their future path, fair treatments for all employees, flexible work load, responsibilities and working hours and Maintain a good reward management practices to minimize the millennial employees turnover intention in sri lanka.

Keywords: Millennial employees, Turnover intention, Hotel industry

Impact of Marketing Mix Factors in Tourists' Decision Making of Revisiting Sri Lanka (with special reference to beach tourism in southern province)

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When comparing about the statistical reports of tourists arrivals and the beach tourist's percentages in recent years there is a decline in the percentage of beach tourists in Sri Lanka though there is a growth in tourist arrivals. The aim of this research is to study - the service marketing mix and how it influence on the tourists' decision to revisit Sri Lanka. The researcher has used a sample of 150 international tourists & selected by using convenient sampling technique. Researcher has used 5 different destinations including, Bentota, Hikkaduwa, Unawatuna, Mirissa and Tangalle by distributing the sample equally. Data related to demographic and marketing mix factors are gathered by using a questionnaire filled by the respondents. Researcher has used descriptive, correlation and regression analysis methods to analyze the data. According to the results of demographic characteristics of beach tourist most of them are young, well-educated and working in the private sector. Most of the tourists prefer swimming in the southern beaches. The analysis exposed that there was a positive relationship between all the marketing mix factors and tourists' tourism decision. The most influencing factor was the product, second highest influencing factor was the place and both of them having a strong positive relationship to the tourists' decision and the least influencing factor was the personnel second least influential factor was the physical evidence and both of them having weak positive relationship to the tourists' decision to revisit Sri Lanka. Price, Promotion and Process are having an average positive relationship towards the tourists' decision. The study recommends improving the promotion of Sri Lankan beach tourism in other countries, developing proper pricing strategy, improving beach tourism activities as well as the quality of beach tourism related products and to reduce the degree of pollution in local beaches.

Keywords: Service marketing mix, Beach tourism, Tourism destinations, Tourists, Tourists' decision

Impact of Destination Attributes to Develop Rural Tourism in Medadumbara Divisional Secretary's Division; Perspective of Foreign Tourists

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Tourism industry is a rapidly growing industry in the world as well as in Sri Lanka. The demand of travelling for experiencing the rural tourism related activities within the world is gradually increased. Destination attributes in each and every tourism destination are playing major role in tourism development and they have different weights for different tourism market segments. In this context, this study was aimed to examine the existing situation of destination attributes in Medadumbara area, to ascertain the relationship between destination attributes and rural tourism development. Study has investigated the impact of destination attributes to develop rural tourism. Data collected from 75 foreign tourists who visited Medadumbara area using self-administrated questionnaire as data collecting technique. Buhalis's 6A's framework for destination attributes has been used to determine the impact levels. The result of descriptive statistics is emphasized that respondents almost agreed with existing level of destination attributes. As per the Correlation Analysis, strong positive relationship is recorded between destination attributes and rural tourism development. Multiple linear regression analysis has confirmed positive impact of destination attributes towards rural tourism development in Medadumbara division. It determines that Attractions, Accessibility, Amenities and Activities are the key considerations as these factors strongly influence on rural tourism development. The study implied that the destination attributes is a key player in rural tourism development. Study suggested that tourism related bodies should pay more attention on introduce new tourism activities within this area, improve information services regarding this area and improve quality accommodation facilities, transportation facilities and other amenities to develop Medadumbara as a rural tourism destination.

Keywords: Rural tourism, Destination attributes, Buhalis's 6A's framework, Foreign tourists

A Comparative Study on the Influence of Promotional Mix Factors on Domestic Tourists' Destination Choice: Evidence from Dambulla & Sigiriya UNESCO World Heritage Sites

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The domestic tourism in Sri Lanka has a long history. A specific feature of domestic tourism in Sri Lanka is the rising middle class that emerged with the opening up the economy of the country. Strategies used in tourist destinations and the factors affecting tourists' destination choice are highly important for the promotional activities. This study depends on domestic tourists' destination choice with respect to two UNESCO World heritage sites. According to Annual Statistical Report of Sri Lanka Tourism Development Authority, it is revealed that there are lowest domestic tourist's arrivals to Dambulla heritage site and highest domestic tourist's arrivals to Sigiriya heritage site. Hence, the intention of this paper is to fill the gap in literature using secondary and primary data. Primary data were gathered through distributing a self-administered questionnaire and fifty domestic tourists per destination were selected by using convenience sampling technique. Correlation coefficient analysis and Regression analysis were used for the purpose of data analysis. Results revealed that the public relations were the most significant tool influence on destination choice in Dambulla heritage site and personal selling was the most significant tool influence in Sigiriya heritage site. According to the results, Dambulla heritage site should consider the other promotional activities such as personal selling, advertising and sales promotions to enhance the domestic tourist arrivals.

Keywords: Destination choice, Domestic tourist, Promotional mix, Comparative study

Impact of Web Quality on Customer Satisfaction and Purchase Intention (special reference to Sri Lankan travel agents)

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The purpose of this research was to test whether the quality of the travel agent websites influences on purchase intention by increasing customer satisfaction. Even though the previous researches have proven the relationship between customer satisfaction and consumer behavior on purchases in the hotel industry, in Sri Lankan context, the online platforms created by the travel industry are still underestimated. Hence, this study has tried to measure the mediator effect of customer satisfaction. A questionnaire was used to collect data from a sample of 204 conveniently selected respondents for the study from conveniently selected travel destinations in Sri Lanka. The primary objective of this study was to determine the impact of Travel Agents' website quality on purchase intention by increasing consumer satisfaction. Then the researcher tested each individual quality dimension's effect on the overall quality and how the overall website quality effect on both customer satisfaction and purchase intention. A revised conceptual framework was used and the researcher defined the paths to carry out a *Sobel Test* to assess the mediator effect of customer satisfaction. The researchers' analyses lead to the conclusion that customer satisfaction acts as a mediator of the effect of overall website's quality on purchase intention. Based on the results, the researcher suggested the managers in developing a more human-friendly interface on online travel and booking platforms. To increase the sale-ability of online tourism products, the researcher recommended increasing the dimensions of website quality and *human-computer interaction* theories. Hence, this research results conclude the importance of the online customer's satisfaction and how it could be advanced for an end result of a repeat and satisfied travel product purchaser.

Keywords: Customer satisfaction, Purchase intention, Tourism industry, Travel agent, Website quality

**Analysis of the Effect of the Working Environment to the Job Satisfaction of the Air Hostesses
(with special reference to Sri Lankan Airlines)**

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The research was done to analyze the job satisfaction of Air hostesses in respect to their working environmental factors and with a special reference to Sri Lankan Airlines. Airhostesses make the first impression of the country. They need to serve food and beverages to the passengers while taking care of the safety and security of all on board. Even if lots of benefits come with air hostess positions, there are difficulties to do the job too. Mostly the working environment factors are affecting the job dissatisfaction. Young ladies are selected to work on the air with strange people, work being far away from beloved ones, tough roster, long hours, odd working times, sleepless nights, routine work and etc. Objectives of the research are, identifying the effect and the major critical factors of working environment that effect to the job satisfaction of the Air Hostesses. Population was all currently working Sri Lankan Airlines airhostesses and a sample was 50 of them. The simple random sampling method was used and with questionnaires and Google forms the data was collected. In the analysis Air hostesses' job satisfaction was the dependent variable and their working environment was the dependent variable including three factors such as Job It Self, Job Environment and Organizational Characteristics. For the analysis, Descriptive statistics was used the Demographic factor analysis and correlation and Regression were used for relationship analysis. With the 0.813 overall Pearson correlation, it proved that there is a strong positive correlation in between independent and dependent variables at the significant level 0.01. Coefficient table of the regression analysis of this study showed all the independent variables had been negatively reacted upon the dependent variable with an unstandardized beta coefficient for the constant -0.059. The major affecting factor for the job satisfaction is the job environment with 0.658 unstandardized coefficient beta value. As the suggestions flexible time schedules for flying, fare duty rosters, provide comfortable garments and the accessories, minimize the injurious and the heavy equipments from ladies and having altered solutions for them, and minimize the monotonous working pattern can be given.

Keywords: Working environment, Job satisfaction, Air hostesses, Relationship, Factors, Effect

Impact of Eco Tourism Practices on Customer Satisfaction (with special reference to hotels in Uva province)

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Sri Lanka has obtained tremendous ecotourism resources with great potential for further development in modern economy. The study based on two main objectives; to identify the existing situation of eco-tourism practices, and to assess the impact of eco-tourism practices on customer satisfaction. Sri Lankan eco resort hoteliers construct the meaning of eco-tourism practices in various ways. They are more towards nature based tourism, wild life tourism and environment conservation tourism. They were unable to target international eco-tourism standard and attract eco tourists. Because the hoteliers' practice of the eco concept differs from international practices and standards, they could not meet the expectations of eco tourists. Even though eco-tourism concept main market is eco tourist market, they cater and address to other type of tourists. Comparing to the international eco-tourism standard, Sri Lankan hoteliers consider only few practices as an essential components of an eco-tourism practices. Many hoteliers are launching awareness programs and interpretation programs to their stakeholders about the environmental conservation practices of the hotel and the hotel facilities. It is not about the eco hotels and ecotourism concepts. Therefore, need to launch correct awareness programs on the eco concept. Data collection of the study was conducted self-administered questionnaire. Questionnaires were distributed among 100 tourists who accommodated in the hotels in Uva province employing convenient sampling method. Ten hotels were selected using random sampling technique and ten guests were selected from each hotel for this study. Study examined the relationship between eco-tourism practices and customer satisfaction. The findings revealed that the existing situation of eco-tourism practices in Uva province the tourists are satisfied. According to Pearson correlation analysis, strong positive relationship has been proven in between eco-tourism practices and customer satisfaction.

Keywords: Customer, satisfaction, Eco-tourism, Hotels, Eco tourists

Exploring Tourism Risk at the Destinations at Jaffna Peninsula with Special Reference to Keerimalai Ritual Beach site.

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Ritual beach sites are considered as one of the major travel motives of the tourists to visit Sri Lanka. Jaffna is rich with wonderful ritual beach sites including *Keerimalai* and *Villunri* areas. Many local and foreign tourists arrive at these ritual beach sites every day. Ensuring safety of tourist in the tourist destinations are considered as one of the important factors that determine the revisit and sustaining the higher number of tourist arrivals. Nevertheless, the literature in this area is very rare, especially in the ritual beach sites. Further, if tourists feel the particular destination is at high risk, the image of the destination can be affected and tourists may negatively convey the message to others. Therefore, the main objective of this study is to identify the factors influencing the tourism risk in Jaffna *Keerimalai* ritual sea site. And also to make recommendations to overcome the destination risks to ensure propensity of the repeat visit and word of mouth promotion. The study was conducted by using the mixed method approach. Furthermore, the *Keerimalai* ritual beach site was selected through the convenience sampling technique. Primary data were collected through self-administered questionnaires and the observation techniques. The study revealed that *Keerimalai* ritual sea site is risky for tourists and this may affect the revisit intention and word of positive promotion. Alcohol addiction, thief activities, violence, rocks under the sea water, safety and security signs and polluted water are harmful to the tourist. In spite of all these risks, there are many tourists who still visit *Keerimalai* ritual area to accomplish their cultural rituals.

Keywords: Destination image, Revisit, Tourism risks, Word of mouth communication, Ritual beach sites.

Travel Motivations of Beach Tourists: Push and Pull Approach from Trincomalee

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Tourist arrivals to Trincomalee destination, Eastern Sri Lanka has been recorded with a positive trend as the destination boast with its rich natural, ancient history and diversity. Importance of tourist arrivals to a destination has been influenced by tourist's motivations and the question arises that which pull and push motivational factors influence on their travel destination decision. These two factors explain people travel because they are pushed by their own internal forces and pulled by the external forces of destination attributes. This study investigates the travel motivational perception of the tourists visited to beaches in the destination and further the study is overlooking inbound characteristics of the destination. The study based on primary data gathered through a questionnaire survey from a sample of 100 tourists including local and foreign who visited to Nilaveli, Uppuveli, Marble, Arisimale and Town beaches in the destination. Descriptive and graphical representations have been adapted to analyze the data. The key findings of this study indicate that both push and pull travel motivational factors stimulate the higher Beach tourists' arrivals to the destination. Further this study concludes that the mean ranking of the constructs within travel motives showed that seeking relaxation and fulfilling prestige were regarded as the most and the least influential push travel motivational factors respectively, where natural resources and events and activities were identified as the most and the least influential pull travel motivational factors respectively. This study recommends that the travel motivational factors are important marketing implications to the destination specially in terms of examination of motives in segmenting markets, designing promotional programs and decision making about destination development.

Keywords: Trincomalee, Beach tourists, Travel motivation, Push factors, Pull factors

A Comparative Study on Tourists' Satisfaction with Attributes of Cultural Heritage Sites (with special reference to select Ancient Heritage of Sigiriya and Golden Temple of Dambulla)

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Tourism is an important driving force of regional economic development of the country. Identifying the determinants of tourist satisfaction is an essential aspect in the tourism industry. Therefore, the purpose of the study is to predict and compare the determinants of tourists' satisfaction (TS) in ancient heritage site of *Sigiriya* and Golden Temple of *Dambulla*. Buhalis 6A's framework was used as the main theoretical tool where the impact of six destination attributes such as; Attractiveness, Accessibility, Amenities, Ancillary services, Activities and Available packages on tourist satisfaction was identified. The study employed convenience sampling method to collect data from 50 tourists from each site. Descriptive statistics, correlation analysis and regression analysis were used to obtain the results. The results concluded that all the six destination attributes have positive relationships with the tourist satisfaction in both destinations. Besides available packages have the most significant impact on tourist satisfaction in *Sigiriya* while attractiveness has most significant impact on TS in Golden Temple. Thus these findings could be used to increase the tourist satisfaction in both destinations.

Keywords: Determinants of Tourists' Satisfaction, Cultural Tourism, Heritage Tourism

Identifying Barriers in Commencing Own Business: Evidence from Hospitality and Tourism Graduates in Sri Lanka

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Tourism has become a booming industry in Sri Lanka in recent decades. As a result, higher educational institutes such as universities tend to focus their attention on the development of tourism industry by offering various tourism related courses. These courses have been designed to create graduates who will reinforce tourism industry in a proper manner by considering contemporary requirements and the output of these courses will be directly or indirectly involved with the tourism industry. As a result, graduates are coming up with new business ideas which in turn to help the development of Sri Lankan economy. But there is a lack of start-ups in this sector though the new business ideas arise from tourism graduates. Understanding common start-up problems can help entrepreneurs to find the right path. Hence a study was carried out to identify the barriers in commencing own business who has been already followed up hospitality and tourism courses in Sri Lanka. Among the population of students who have already followed up tourism related degrees, 120 graduates in three universities namely, Uva Wellassa University of Sri Lanka, Sabaragamuwa University of Sri Lanka and Rajarata University of Sri Lanka were selected as the sample using the convenience sampling technique. Data was collected using self-administrated questionnaires. They were analysed using Principle Component Factor Analysis Method. Results revealed that three major factors affect as the barriers to start a business. They are aversion to risk, socio cultural influence and negative perception. Further they overlook on the competition in the market and avoid preparing business plans and tend to find jobs in the industry. Study also revealed that to mitigate such type of barriers, obtaining the attention of financial institutions, which reinforce the upliftment of tourism graduates through the universities, build up positive perception toward entrepreneurship by conducting different programs.

Keywords: Barriers, Graduates, Start up, Courses

The Study on Impact of Service Quality on Guest Loyalty in Hotel Industry: (with special reference to five star hotels in Kandy district)

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Sri Lankan tourism industry is rapidly growing at present. Therefore tourism was able to upgrade its rank to the third among the important sources of Foreign Exchange Earner of the national economy. Within that, the hotel sector mainly contribute to the GDP of the country. In this context, this study investigated the impact of service quality on guests' loyalty in hotel industry with special reference to five star hotels in Kandy District. The researcher selected all the three five star hotels in Kandy District and collected data from 120 guests who visited those three five star hotels using convenience sampling method and questionnaire is used as the data collecting technique. The SERVQUAL model has been used to measure the service quality as it proved as a best yardstick to measure it. Descriptive statistics, correlation and regression analysis were used to analyse the data with the support of SPSS 21.0. Existing level of service quality and guests' loyalty is in agreed level according to the descriptive statistics. According to the correlation analysis, there is a positive relationship between all service quality dimensions and guests' loyalty in hotel industry. In addition to that multiple linear regression analysis confirmed the positive impact of service quality towards guests' loyalty. Since the study found that service quality is a key driver of guests' loyalty in hotel industry, study provides recommendations and suggestions for practical implementation in hotel management based on research findings. It suggests that empathy, tangibility and reliability of a service are key consideration as these factors strongly influence on guests' loyalty according to the analytical results. Hoteliers should improve the service based on these factors and its indicators to enhance their loyal customer base since it affect to the profitability of the hotel. The quality service is mainly affect to the guests' loyalty.

Keywords: Guests' Loyalty, Service Quality, SERVQUAL model, five star hotels.

Examining Key Areas of Tourists' Complains: Case of Freelance Tour Guides

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The Tourist guide is a key sub service sector in the tourism industry and is a frontline character to interpret and share knowledge among tourists around. Four main guide types can be identified as a national guide, chauffeur-guide, area guide and site guide. Tourist can select the guide type according to their requirements and preference. Currently, Sri Lanka has a huge demand for tourist guides due to the rapid expansion of the tourism industry in recent time. Hence, a dearth of tourist guides can be seen within the industry. Some guides conduct tours having improper qualifications to avoid the occurring gap between the demand and supply. Thus, the knowledge and service, they provide is not up to the stranded level to fulfill the tourist expectations and it causes many complaints. Accordingly, this case study strives to examine the key areas of the tourists' complain on freelance tourist guide. Fifty complains were collected as primary data from the tourists who had accompanied by tourist guide and whom complained against guides by using convenience sampling technique for this case study. Semi structured questions and open ended questions consist in the questionnaire. Descriptive analysis method was used to analyze the qualitative data. As the key complaint, it is identified that improper handling of the tour by the tourist guide leads to the dissatisfaction of tourist. Further, unethical and unprofessional behavior can be identified. Additional payments for entrance fees and transport also marks another major complaint area. Punctuality, reckless driving, not accompanied with tourist, changing the itinerary, providing fallacious information, deficiency of knowledge, language problems, inflexibility of service, shopping, consumption of alcohol, sexual harassment and vehicle condition are the rest of complaints area which identified against freelance tourist guides.

Keywords: Freelance tour guides, Complaints, Tourists

Stepping Boom to Doom Tourism? A Special Focus on Elephant Seeing in Sri Lanka

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Doom Tourism indicates a significant role in an emerging travel trend which explains visiting of vulnerable places and features before they disappear or are essential and irrevocably changed by tourists. Elephants, the symbolic creature of culture and nature of Sri Lanka are playing a major role of Sri Lanka's natural asset portfolio. Therefore, elephants are identified as an icon of booming of Sri Lankan tourism with elephant seeing, elephant safari, elephant ride, and using for foreign weddings etc., Elephant' destinations have been economically benefitted through the tourism but similarly and gradually threatened by human activities. Considering this doubtful background, this study aims to identify the problems associated with elephant seeing and whether elephant seeing of Sri Lankan tourism moving to Doom Tourism in the future. Dambulla, Habarana and Minneriya were selected as research field to the study. Primary data was collected from a sample of 85 tourists distributing a self-administered questionnaire and from 25 tourism stakeholders around the area through interviews. The secondary data was collected from books, magazines, newspapers and government offices. A mixed methodology was employed to analyze the collected data while importing them to the Statistical Package for the Social science (SPSS). The results show that elephants are in a severe risk due to killing for commercialization, dumping in forests and overloaded jeep safaris etc. and local guests emphasized that existing elephants in Sri Lanka are visited by them as they observed that elephants are threatened by humans. Further, both local and foreign tourists suggested to engage in Doom Tourism as Elephants in Sri Lanka is the image of Asian Elephants. Moreover, it is recommended that elephant seeing should be a form of responsible tourism in Sri Lankan Tourism Industry.

Keywords: Doom Tourism, Elephants' Destination, Elephant Seeing

Developing Tea Tourism Niche Market in Sri Lanka: Stakeholders' Perspective

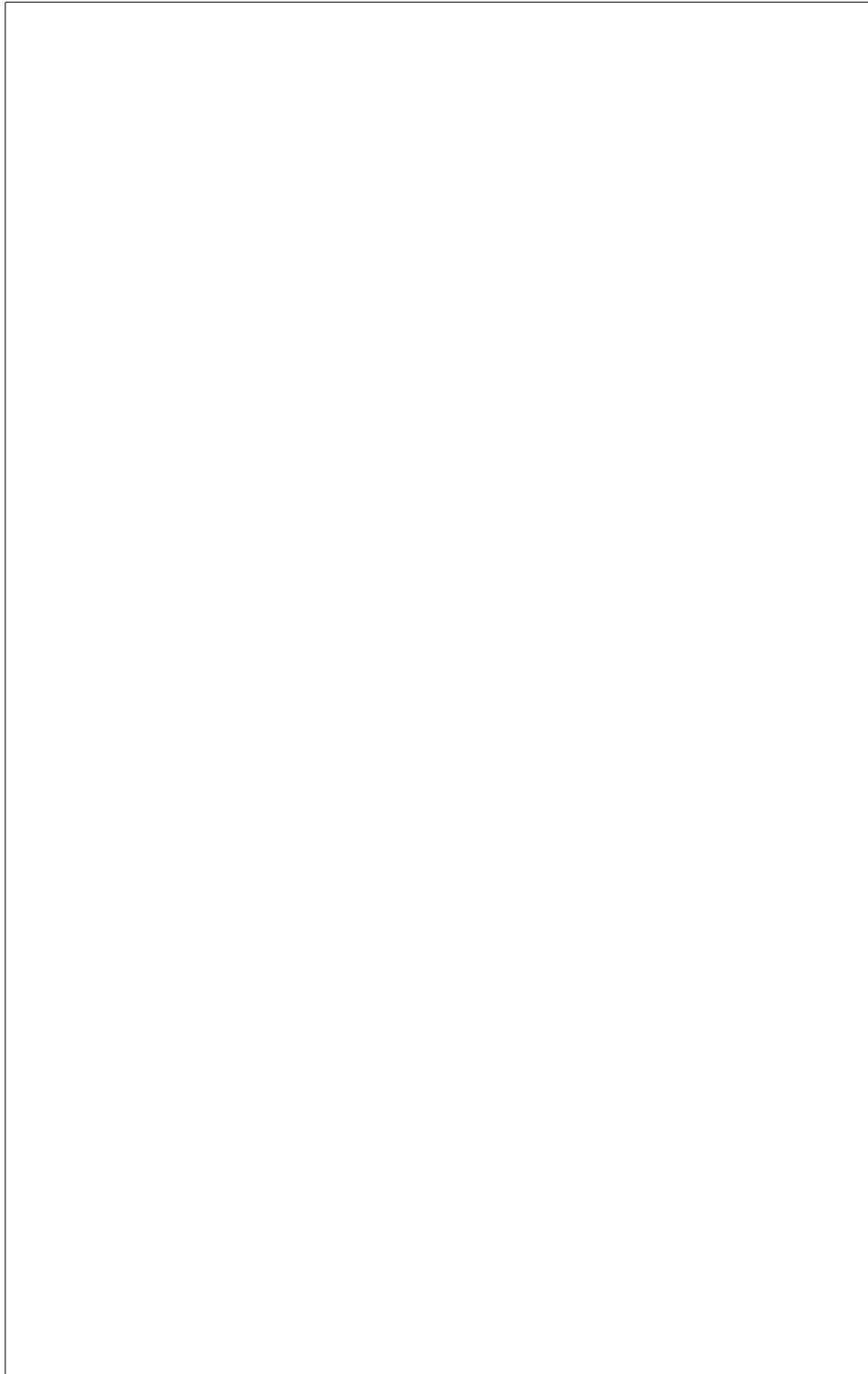
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Tea is considered as one of the popular beverages in global context. Combining Tea with tourism, as a new niche market, is an emerging concept provides win-win situation for both Industries. Since tourism is booming in Sri Lanka, a great opportunity exists to promote tea tourism by introducing Tea with tourism. Present context the academic research has lagged behind on tea tourism, specially in Sri Lankan perspective resulted to this study on stakeholder perspective to fill the research gap. Objective of this paper is to identify the stakeholders' views of Tea tourism development, concerns and future recommendations within Tea Plantations in Central and Uva Provinces, Sri Lanka. Series of focus group interviews has been conducted with supply side stakeholders and in-depth views were taken. Sample consisted with two stakeholder groups as such; ten Tourist hoteliers engaging with tea tourism currently and potentiality to adopt the tea tourism practices and 60 tourists who were participated to Tea tourism activities. Thematic analysis method has been adopted. According to main findings following could highlighted; 1) Tea tourism is a promising sector due to grate demand for Ceylon Tea 2) Tea tourism promotion would be catered specially to the European market through social media and Websites 3) Collaboration between stakeholder groups including community is crucial 4) promoting tea estate bungalows as tea resorts/hotels as a strategy .As recommendations, development of tea tourism niche market with the brand name of "Ceylon Tea", converting Estate Bungalows in feasible Tea gardens to practice Tea tourism and Market development through promotional campaigns within European market is highlighted. Further, the participatory approach of community within Tea tourism for win-win situation for both segments is recommended.

Key words: Ceylon Tea, market development, niche market, Sri Lanka ,Tea Tourism



Humanities and Social Science

- Language Studies and Communication
- Economics and Development
- Law and Policy
- Psychology and Social Behaviour
- Philosophy and Religion

Effectiveness of E-Learning on Interest in Carbon footprint and Environmental Awareness among School Students in Kurunegala District

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Environmental awareness proves paramount, it fosters a sense of connection to the natural world, promotes sustainable development and encourages conservation of irreplaceable natural resources and the world. Carbon footprint is a way to provide a number to the release of greenhouse gases by a particular action. The present research aims at evaluating the efficacy of e-Learning to teach Carbon footprint and Environmental Awareness. The present study is experimental in nature. Pre-test post-test equivalent group experimental design was followed in the present study. In this design, pre-tests were administered afore the experimental and control group treatment and post-tests at the cessation of the treatment period. A sample of 70 students was culled from Kurunegala District utilizing convenience sampling. Results denote that e-Learning is more efficacious than the conventional method in enhancing the achievements. There is a significant difference between the post experiment and delayed post-test among boys and girls at 0.05 level and insignificant at 0.01 level on Carbon footprint. Additionally, there is a significant difference between the rural ($N = 12$) & urban ($N = 23$) students, in which rural students possess high when compared to that of the obverse. But if the significance can be diluted to 5% we can optically distinguish the pattern where rural students are more inclined to Carbon footprint and environmental awareness in all pre, post, and post delayed scores. There is no significant difference between joint and nuclear family at 1% in pre, post and delayed post-test scores in Carbon footprint and environmental awareness. In conclusion, there is a significant difference between pre-test and post-test scores. It is evident from the present research that e-learning media and multimedia and its resources can elucidate the most of the abstract concepts.

Keywords: Carbon Footprint, e-Learning, Environmental Awareness, Kurunegala District

The Uses of Blogs as an E-learning Tool in Sri Lankan Higher Education

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The aspects of the education are changing in parallel to the innovations in technology. It is very essential for instructors benefit from the opportunities and possibilities of these innovations in order to facilitate the effective teaching and learning according to their needs. Socialization, communication and level of interactivity are the factors that directly influence the quality of online learning environments. Blogs are like online diaries published on the web that reflects personal opinions, feelings, hobbies and experiences about specific topic or theme. In addition to their growing popularity, blogs can be used in higher environments for many purposes. New technologies have an important effect on changing education. Using technology also has effect on improving learning and teaching in education and especially higher education. Now some universities and institutes use these technologies to apply virtual and distance education but there are other approaches to use them. Weblog is one of them. Weblogs can be used in conventional universities alongside the traditional classroom teaching method because of it is easy to learn and apply. Weblog provides a good opportunity for collaborative learning and communication between students even among the students. In this research my aim is to critically study about the usage of web-blogs as an e-Learning tool in Sri Lankan higher education. Both qualitative and quantitative measures were used to gather and analyse the data. The result of the study revealed that the participants favoured creating, managing their own blog page and sharing their own works through their blog pages with others.

Keywords: Blogs, e-Learning, Higher Education, Learning Methods, Technology

Factors Affecting on the Lack of Online Education Practices among Undergraduates of Social Sciences and Humanities

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The modern educational system has a tendency to provide online education for higher education to serve all students with more appropriate and successful environmental settings and done by replacing the traditional face-to-face teaching model with online instruction to better meet the needs of students. According to Sri Lankan context, the online education in Sri Lanka has not developed when it compared to the global level. Online education can be used as a solution for problems faced by students who are following subjects related to social sciences and humanities in higher education because of the bulky student population than the other faculties. The general objective of this study is to find the factors affecting online education among students who are following social sciences and humanities in Sri Lankan universities. The sample includes 100 students of the faculty of social sciences and humanities of the Rajarata University of Sri Lanka. Primary data were collected by using questionnaire and secondary data were followed by a literature survey. Descriptive statistical methods were used to analyze and present data. According to literature survey, there are 3 major factors that effect on online education; available infrastructure facilities, benefit from online education and knowledge on information technology etc. According to findings of this study, infrastructure facilities that effect on the online education are at an excellent level in the university. Most of the students are strongly satisfied with the benefits of online education. However, the knowledge on information technology is not strongly satisfactory among undergraduates of social sciences and humanities. The lack of knowledge of information technology is a major barrier to use online education. Therefore, this study suggests to develop the knowledge based on information technology among the undergraduates of social sciences and humanities.

Keywords: Information Technology, Literature Survey, Online Education, Social Sciences, Undergraduates

Language Testing in Second National Language Development among Sri Lankans: An Initial Review

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This paper aims to discuss the importance of second national language testing in Sri Lanka. Government has taken actions to teach Tamil or Sinhala as a second national language in different levels i.e. at school, university, and public administration and test them. Language testing at any level is a highly complex undertaking that must be based on theory as well as practice. Language testing in Sri Lanka, concentrates mostly on reading and writing, which are considered outdated and need to be improved, especially to meet the electronic era when the oral skills are dominating than other skills. In fact, there are no researches conducted to discuss the roles of second national language testing and its development in Sri Lanka even though there are various methods employed in language testing. In this initial studies, alignment studies of standards-based assessments have been applied. This methodology analyzes the alignment between the testing models and a set of content standards to provide evidence of testing validity and accountability which will help to achieve the essential goals of participants. For that, the selected content standards – curriculum and teachers' guide - followed by Sri Lankan institutions and assessment models – exam papers and the models - are collected and investigated. Discussing the importance of testing based on participants perspective which explores students' learning processes and exemplary performance. This review suggests that it is essential to examine not only final linguistic products of tests but also the entire test taking process to make language tests more communicatively relevant. The four-skill testing and alternative models are suggested to improve an alignment between the content standards and the assessments of Tamil or Sinhala for the sake of students. It also helps to identify that what actions can Sri Lankan institutions be taken to create a comprehensive testing system to develop students' communicative competence of second national language.

Keywords: Language Testing, Communicative Competence, Tamil, Sinhala, Second National Language Development

Perception of the Students on Obtaining the Assistance of ESL/EFL Websites to Learn English; a Study with Special Reference to the Second Year Undergraduates of Uva Wellassa University

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Twentieth century students tend to mingle the modern technology with every aspect of their life and education is no exception. Online education system is now not a novel to most countries. The best way to learn a language is in interactive, authentic environments. Computer technologies and the internet are powerful tools for assisting these approaches to language teaching. This research focuses on the potential role of ESL/EFL websites as a means of supplement in classrooms teaching. The main objective of this research is to find the students' perception on learning English through ESL/EFL websites. Data for this study was collected by taking a random sample of students from second year. Students were given a questionnaire before and after an assignment. The students were introduced to three websites where they have to do the assignment based on the given websites. The study found that the students held a positive reaction over the using of ESL/EFL websites to learn English. The results revealed that, the majority of students (88%) found the strategy used by the teacher was effective and interesting. Thus the researcher arrived to a conclusion that obtaining the assistance of ESL/EFL websites to learn English is effective and the students are caring a positive perception of the same.

Keywords: Websites, Technology, English as a Second Language (ESL), English as a Foreign Language (EFL)

Analysis of the Contemporary Situation of Illicit Alcohol Consumption in Sri Lanka

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Illicit alcohol "Kassippu" consumption is a serious threat in Sri Lankan community causing many deaths, especially in low-income families and common among both male and females. Excessive use of illicit alcohol can lead to physical, psychological and social harm since it contains methanol, a lethal substance in the brew in varying proportions. There are more than 200,000 illicit alcohol outlets operating in the country and about 5,000 manufacturers. Thus, an investigation was carried out by the President's Task Force to see whether the consumption has decreased or increased between 2015 to 2017. Two methods have been followed where the President's Task Force (a) collected information from 228 out of 332 divisional secretariats through the respective divisional secretary (b) and collected information from 438 police stations in all nine provinces from the Officer in Charge of the relevant police station. A questionnaire was used to collect information to see whether the illicit alcohol consumption is low, moderate or high. The relevant highest officer in charge has certified the data collection. The results clearly show that the consumption of illicit alcohol in all provinces, percent mean for low, moderate and high was 51.5, 30.5, and 18.0 respectively. In the divisional secretariats, percent mean for low, moderate and high was 54.1, 33.6, and 12.3 respectively. Both methods show comparable results and a drastic decrease in 2017 since 2015. Especially high consumption category shows a 47.8% decrease ($p < 0.0001$, CI 95%). Eastern, Northern and Uva provinces show high percentages of low consumption in both cases while the Western province shows a high percentage for high consumption as for police data. The study concluded that there is a decrease in illicit alcohol consumption between 2015 and 2017 in Sri Lanka in almost all provinces where North, East and Uva provinces show a dramatic decrease.

Keywords: Illicit alcohol, President's Task Force, Divisional secretariats, Police stations

Public Perception on the Aranayake land Slide: Post-Disaster and Pre-Disaster

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Natural Disaster can occur at any time in any community. The people who experienced these kinds of disasters build up common perceptions. Among these perceptions, the concepts, which were created, based on myths and misconceptions are found, in addition to certain truth and falsehoods. Recently, on 18.05.2016 a devastated landslide occurred in “Samasara” village, situated in Kegalle district in Sabaragamuwa Province, Sri Lanka. Which made more than 3000 people vulnerable by this disaster. This study expects to identify the public perceptions of some common features in the centered areas of the disaster. Which is more important to assist in the post-disaster management program, after the collapse of the “Samasara” mountain area. From among more than 3000 refugees, it is expected to get the perception of 30% of the total population who were affected from this disaster. In selecting the sample both male, female and for age categories had equal number of the representation. 70% of them did not have any understanding about landslide, 81% of them mentioned that a severe damage was due to not receiving early warning before the disaster, which made them unresponsive during the disaster. 94% of the respondents call for proper training on disaster and immediate responses. In addition, 59% to 70% of the population is suspected of landslide due to the activities of the people in this area. 54% people assumed that they are responsible for this accident, which was designed by God to show his power in this area. 80% of the people believed that after this incident, the interactions between the villagers have been increased and the needs and wants of the people were fulfilled. Therefore, during resettlement programs and post disaster programs it is important to study the sociological behavior and conceptions of people’s perceptions.

Keywords: Disaster, Public perceptions, People

Organizational Challenges in Managing Schools: Experiences of Government Schools in Sri Lanka

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The Ministry of Education in Sri Lanka (MoESL) expects to decentralize decision making power and responsibility to schools through School Based Management (SBM). This study is a qualitative case study, and thirty School Development Committee members (SDC) were purposively selected from the Colombo District government schools. The data gathered through interviews and document survey was analyzed by using thematic analysis. Since the schools make many efforts, it was revealed that the majority of schools face a big problem in enhancing the performance of the students. It appeared that the key intention of the stakeholders is to improve the performance at the national examinations. Hence, the majority of them overlook the total development of the students. Lack of training and awareness of SDC members hinder the development of schools. Limited time of staff members is a fact that hampers the effective implementation of managerial and school developmental activities of almost all the schools. The lack of human and physical resources is a key problem in which all of them faced in developing their schools. It was observed that some schools perform very well, even though; they have many obstacles and problems. It seems that intellectual contribution of the instructional leaders is very less in developing their schools. It was noticed that the attention of education authorities on supervision, monitoring, training, and development of managers and leaders at the school level was not adequate. The majority of principals and school leaders expect more power and authority for decision making on human and other resources. It was noticed that there is a big need to have a proper monitoring and supervision mechanism for handling big issues at school level since some stakeholders of schools are very abandoned, thus, they face big problems in managing their schools.

Key Words: School Development, Decentralization, School Based Management

A Study of Identifying the Common Causes for Dementia

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Dementia is not an individual disease. The term dementia is used to describe a collection of symptoms caused by disorders affecting the brain's normal health. There are many different disorders causing dementia. The most common are; Alzheimer's disease (50-70%), Vascular Dementia (20%), Dementia with Lewy Bodies (15%), Frontal Temporal Dementia (5%). The word dementia comes from the Latin *de* meaning 'apart' and *mens* from the genitive *mentis* meaning 'mind'. Dementia is the progressive difficulties in cognitive function, the ability to process thought or intelligence. Dementia, unlike Alzheimer's is not a single disease. When dementia attacks the higher mental functions of the patient are involved initially. Dementia is significantly more common among elderly people. However, it can affect adults mind of any age. Dementia has many different causes. Some may be reversible, such as certain infections, drug intoxication, and liver diseases. Of the irreversible causes, the most common in older adults is Alzheimer's disease. Objective of this study was, to show the most common specific causes for adult's dementia patients (over 50 years adults), who attending the Mental Disease Clinic at Borella National Ayurvedic Teaching Hospital. An audit tool was used to review medical records and questionnaire of patients attending the Mental Disease Clinic. Data were collected between 1st of July 2017 to 1st of October 2017. 35 of patients participated in this study. During the follow-up period, 35 patients answered to the questionnaire, who was diagnosed with dementia. A total of 15 individuals (42.85%) were diagnosed with dementia. The study found that dementia is more common among the 81 – 90 years of age (25.71%) adults. Conclusion of this survey was that the middle age hypertension was more common in men while it was only associated with risk in women for dementia. The risk of dementia is elevated in urban people, than rural people.

Keywords: Dementia, Alzheimer's disease, Lewy bodies

Emotional Intelligence in Buddhism

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When it comes to human development, modern world is now focusing on four intelligences of the individual, namely: Physical Intelligence (PQ), Mental Intelligence (IQ), Emotional Intelligence (EQ), and Spiritual Intelligence (SQ). However, this is not a new concept as all these four areas have been thoroughly discussed in Buddhist teachings. Buddhist concept of Emotional Intelligence is go beyond this interpretation as it discusses the root causes, need of managing, and the way of managing emotions in detail. Purpose of this research is to identify the Buddhist approach on Emotional Intelligence. Documentary study is the method of data collecting and content analysis is used for data analyzing in this research. Base of all emotions generated in human mind is based on three basic mental components of the person: *Raga* (passion), *Dosa* (hate), *Moha* (delusion). These mental components have negative effects on individual and the society, if they are not managed. Buddhist teachings analyse the three basic mental components according to its nature: whether it is easy to overcome or not, thought processes create by the mental component: how the individual think according to the each mental component, and how to overcome these mental components: which method should be used to overcome, and the outcome of the act: if individual stay with each mentality what will he will gain. When it comes to outcome, it is clearly explain what are the negative outcomes individual will gain if he/she stay with that mentality. And also what are the benefits one can gain by overcoming the three mental components. As the actions related to these three mental components are directly related to other members of the society, it also guide the individual to deal with other members of the society without creating negative thoughts. Therefore, it is clear that emotional intelligence in Buddhism guide the individual to become more self-friendly and social friendly person.

Key Words: Mental Components, Negative Outcomes, Self Friendly Benefits, Social Friendly Benefits

The Impact of Micro Financial and Non-Financial Services on the Productivity Growth of the Microenterprises in Sri Lanka

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The microfinance is a financial tool which was introduced by small thrift societies in villages to help poor people who were at work in various business and agricultural activities, which has become a modernized system of provisioning of financial and non-financial assistance to the low income groups and small enterprise which are now otherwise termed as "Microenterprises". These microenterprises play a big role to boost the economy of a country. There are large number of microenterprises operating in Sri Lanka but most of them are less privileged of proper financial, technical and educational assistance. The less studies have been conducted to ascertain the impact of micro financial services on the productivity growth of the enterprises. Thus, the objective of the study is to ascertain impact of micro loans, advisory and training services provided by such institutions on the productivity growth of the microenterprises. Sixty microenterprises in Homagama DS division operating on such loans and assistance were selected as a sample. The primary data were collected through questionnaires by interviewing the enterprises. The paired sample t-test, multiple regression, chi-Square test, Gamma and Kendal tau-b tests were used to achieve the expected objective. The findings of the study proved that microloan, advisory and training services create positive impact on the productivity growth on the microenterprises. Majority were satisfied with financial related assistances and agreed that loans were fair enough for the expected goal. The conclusion of the study proved that financial and non-financial micro services create a positive impact on the productivity growth of the microenterprises. It is observed that microfinance institutions should develop their product diversification in the financial services and security mechanism from the government for the industry to operate in legal and regulatory environment.

Key Words: Growth, Microenterprises, Microfinance

Trial and Error Learning in Influence in Fashion: Clothing Attitudes of the Kings of the Kandyan Kingdom of Sri Lanka

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Fashion, an essentially a dynamic human activity, earns its survival by influencing others. The objective of this paper is to find out how learning affects on influence in fashion. A qualitative approach was used for this purpose with a historical study setting. Kandyan reign of Sri Lanka from 15th Century to 1815 is a well-known historical era for the strong effects of western influences on the society. Clothing attitudes of the selective kings of the era were studied in this research. Kandyan royalties used foreign influenced dress as a problem solving tool. Kandyan royalties' problem was protecting the throne from their own royal clan. They tried different strategies to win over powerful westerners' faith and have military aids to protect the sovereignty. Kings of the Kandyan Kingdom adapted western dress considering its political advantages. During the course of time they learnt through their experience that wearing western dress give more rewards. It can be suggested that the trying of various methods, alternatives were carried out until the right one happens to appear or be found. It is a method of applying a particular set of rules for working out the solution to a problem. The methodology of the research was based on 'Grounded Theory Method'. Information is gathered and analyzed in a way that the logical philosophy is generated. Validity is tested from cross checking of data, and comparing with formerly established theory related to the field. The analysis was done through political factors of the era. The analysis has resulted in developing a theory on trial and error learning to explain how such status was instrumental in bringing about influences in fashions. The study found that the royal dress of the kings of the Kandyan Kingdom of Sri Lanka was influenced by the western dress. At the beginning, western influences were not prominent in the dress, however, later kings were heavily influenced by the western dress and social etiquettes. The research found out a schematic pattern in influence fashion. It was shown that political factors have direct correlation in influence fashion.

Keywords: Costume of the Kings, Political Factors, Western Influences, Trial and Error Learning, Kandyan Kingdom.

Impact of Technology on Children Growth and Development

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Nowadays, families are different from earlier. The influence of the technology breaks the chain and bonds of a family in the 21st century and leads to isolate from core values and customs. Parents and children highly believe in communication, information and transformation technology to ease their day to day life faster and more efficient. Technology is being highly utilized by families and children to a great extend for entertainment purposes. The utilization of television, computer, games and internet has swiftly increased in recent past; however, many parents ignore these developments. On this basis, this study was conducted to explore how the child development and growth are affected by Technology. This research was done in the Eastern province of Sri Lanka. There are about 1.5 Million people living in Eastern province of Sri Lanka, 200 families were randomly selected and surveyed. Data were collected mainly using the semi-structural questionnaire and the focus interviews. This research revealed that on the pro side, technology engages children for the real world that they will have to arrive into. 90% of jobs in the market are based on technology and children must need the technology advantage to be fruitful in such an environment. At the same time, children using technology are becoming socially stunted, unappreciative, and harassed with health related problems. By providing children with chances to increase their technology abilities, can prepare them to live in technological world progressively. However, parents must be careful that requirement and demand of the technology in the society should not affect health and development of children.

Key words: Technology, Development, Children, Eastern province, Technological World

Ragging and Its Impact on Learning English as a Second Language; a Qualitative Study with Special Focus to the Faculty of Humanities and Social Sciences, University of Ruhuna

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Fluency in English is considered as a key component in the academic life of the university students in achieving the best results. However, English within the context of Sri Lankan government universities is not just a language as English inhibits several ideologies given by the university subculture. Thus, fluency in English of the arts undergraduates of the university is highly criticized. Therefore, with the aim of finding the root causes for the issue the data was collected from 150 students of the first and second year of the Faculty of Humanities and Social Sciences, University of Ruhuna and 30 academics were also interviewed. The findings revealed that ragging was one of the major factors, which negatively affects the language learning process. Ragging has demotivated, discouraged and depressed not only the language learners but also the language teachers. The initial negative impressions created by ragging regarding language learning has paralyzed the language learners forming an unnecessary dislike in learning English that they remain passive until they leave the university. Student and teacher interactions have also collapsed. Undergraduates with language issues prior to the university entry had encouraged ragging to control the attitudes and mentality of the students. Hence, the students were not strong enough to discard the adverse influence exercised by ragging during their course of language learning. Therefore, it is essential to control the negative influence of ragging on language learning to success the efforts of the university to produce a set of challenging and marketable graduates. It is suggested that the faculty needs to conduct a sound intensive programme, establish language empowering bodies, arrange language events and competitions, introduce new subjects focusing language skills and go for new and innovative teaching strategies.

Key words: Academic life, Ragging, University Subculture, Undergraduates, Language learning

**Perceptions towards New Restrictions on Polythene Usage in Sri Lanka
- Case Study in Colombo City**

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Increasing use of thin polythene (PE) has become a global challenge for our oceans. To address the PE nuisance, the Sri Lankan government has enforced the restrictions on the usage of PE products since September 01, 2017 (The National Environmental Act, 47 of 1980). These new restrictions have various impacts on stakeholders at different scales and this study aimed at assessing the perceptions of two key stakeholders, namely supermarkets and customers with respect to PE usage and actual behavior, two months after the restriction was announced. The study was carried out in the Colombo Municipal Council area which is the commercial capital of the country. The data were collected by means of a semi-structured questionnaire at 10 supermarkets, covering the four main supermarket chains. Ten customers from each supermarket (total n = 100), selected randomly and one executive officer from each supermarket chain at their respective headquarters (n = 4) was interviewed. Customer behavior and supermarket practices were observed at the same supermarkets watching 300 customers (n=300). Probably due to the significant media attention, 94% of the interviewed customers had heard about the new restriction although only 2% had detailed knowledge. Customer agreement with the new regulation was very high with 89% and 54% expressed that they have already changed their behavior. In addition, 39% of customers expressed that they will not have any issues finding alternative packaging materials. Also, all four supermarket chains considered under this study were in favor of the regulation. Nevertheless, observations of customer behavior in the shops showed that only 11% were using own reusable bags which showed a significant difference between their perception and actual behavior. While these days, stronger PE material is used in the shops, an actual reduction in overall PE use will need more options to increase customers' motivation for using environmentally friendly materials.

Keywords: Polythene, Disposable Bags, Supermarket, Customers

Fashion Identity; a Self in Context and Visual Expression

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According to the trickledown theory of fashion diffusion the royalties set fashion and it diffused down the social hierarchy. The objective of the study is to explore how the royalty anticipated what identities they would like to have in the social situation and how they presented themselves accordingly to others, thus generating basic theoretical concepts to the field of fashion. Kotte era (1411-1597AD) was the selected study setting whose significance is of much concern because the period had enormous Portuguese influence in socio, political and cultural dimensions. The Portuguese influences directly affected the dress code of the royalties and immediately visible ambiguities embraced in their process of appearance management because of their imitation of western fashion. Relief carvings in two special ivory carved boxes presently at the Munich Treasury in Germany of King Buwanekabahu VII (1521-1555AD), prince Dharmapala (1551-1597 AD) of Kotte, pictorial images of King Wimaladharmasooriya I (1591-1604 AD) and his nephew King Rajasimha II (1635-1687AD), Kirthi Sri Rajasimha (1747-1782 AD) and King Sri Wickrama Rajasimha's (1798-1815AD) full relief sculpture of dressed bodies were identified and analyzed according to their dresses as trouser (*pantaloons*) coat (*cabaya*), jacket (*hettaya*) short jacket with collar (*manthe hettaya*) and attached collar (*tippet*). The study is based on qualitative research method. Sequences of in-depth observational studies were carried out. The literature review employed original documents, manuscripts, chronicles and records of foreign travellers. By triangulating data the validity was confirmed. The research reveals that fashion and identity plays a major role in shaping identity, imbibing directly from material reality. Although people have only one self-concept, they have many contextually relevant identities.

Keywords: Fashion, Identity, Trickled Down Theory, Visual Expression, Royalty

The Impact of Television Food Advertisements on Children, with Special Reference to the Plantation Community in Badulla DistrictH.M.W.M. Herath*Department of Management Sciences, Uva Wellassa University, Badulla, Sri Lanka*

Many studies have been conducted on the impact of advertisements on children, and it has been accepted that the television advertisements make the biggest impact on children. Children spend many hours watching television and they are bombarded with advertisements daily. Hence, the parents should be conscious about the messages the advertisements bring to their children. This study aims at investigating the impact of advertisements on children in the plantation community in Badulla district. Using the convenient sample method, 50 children (20 males and 30 females) in age between 4 to 6 years were selected for the survey. The survey was conducted in an estate located in Passara area in the Badulla district, where socio-economic and health indicators were very low compared to other districts of the island. A self-constructed questionnaire was used to collect data and interviews were held with the children and their parents in order to collect personal qualitative data. Close observation was also used as a qualitative data collection method. To analyze data, Statistical Package for the Social Sciences (SPSS) 17 was used. It was found that the food advertisements have a statistically significant impact on children's behavior. Further, it revealed that when children watch more television they are likely to request unhealthier junk foods than the proper healthy meals. Further, it found that the uneducated parents are inclined to buy the food demanded by the children rather than giving them healthy and balanced meals. The majority of the children showed that their attitude of food advertisements were very positive and that they rely on the information given by the advertisements.

Keywords: Advertisements, Children, Plantation Community, Healthy meals

Correlation between Sri Lankan University Students' Self –Esteem and their English Speaking Skills

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Attitudes of individuals on themselves and self-evaluation have continuously been subjected to many researches in social psychology. This research was conducted to discover the relationship between self – esteem and English speaking skills of undergraduates in Sri Lankan universities. To conduct the study, both male and female undergraduates in two state universities; Uva Wellassa University and University of Kelaniya in Sri Lanka were selected. The sample of 100 first year undergraduates (42 male and 58 female) from Faculty of Management were taken as the sample. To measure the self – esteem of the undergraduates, Rosenberg self-esteem scale was used. All items in the questionnaire were answered using a 4-point Likert scale format ranging from strongly agree to strongly disagree. An oral proficiency test (OPT) was administrated to determine the level of students' speaking ability. The levels of skills were tested in term of accent, structure, vocabulary, fluency, and comprehension. In addition to those, their nonverbal skills were also taken in to the consideration. To analyze the data Statistical Package for the Social Sciences software (SPSS 11) was used. T-test was used to find whether there is a statistically significant relationship between the spoken performances of the students and their self-esteem. The study also revealed that there is a significant positive relationship between English language speaking skills and self-esteem of undergraduates in tertiary level education. The results showed that students with lower level of English speaking skills have lower level of self-esteem and students with high level of English speaking skills have high self-esteem. The students who suffer from lowered self-esteem as they examine themselves; they tend to focus their attention on negative thoughts, which thereby increases self-dissatisfaction.

Key words: University Students, Self –Esteem, English Speaking Skills, Education

Mindfulness, Perception and Wisdom

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Mindfulness (*Sati*) means calling back to mind, remembering and entering into and plunging down into objects of thought. It also means awareness or skillful attentiveness. The objective of this research is to examine the interrelationship among three terms of Buddhist teachings and this research based on literature review. *Sati* is a natural presence of mind. It stands near and hence serves and guards the mind. *Sati* calls to mind. That is, it remembers things in association with other things or in relationship to things and thus tends to know their value and widen the view. *Sampajañña* is another term founded closed to teaching of mindfulness. It means clarity of consciousness and clear comprehension. In this context, it is clear that the function of mindfulness is to bring one's mind to the present moment; it therefore be able to realize the world as it is and others' minds and thoughts accurately. Perception (*Saññā*) is another term examined with reference to the function of mindfulness. If in repeated perception of an object, these marks are recognized. According to research findings, the perception which perceives the qualities of the object is based on mindfulness. It leads to build the healthy life mentally and physically. Strong perceptions based on mindfulness. Wisdom, therefore, develops through the development of practicing mindfulness in Buddhism. So the practice of mindfulness will contribute to both the analytical knowledge and the arising of wisdom.

Keywords: *Sati, Mindfulness, Perception, Buddhism, Wisdom*

**An Archeological and Religious Study of *Sagama Rajamaha Vihara* and
*Sagama Rock Inscription***

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This study is based on the site of the *Sagama Rajamaha Vihara* belonging to the *Pathahewahete* Divisional Secretariat Office of the Kandy District. The word “*Sagama*” means six Villages. It is surrounded by six villages namely *Nugaliyadda*, *Butawatta*, *Godamunna*, *Kapuliyadda*, *Haputale* and *Mahamedagama*. Research problem of this Study is how far devotees followed by the ancient rite, ceremonies, and what were the archeological heritages depicted from the site of the *Sagama Rajamaha Vihara*. The data for this study was collected from a field study and the relevant books and articles related to this field. The method followed for this paper is to draw a narrative by interpreting the research findings and information included in the *Sagama* rock inscription. The paintings of the old *vihara* belong to the *Gampola* era. The *Bo* Tree which is the great significant of the heritage of this temple. It is mentioned that forty-five acres of the Village of *Haputale* have been offered to the *Sagama Vihara* by two soldiers namely *Alakeswara* and *Devamantri* of the six *Bhuvanekabahu*, king of the *Gampola* Kingdom. There is an annual rite called ‘*Budumagula*’ which is the great offering to the Bo tree. In this Study, Archeological heritage and religious background could be identified from the *Sagama Rajamaha Vihara* premise and rock inscription established in the village of *Nugaliyadda*.

Keywords: *Sagama*, Rock Inscription, *Budumagula*, Rite and Ceremonies.

Difference Among 〇[i]/가[ga], 은[eun]/는[neun] and 을[eul]/를[leul] Grammar Particles in Korean Language

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An increasing number of Sri Lankans are showing interest in learning and improving their Korean language skills after coming into contact with the outstanding job market as well as the variety of Korean dramas, music and the culture itself. Recently, Korean language has become one of the most popular modern languages among younger generation, not only in Sri Lanka but also all over the world. With the growing demand, a numerous number of institutions have been established to teach Korean language in the country. However, it is observed that Sri Lankan students following Korean language, are facing some difficulties to understand the different usage of Korean grammar particles; 〇/가, 은/는, and 을/를. The topic marking particles (〇/가, 은/는) and the subject marking particles (을/를) play a very important role in Korean language. Therefore, it is very important that the students learn them well. Further, it shows that most of Korean learners have the hardest time choosing which are the right particles, especially between 〇/가 and 은/는. In this connection, the author tries to give a clear clarification on the difference among the grammar particles mentioned above. The author expects this paper shall help the Korean language learners to solve their issues in this connection and write and speak Korean correctly without any grammar mistake. Further, Korean language learners' ability of expressing their ideas exactly and correctly to the listening party shall be improved by understanding the difference between above particles.

Key words: Korean language, topic marking particles (〇/가, 은/는), subject marking particles (을/를).

**Farmers' Perception on Transition towards Organic Paddy Cultivation:
A Case Study in Matara District.**

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Organic agriculture is growing at a rapid pace in response to progressively observed deterioration in the health of people and the environment. In such context, the present study is an attempt to identify farmers' perception on transition towards the organic paddy cultivation and the influences behind their perception. One hundred of paddy farmers were selected for primary data collection through multi-stage random sampling technique from four *Grama Niladhari* divisions in Matara District namely Welipitiya (34), Karandeniya (20), Kokmaduwa (22) and Kamburupitiya (24). The data were collected through structured interviews by farm/home visits. The collected data were analyzed using descriptive and inferential analytical tools. Results revealed that majority of the respondents (74%) have a satisfactory awareness of organic farming. About 50% of the respondents stated ancestral knowledge is the most effective method to gain knowledge regarding organic farming while, 18% of respondents stated mass media is the second best method. Among the rice varieties, *Suwadel* and *Kuruluthudu* were stated as the most suitable varieties to grow organically. Moreover, 54% of the sample was aware on the demand for organic paddy. The majority (78%) of the respondents mentioned supermarkets are the best place to sell organic products while export market and normal markets are alternative places. Further, 68% of the sample showed a positive perception to move towards organic farming. The results of the Pearson correlation coefficient explored that farmers' age, education, land area, income, and experience are the significant influences behind their perception. The study concluded that farmers' perception on organic paddy production is at a favorable level. Hence, these influencing factors could be tapped into further extension activities related to organic farming in order to foster paddy farmers towards organic farming.

Keywords: Farmers' Perception, Influencing Factors, Organic Farming, Paddy

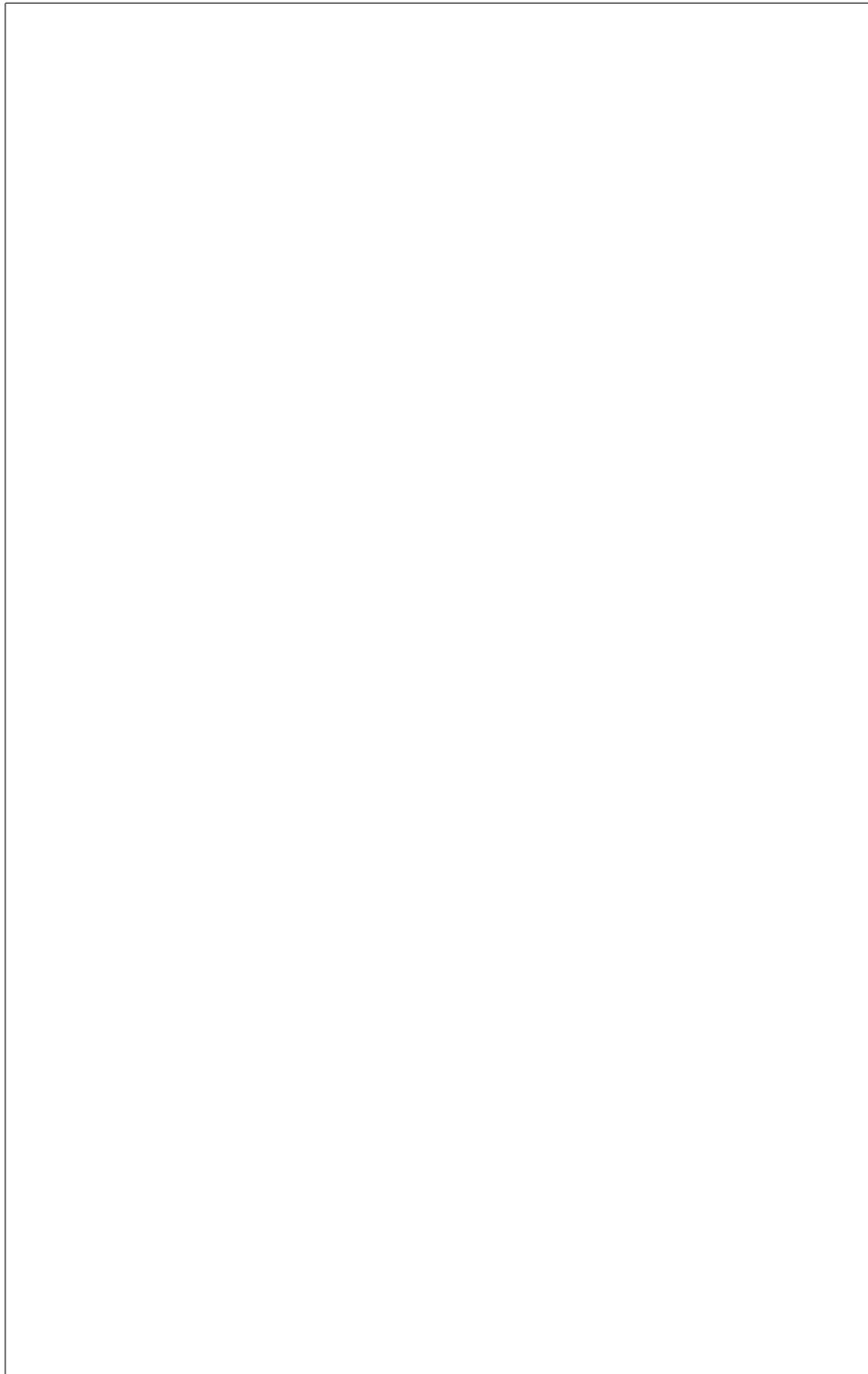
Impact of Pursuing Certificate in English for Junior Executives on Enhancement of Communication through English Language

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Having gained international acceptance as widely used medium of communication, English reigns supreme in all aspects of the society. This research intends discovering the prime objective, the impact of pursuing ‘Certificate in English for Junior Executives (CEJE)’ on enhancement of communication skill through English and the research problem was formulated as, is there a significant impact of pursuing CEJE on enhancing communication through English? Randomly selected sample of 80 Junior Executives in different public and private institutions in Uva Province was considered while employing questionnaire and observations to collect primary data. The statistical software, Minitab 15 was used for analytical purpose. In addition, graphs and charts were used for graphical representation of the results. As to the results ascertained, the respondents have gained better improvement in all language skills than the previous stage after pursuing CEJE recording significant boost in ‘very good’ and ‘good’ levels of communication through English while reflecting negative effect on ‘fair’, ‘poor’ and ‘very poor’ levels in particular aspect. Hence, the research highlighted the positive impact of pursuing CEJE on enhancement of communication through English language among adult learners. Further, the findings illustrated the importance of applying interactive activities in language classrooms to better facilitate learners as majority of the learners have the belief that they could be competent communicators in English while enhancing their language skills through array of interesting activities. Consequently, the current research intends to challenge the Critical Period Hypothesis (CPH). Thus, outcome of this research is beneficial for designing training programs for employees enlightening the teaching and learning process of English as a Second Language in Sri Lanka especially with the implementation of creative teaching methodologies including diversified yet interesting activities and further research can be conducted pursuing this line of the research..

Keywords: English, Communication, Junior Executives



Materials and Mineral Sciences

- Materials Science/ Nano Technology
- Rubber Research
- Metallurgy
- Mineral Processing and Mining
- Gemmology

Uranium Extraction from Seawater around Sri Lanka using Amidoxime Modified Nano and Mesoporous SilicaChamila Gunathilake

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Amidoxime modified ordered nano & mesoporous silica (AO-OMS) materials were prepared for the first time by a two-step process involving: (1) synthesis of cyanopropyl-containing ordered mesoporous silica (CP-OMS) by cocondensation of (3-cyanopropyl) triethoxysilane (CPTS) and tetraethylorthosilicate (TEOS) in the presence of Pluronic P123 triblock copolymer under acidic conditions, and (2) conversion of cyanopropyl groups into amidoxime upon treatment with hydroxylamine hydrochloride under suitable conditions. The as-synthesized, extracted, and amidoximated mesoporous silica samples were characterized by variety of techniques such as thermogravimetry (TG), Fourier transform infrared spectroscopy (FTIR), nitrogen adsorption, small angle X ray diffraction (XRD), high resolution transmission electron microscopy (TEM), and CHNS analyzer. These characterizations permitted identifying internal-external surface properties and assuring functional groups formation inside the mesostructure. CP-OMS samples exhibit structurally ordered uniform mesoporous, high specific surface area, and narrow pore size distribution. The conversion of cyanopropyl incorporated OMS samples to amidoxime modified counterparts increased specific surface area, total pore volume, microporosity, and nitrogen content. The high affinity of amidoxime groups towards the uranyl ions makes the amidoxime-modified OMS materials as an attractive sorbents for uranium uptake. The presence of vast number of amidoxime binding groups further causes a momentous enhancement of the uranyl ions uptake (reaching 57 mg of U per gram of adsorbent). This proposed approach to obtain high uranium uptake is particularly important due to the low concentration (3 ppb) of uranium exists in the seawater around Sri Lanka. Simple and less time consuming co-condensation strategy assures high loading of cyanopropyl functionalities and full participation of all precursors in the structure formation as compared with the typical post-grafting technique where radiation induced graft polymerization or suspension polymerization is used. The resulting amidoxime- modified OMS materials, because of their remarkable uranium recovery, are of great interest for alternative resource to generate nuclear power in the near future in Sri Lanka.

keywords: Uranium extraction, Sea water, Nuclear power, Amidoxime, Silica

Depositional History of Sediments in Eastern Lagoons of Sri Lanka: Sedimentological and Mineralogical Evidences

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Characteristics of sediments and minerals are useful in identification of paleo-depositional environments. Specially, clay mineralogy shows the specific environmental conditions that are related to the marine or terrestrial environments. Present study used sedimentological and mineralogical characteristics of recent age sediments of Batticaloa lagoon and Kiran lagoon to interpret the depositional environments. Four sediment core samples with an average height of 1 m were collected from both lagoons and analyzed for temporal grain size distributions using mechanical sieving techniques. Vertical profiles of sand and clay mineralogy were investigated by grain counting technique, X-ray diffraction and Fourier-transform infrared spectroscopy. Medium size sediments are the dominant type indicating prevailed moderate energy conditions for the history. Several coarse grain events are recorded in cores which might be originated from storms. Statistical parameters of sediment grain size and Quartz-Feldspar-Lithic fragments triangular diagram of sands show matured riverine continental origin for the depositional history. Main clay minerals of the depositions include kaolinites, smectites, illites and chlorites. Clay mineral profile also confirms the continuous sedimentation history for the past centuries. The results of the study conclude that the recent history of the sediment depositions in eastern lagoons have not been affected by considerable environmental changes except some coarse events such as high energy storms.

Keywords: Clay mineralogy, Sediments, Eastern lagoon, Depositional history, Sedimentological

Kaolin - based Filter Material to Remove Textile Dyes in Water

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In this research, the adsorption capabilities of four kaolin - based filter materials for dye removal was tested and locally available kaolin (collected from Meetiyagoda, Sri Lanka) is the main component of these four materials. First filter material (M1) is based only on kaolin. Second filter material (M2) is based on kaolin and activated carbon (5% w/w). Third filter material (M3) is based on kaolin and calcium hydroxide (5% w/w). Fourth filter material (M4) is based on kaolin and calcined eggshells (5% w/w). Pellets of each material had average diameter (2 mm) and average length (4 mm). Methylene blue (MB) was used as a model dye to understand properties of filter materials and also the adsorption capabilities of materials were tested with an industrial dye. The effect of dark (Reagent bottles were covered by aluminum foils) and light conditions (light box consisting of 20W, CFL bulb was used due to potential photocatalytic pathways possible), effect of initial concentration, effect of contact time for adsorption of MB and industrial dye was tested in this study. M3 has the highest MB removal efficiency (37.29%) and M1 has the highest industrial removal efficiency (13.69%) in light conditions. The removal efficiencies under dark conditions are considerably lower for all four filter materials. Next, adsorption of MB onto M3 was found to follow Freundlich isotherm ($r^2 = 0.96$, $n = 1.96$, $K_F = 0.06 \text{ L g}^{-1}$) than Langmuir isotherm ($r^2_L = 0.95$, $q_{\max} = 0.20 \text{ mg g}^{-1}$). Furthermore, MB adsorption was found to follow pseudo-second order kinetics ($R^2 = 0.99$, $k_2 = 1.11 \times 10^{-2} \text{ g mg}^{-1}\text{min}^{-1}$). Adsorption of industrial dye onto M1 was found to follow Langmuir isotherm ($r^2_L = 0.89$, $q_{\max} = 0.34$). In conclusion, the study reveals M3 can be used to remove MB and M1 can be used to remove industrial dye in water more efficiently. Unlike activated carbon, kaolin based materials can be reused several times and can prevent the secondary pollution due to adsorbents.

Keywords: Kaolin, Filter media, Textile dyes, Water purification, Photo catalysts

Silica from Rice Husk as an Alternative to Commercially Available Silica Fillers in Tyre Compounding

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Rice husk is one of the major agricultural wastes. It is currently dumped into landfills in its raw form or is used as an alternative energy source. When burnt for energy it results in rice husk ash (RHA) which is disposed without use. RHA has very high economical value since approximately 90% RHA is silica. Thus, a proper management of such solid wastes can add value to rice industry. This work presents the extraction of silica from RHA using precipitation method, characterization and utilization of such silica as an alternative to commercially available silica in rubber compounding. The extracted silica was characterized using Fourier transform infrared spectroscopy, X- ray diffractometry, X-ray fluorescence spectrometry and scanning electron microscopy (SEM). The results were benchmarked against commercially used silica. The extracted silica has comparable chemical and amorphous properties as commercially used silica in rubber compounding. The SEM study confirmed, the extracted silica is in sub-micrometre length scale in size. Tyre compounds were made using extracted silica and commercially available silica by keeping other ingredients and conditions same. Mechanical properties of both compounds were evaluated. Silica from RHA added composite showed boost in resilience and drastic decrement in tensile and tear strength, elongation at break, abrasion resistance and hardness compared to the composite made using commercially existing silica. Both composites showed moderately similar value of 100% and 200% modulus. With the extracted silica, the fly off while mixing was less. Then, it needs higher mixing time. Compound viscosity drastically reduced and became soft after mixing. These preliminary works confirm that extracted silica cannot be used, as it is to get the comparable properties in rubber compounding as commercially available silica does. Thus, further improvements in extracted silica are being carried out to make it compatible with rubber.

Keywords: Rice husk ash, Silica, Rubber compounding

Ceramic Waste-Based Natural Rubber Composites: An Exciting Way for Improving Mechanical Properties

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Large amounts of fired ceramic waste produced in ceramic industry do not have a proper method to reuse and dumped into landfills. These solid wastes have a major environmental and economic concern. Thus, a proper management of such solid wastes is eminent. Since fired ceramics have already been sintered, their utilization as a raw material is limited. This research is dedicated to evaluating the possibility of using such ceramic waste as a low-cost filler material in the manufacture of natural rubber based composites. Ceramic particles smaller than 125 µm were selected for the preparation of our initial composites. For the latter part of the study, particles in sub-micrometer length scales were used. Elemental analysis and composition of the phases of the ceramic particles were determined by x-ray fluorescence and diffraction, respectively. The average particle size was characterized by scanning electron microscope (SEM) and digital particle size analyzer. The surfaces of the sub micrometer size ceramic particles were modified using Silane69 coupling agent and Oleic acid. The surface modification was confirmed by fourier-transform infrared spectroscopy, thermogravimetric analysis and SEM coupled with energy-dispersive x-ray spectroscopy. Natural rubber based composites were prepared with different levels of ceramic filler loadings. The mechanical properties of the composites such as hardness, resilience, compression set, abrasion volume loss and tensile properties were evaluated. These properties of the composites were compared with those of the composites prepared according to the same formulation except the ceramic filler (pristine rubber sample). The composites were found to have an exciting enhancement of mechanical properties with respect to the pristine rubber sample. The mechanical property improvement is higher when the ball milled sub-micrometer size ceramic filler is used and it is even better when surface modified ceramic particles are used.

Keywords: Waste ceramic, Surface modification, Rubber composite

Synthesis of Expanded Graphite using Sri Lankan Vein Graphite via Ultrasonication

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Sri Lankan vein graphite, which is found in highly crystallized form with high purity (95 - 99 % carbon), have already been successfully developed for the anode of the lithium ion rechargeable battery. However, for their use in future energy storage applications, such as in sodium ion batteries, modification of the vein graphite structure is essential. Hence, this study focuses on structural modification of purified vein graphite by converting into expanded graphite via solvent assisted ultrasonication. Graphite oxide was synthesized from purified vein graphite by employing improved Hummer's method and then sonicated with propylene carbonate. The dried product was heated and again subjected to sonication with the same solvent. Then the solution was centrifuged to remove any non exfoliated graphite. Finally, the solution containing Graphite Oxide (GO) particles in PC were thermally reduced to produce reduced graphite oxide (rGO-PC). X-ray diffraction of crystal phase of the resulted graphite oxide shows the existence of a broad peak at 23.19 ° (2θ) corresponding to an interlayer spacing of 0.38 nm. The Fourier transform infrared spectrum obtained on the synthesized GO confirm the presence of O-H, C=O, COOH and C-O oxygen functionalities, which are then, confirm to be partly removed by the successive thermal treatment. Scanning electron microscopic images are evidence for the expanded structure with wrinkles and folded nature in contrast to the opaque and smooth structure observed in the pristine graphite. Altogether, these results confirm the successful formation of expanded graphite by the solvent assisted ultrasonication technique.

Keywords: Propylene carbonate, Sonication, Sri Lankan vein graphite, Graphene oxide

Antibacterial Activity of Silver Deposited Vein Graphite against Waterborne Pathogenic *Escherichia coli*

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The microbial contamination of drinking water is a major health problem in the world which requires an effective treatment. Silver ion (Ag^{+2}) is used as nonspecific antibacterial factor and it acts against a very broad spectrum of bacterial species. In this study, antibacterial efficiency of Ag deposited vein graphite were studied using *Escherichia coli* strain. Ag was deposited on the graphite surface by reduction of Ag^{+2} in silver nitrate solution using reducing agent. Scanning electron microphotographs of the Ag deposited graphite reveal that the deposited silver particles are highly agglomerated or spongy voids. Although the size of silver particle agglomerates are relatively coarse, the average size of individual silver nanoparticle is around 75 nm. Antibacterial efficacy of the synthesized sample was investigated using waterborne pathogenic *E. coli* strain. The antibacterial test was done using prepared composite samples and samples of *E. coli*, using shake flask method. A commercial antibiotic (Ofloxacin-200 mg) was used as the positive control. The samples were drawn periodically (1, 1.5, 2, 2.5 and 3 hours) from the flask and tested against *E. coli* by plate count method using standard procedures. There was a significant *E. coli* removal efficiency by the synthesized Ag Graphite composite compared to purified graphite and positive control (One-way ANOVA, p-value=0.00). Therefore, this study suggests that Ag- vein graphite composite could be used as an effective material in water purification, especially in removing of *E. coli*.

Keywords: Graphite, Silver

Confirmation of Newly Discovered Area in Eppawala Phosphate Deposit Using Geological, Geochemical and Geophysical Methods

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Parent rock of the Eppawala apatite deposit is suggested to be a carbonatite in origin and one of the associated minerals of apatite is magnetite. A high concentration of magnetite has been seen within the deposit. A regional ground magnetic survey concluded that the deposit extends to the North further than the formally known boundaries. Also, the studies indicate that the deposit runs along the E-W direction as two ore bodies. Appear in this study, the newly discovered area in Eppawala phosphate deposit was demarcated using geological, geochemical and geophysical methods. Geological studies revealed the presence of carbonatite and apatite outcrops along E-W direction. Representative soil samples were collected during field work for chemical analysis. As the carbonatite is highly weathered anomalous peak of calcium and magnesium should be recorded in the samples collected along the magnetic anomaly, which in turn help to identify the presence of carbonatite bodies within the subsurface. In deeper horizons along E-W direction, the elemental availability is relatively high (High peak values of Ca, Mg in anomalous area is 5000 mg kg⁻¹, 1655 mg kg⁻¹ and in background it is 890 mg kg⁻¹, 720 mg kg⁻¹, respectively) which indicates the possible presence of subsurface carbonatite bodies. Resistivity surveys were carried out in the study area and resulted resistivity signatures show similarity to the known phosphate deposit. Detailed magnetic map resulted from the magnetic survey done by early workers confirmed the boundary indicated in the magnetic anomaly map. Hence existence of the newly discovered deposit in Eppawala along E-W direction was verified by using integrated geological, geochemical and geophysical study.

Keywords: Carbonatite, Phosphate, 1- D Resistivity, Magnetic Survey

Geophysical instrumental support by Geological Survey and Mines Bureau (GSMB, Sri Lanka) and field guidance given by Mr. Nalin De Silva and Eppawala Lanka Phosphate Limited for providing laboratory facilities and field assistance given by are gratefully acknowledged.

Purification of Low Grade Quartz Bearing River Sand

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The demand for the high-grade quartz is increasing rapidly with the advancement of semiconductor and photovoltaic industries. Therefore, it is essential to enhance the purity of low grade quartz. Quartz bearing gravel, quartzite and, river and beach sand are the major low-grade silica sand deposits in Sri Lanka. In this study, a method was investigated to remove impurities in quartz bearing river sand depending on its mode of occurrence. Microscopic analysis implies that the impurities in the silica sand are present as mineral grains, coatings, interlocking grains and inclusions. In the physical purification process, sieving was carried out to separate river sand according to the grain size. The highest weight percentage of river sand is in the size range between 0.5 and 0.15 mm. This portion consists of more than 90% of quartz. Therefore, physical separation, depending on the grain sizes, can effectively use to remove the mineral grains present as impurities in quartz grains. Panning together with scrubbing and washing was carried out to remove the clay particles, heavy minerals and other undesirable materials present in the river sand. A chemical purification of physically separated river sand was carried out by acid leaching with 5 - 30 vol. % of HCl solutions in the temperature range between 27 and 100 °C. The mineralogical analysis and X-ray diffraction analysis imply the possibilities to remove iron oxide coating from the surface of quartz grains with low concentration of HCl, at low temperature. Accordingly, this physical separation and chemical treatment process is a more effective method to purify the low-grade river sand suitable for the advanced technological applications.

Keywords: Low grade quartz, Impurity, Purification, Acid leaching

Synthesis and Characterization of Ionic Liquid Based Gel Polymer Electrolyte for Rechargeable Batteries

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In the present battery market, Lithium-ion batteries have appeared as the preferred type due to its high gravimetric and volumetric energy density. However, there is a need to improve the performance of the electrolyte and electrode materials for high-performance of these devices. The objectives of this study are to synthetization of a gel polymer electrolyte and analyze the structure to understand ion-polymer and ion-solvent interactions. In this study, *polyethylene oxide* (PEO) based gel electrolytes were synthesized using different amounts of *lithium bis(oxalato borate)* (LiBOB) salt mixed with *propylene carbonate* (PC) and *ethylene carbonate* (EC) (weight ratio of 1:1). The prepared samples were characterized using Fourier-transform infrared spectroscopy (FTIR), in order to study interactions between Li⁺ ions, polymer, and solvent molecules. The FTIR analysis of the binary liquid electrolyte shows that a significant influence on the vibrational modes of the EC and PC molecules. A fixed amount (1g) of *1-Butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl)imide* (PyR14TFSI) ionic liquid was added to the liquid electrolyte system to enhance the electrochemical performance of the systems. The FTIR analysis of the liquid electrolytes with ionic liquid samples exhibits alternations on the vibrational modes of the solvent molecules and the ionic liquid since lithium ion might be coordinate with the polar groups of the system. Finally, gel polymer electrolyte (GPE) was prepared by adding different percentages of PEO (average M_v ~2,000,000) for each liquid sample. clear changes can be observed in the vibrational modes of PEO with salt addition confirming that coordination of the lithium ion with polymer matrix. In order to use developed electrolyte in real applications, future studies on ionic conductivity and electrochemical performance will be carried out.

Key word: Gel polymer electrolytes, FTIR, LiBOB, Ionic liquids

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Cellulose Whiskers Extracted from Banana Pseudo-Stem as Reinforcing Filler for Natural Rubber Tyre Treads Using Latex Intercalation Method

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Reinforcing the rubber compounds using cellulose fibre is an emerging trend in rubber industry because of unique physical properties of cellulose fibre. In this study, cellulose fibres were extracted from pseudo-stem of banana using alkali treatments and converted into cellulose whiskers (CW) with high pressure defibrillation followed by acid treatment and bleaching. The CW was characterized using Fourier Transform Infrared Spectroscopy (FTIR), X-ray Diffractometry (XRD) and Particle Size Analyzing. Both FTIR and XRD confirm the cellulose structure. XRD studies showed that the percentage crystallinity of bleached fibres is about 69%. The particle size shows a bimodal distribution where approximately 21% of the sample has average size of 110 nm and the rest has the size of 795 nm. The purified CW was intercalated in diluted natural rubber (NR) centrifuged latex in order to prepare CW/NR composites and converted into rubber sheets. Mooney viscosity and stress relaxation coefficient of CW/NR composites were measured. The lowest Mooney viscosity and the highest stress relaxation coefficient were observed in CW/NR composites ensuring higher processability. The compounds were prepared in an internal mixture according to a tyre tread formulation, keeping the sample without CW as the control. Cure characteristics were evaluated at 120 °C and physical properties were evaluated on par with the ASTM standards. The highest cure rate and better scorch time were observed in CW/NR composite. The density, hardness, resilience, cut & chip and tensile strength of the composite were superior while tear strength and abrasion volume loss were inferior to the control. In overall, we observed that cellulose whiskers have a great potential to use as a reinforcing material for natural rubber tyre tread compounds.

Keywords: Banana fibre, Cellulose nano-whiskers, Latex intercalation

Application of Solar Desalination Technology to Provide Safe Drinking Water for Water-scarce Areas in Jaffna Peninsula

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Jaffna is fully depending on ground water or ground water for their entire water demand. The available water is contaminated by sea water and other anthropogenic contaminants. Due to this, the people of the area are facing severe water quality issues. Alternative sources should be adopted to rectify the problem. Reverse osmosis is one of the solutions, but it is very expensive. Solar desalination technology is the cheapest method for desalination. A solar desalination plant utilizes solar energy, converting it to heat energy. A special nano cloth was used as solar collector and Polythene cover was used as condenser. The nano cloth captures water that evaporates during the sunshine and then it condenses and collects into outlet grid. Water source, temperature of the raw water and flow rate of raw water were changed to determine the rate of desalination. Saline water, brackish water and ground water sources were used. The Electrical conductivity of the desalinated water was observed to be in the range of $200 \mu\text{S cm}^{-1}$ – $205 \mu\text{S cm}^{-1}$ for sea water, $34 \mu\text{S cm}^{-1}$ – $150 \mu\text{S cm}^{-1}$ for brackish water and $25 \mu\text{S cm}^{-1}$ – $70 \mu\text{S cm}^{-1}$ for groundwater. Raw water temperature was changed as 305 K, 310 K and 315 K, the rate of desalination were observed as $0.37 \text{ L h}^{-1} \text{ m}^{-2}$, $0.47 \text{ L h}^{-1} \text{ m}^{-2}$ and $0.54 \text{ L h}^{-1} \text{ m}^{-2}$ respectively. Inlet flow rate was changed as 2 L h^{-1} , 2.85 L h^{-1} and 3.33 L h^{-1} , the rate of desalination was observed as $0.61 \text{ L h}^{-1} \text{ m}^{-2}$, $0.67 \text{ L h}^{-1} \text{ m}^{-2}$ and $0.62 \text{ L h}^{-1} \text{ m}^{-2}$ respectively. Rate of desalination of the ground water, brackish water and saline water were $0.35 \text{ L h}^{-1} \text{ m}^{-2}$, $0.39 \text{ L h}^{-1} \text{ m}^{-2}$ and $0.37 \text{ L h}^{-1} \text{ m}^{-2}$, respectively. These results indicate that there is no significant difference of efficiency with the water matrix, increasing with raw water temperature. This solar desalination system can produce $10 \text{ L} – 15 \text{ L}$ desalinated water per day in dry season. Therefore, it is suggested that, this method is suitable for mainly isolated islands of Jaffna which are facing severe water scarcity.

Keywords: Solar desalination, Solar collector, Rate of desalination, Electrical conductivity, Reverse osmosis

Silica Extracted from Rice Husk Ash as an Effective Reinforcing Filler for Natural Rubber Composites

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Rice husk is abundantly available in Sri Lanka, which is generated in larger volumes as rice husk ash (RHA) due to combustion. In general, RHA dumped at landfills as a waste. However, RHA is a promising source of silica as it contains more than 90% by weight. This silica can effectively be extracted by Sol-Gel method. In this research such silica was extracted and characterized using Fourier Transform Infrared Spectroscopy (FTIR) and X-ray Diffractometry (XRD). Both FTIR and XRD analysis confirmed the chemical and amorphous nature of the extracted silica. Natural rubber composites were prepared incorporating silica from 0-10 parts per hundred Rubber (phr) at 2.5 phr intervals using two-roll mill. The effect of silica on curing characteristics and the mechanical properties of vulcanizates were studied. The curing characteristics of the compounds revealed an increase in cure rate and thus considerable decrease in cure time and scorch. Tensile strength, modulus at 100% elongation and tear strength has increased significantly compared to control sample. The effect is prominent with increasing the silica loading. The abrasion volume loss has significantly decreased with the increase of silica loading. The lowest abrasion volume loss and the highest tear strength have reached at 7.5 phr of silica loading level. Whilst the resilience has decreased when increase the silica loading. However, silica loading does not show an impact on hardness. In conclusion, preferred curing characteristics and improved mechanical properties have been achieved. Moreover, it is important to emphasize that in this study the effect of extracted silica on mechanical properties of NR composites has not been compared with the commercially available silica and further studies are suggested.

Keywords: Natural rubber composites, Rice husk ash, Silica

Effect of Ethephon Stimulation on Physico-Mechanical Properties of Carbon Black Filled Natural Rubber Vulcanizates

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Low intensity harvesting systems (LIH) with ethephon stimulation were introduced to rubber plantations due to the shortage of skilled latex harvesters. The objective of this research study was to identify the effect of ethephon stimulation on physico-mechanical properties of the carbon black filled natural rubber vulcanizates. The study was conducted with the RRIC 121 clone using half spiral, once in three-day harvesting system. Experiments were laid out in Randomized Complete Block Design using three blocks with six ethephon treatments (0, 1, 2, 3, 4, 5 %). Each block was composed of 150 trees and each treatment was applied in 25 trees while the non- stimulated (0%) trees were considered as the control. Latex was separately collected from each treatment and processed into unfractioned, unbleached crepe rubber (UFUBCR) and carbon black filled natural rubber vulcanizates were produced according to the general compounding formulation. The vulcanization was carried out at 150 °C for 10 minutes. Initial Plasticity and Mooney Viscosity of UFUBCR reduced with the increase of ethephon concentration, while Plasticity Retention Index showed marked reduction at 4% and 5% ethephon concentrations. Rebound resilience, tensile strength and elongation at break have reduced with high ethephon concentrations. However, hardness, compression set and tear strength has increased with high concentrations of ethephon. Results revealed that elastic properties have reduced and filler reinforcement has increased with high ethephon concentrations. LIH systems with ethephon stimulation does not have any adverse effect on physico-mechanical properties up to 3% ethephon concentrations. However, such properties were negatively affected with the application of higher ethephon concentrations beyond 3%, therefore the application of ethephon up to 3% could be recommended.

Keywords: Etephon stimulation, Physico-mechanical properties, Natural rubber carbon black filled vulcanizate

Fabrication of Smart Umbrella Canopy with Super Hydrophobic Property

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Super hydrophobic textiles are very popular in recent years due to their self-cleaning ability and non-wettability. However this useful property has limitedly been introduced to umbrella canopies. In this study, super hydrophobic umbrella canopy has been produced by a convenient method. Herein, existing umbrella canopy comprised of polyurethane (PU) and polyacrylic (PA) coated polyester was used to produce super hydrophobic umbrella which was provided by Rainco (Pvt) Ltd, a leading umbrella manufacturer in Sri Lanka. Zinc oxide (ZnO) nanostructures were grown on the fabric by dipping the fabric in a mixture of hexamethylenetetramine and zinc nitrate followed by heating the mixture at 100 °C for 2 h. The modified fabric was dried well and dipped in a solution of stearic acid for 15 h in order to self-assemble stearic acid on ZnO nanostructures. The final product was air-dried to obtain super hydrophobic umbrella canopy. PA and PU coated fabric has water contact angle of 105°. Scanning electron microscopic (SEM) images showed ZnO nanostructures with size range of 100 to 500 nm with spherical shape and rod shape on the surface of the fabric to make the surface rough. The resulted fabric showed super hydrophobicity with water contact angle of 155 °C and the sliding angle of 3 °C. The sample was further characterized using X-ray florescence (XRF), Thermo gravimetric analysis (TGA), Energy dispersive X-ray analysis (EDX), UV-Vis spectroscopy and Fourier transform infrared (FTIR) spectroscopy. The develop method is useful to fabricate super hydrophobic umbrella canopies.

Keywords: Super hydrophobic, Smart Umbrella, Nanoparticles, Self assembly

Carbon Fiber Networked Nano Carbon Black as a Novel Conductive Filler to Enhance the Thermal Conductivity of Natural Rubber Composites

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Thermal conductivity of natural rubber (NR) was enhanced by incorporating a novel conductive hybrid nano filler, namely carbon fiber (CF) networked spherical carbon black (CB) nanoparticles. The CF/CB hybrid fillers were artificially generated *in-situ* in the rubber matrix by means of melt mixing, where the carbon black nanoparticles initially dispersed in natural rubber matrix with aid of rubber processing oil (polycyclic aromatic oil (PCA)) and hereafter, it was added CF to interconnect the CB domains. The preparation of master batch and final batch were done through the melt mixing in internal mixture where CF/CB total filler loading was kept at 40 parts per hundred of rubber (phr). Thermal conductivity of prepared composites were measured using lees disc method and the value of CF/CB rubber composite was $0.45 \text{ Wm}^{-1}\text{K}^{-1}$ and it was significantly improved compared to the control ($0.25 \text{ Wm}^{-1}\text{K}^{-1}$). The neat carbon black (CB) composite was also prepared (at 40 phr) for comparison purposes and the thermal conductivity value deemed to be $0.35 \text{ Wm}^{-1}\text{K}^{-1}$. The higher conductivity of CF/CB composite suggests that the presence of CF network within CB nanoparticles has significantly contributed to enhance the thermal conductivity compared to that of the neat CB rubber composite. Thermal stability of the prepared CF/CB composites were enhanced significantly compared to control and the neat CB composite. Scanning electron micro photo graphs confirmed the generated network of CF onto the spherical CB nanoparticles and interconnected morphology of CF/CB hybrid fillers. The enhanced thermal conductivity of the compounds can be related to produce industrial applications such as tyres.

Keywords: Natural rubber nanocomposites, Thermal conductivity, Carbon fibers, Carbon black

Highly Adsorptive Filter Based On Iron Oxide Nanoparticles for Dye Removal from Aqueous Solutions

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Dyes are major contaminants in the industrial effluents which cause adverse effects to living beings. Today, the removal of these dyes plays a major role in water purification processes. The nanoscale iron oxides as a high adsorptive filter material can be identified as a versatile dye removal method. Due to high abundance and low cost, ferruginous laterite can be considered as an alternative iron source for the synthesis of iron oxide nanoparticles. This work was performed to synthesis iron oxide nanoparticles using laterite through an obvious and innovative route and to evaluate their potential dye adsorptive removal behavior. First, powdered laterite was reacted with HCl to extract Fe³⁺ ions as we have studied previously. The digested solution separated by centrifugation was mixed with urea and heated in reflux condition for 5 h. Then the resultant precipitate was separated, dried and calcined for 2 h at 650 °C to obtain iron oxide nanoparticles (IONPs). Synthesized nanoparticles were characterized by Scanning Electron Microscope (SEM), Thermo Gravimetric Analysis (TGA), Fourier Transform Infrared (FT-IR) spectrometer and X-ray Diffractometer (XRD). SEM images revealed the spherical morphology of particles with 50 nm average particle sizes of the iron oxide nanoparticles, while FTIR and XRD data confirmed the presence of hematite crystalline phase. IONPs were used as an absorbent in a specially designed laboratory scale filter apparatus and several aqueous solutions of acid dyes were used as an adsorbates. The adsorption behavior was evaluated by varying the dye concentration and inlet flow rate of the filter and analyzing the filtrate by UV-VIS spectrophotometer. The filter proved to be effective in removing these dyes fully when the dye concentration is as high as 1000 ppm.

Keywords: Laterite, Hematite, Nanoparticles, Adsorption, Filter

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Garnet rich mineral sand based filter media for Removal of fresh water algae

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Algal blooms have become a stigma for present day stagnant surface water bodies. Therefore, consumption of water without treatment would be harmful. Garnet granules have the ability of reduction of bed expansion and particle abrasion in multi-media filters during back flushing due to its high specific gravity and high hardness. In this study, garnet granules separated from beach sand in southwestern costal area in Sri Lanka were investigated as a filter media to remove fresh water algae. Microscopic and particle size analysis indicated that the beach sand consists predominantly of garnet, quartz and ilmenite. The garnet grains are round to elongate shaped in the size range between 1 mm and 0.15 mm. Particle size and shape of the extracted garnet are optimum for the use as water filtering medium. Garnet enrich fraction grains (1 mm – 0.15 mm) were further concentrated by density separation via panning. Algae samples from Beira Lake, Colombo were collected, in the depth at illumination level 1% from surface. Algae were grown giving nutrient, sunlight and aeration. Nutrient medium used was the Bristol solution. For varying flow rates, algae filtered through 0.50 mm and 0.15 mm sieved fractions. Parallel determination for the efficiency of the filter bed with time was done and turbidity was measured by turbidity meter. When considering the algae filtration, removal of *Microcystis* is efficient for 0.15 mm panned fraction. Removal of *Closterium* was not efficient probably due to shape of the organism. *Chroococcus* and *Volvox*, were not removed well possibly due to their small size. Removal of algae was decreasing with the time from both filter beds. The study concludes that prepared garnet filter is useful in filtering *Microcystis* and further modifications should be done prior to use as a filter.

Keywords: Algae, Garnet, Panning, Filtration, Mineral sand

Synthesis of Feldspar Nanoparticles by Top Down Approach

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Feldspars are group of rock forming tectosilicates that found as deposits mainly in central part of Sri Lanka such as Owala Rattota and Matale. Feldspars are used for the industrial purposes such as, ceramic tiles, glazes, glass industry, filler, welding electrodes and abrasives, due to their durability and resistance to chemical corrosion in the macrometer-range. However to the best of our knowledge, there is no reported studies related to synthesis of feldspar nanoparticles which have potential applications in different industrial applications. Usually, materials show different properties in nanometer scale such a thermally stability and Infrared Radiation Absorbance. In this study, we have synthesized nanoparticles of feldspar using a top down approach. Sri Lankan feldspar samples were collected, powdered up to micro meter range using ball mill and further reduced its particle size following two step process of nano-grinding, such that dry grinding and wet grinding using 0.6 mm tungsten carbide balls for 1 h each. The prepared particles were characterized by scanning electron microscopy (SEM), X- ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR). Mineralogical analysis using X-ray diffraction (XRD) show that the product feldspar samples are composed of mainly of potassium oxides and silica oxides with minor aluminium. The particle sizes are in the range of nanometer scale and the average particle size is around 50 nm. The composition of these nanoparticles are proved not to be changing from the original composition as the XRD and FT-IR suggests. When coming down into nanoscale from a higher particle size, some property enhancements can be acquired. Typically, feldspar reflects UV light and absorbs some IR wavelengths. So this property can be applied as a potential application for textile and construction industries using the properties of these nano-feldspar.

Keywords: Feldspar, Infrared radiation reflectance, Top down approach, Orthoclase, Filler

Nano-Porous Iron Yttrium Oxide Particles Synthesis as Value Addition to Sri Lankan Garnet Sand

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Garnet sand is a variety of mineral sands which is widely distributed in the southern coastal line of Sri Lanka with large minable quantities. However, these sands have limitedly use in industries, and more applications and products should be studied. In this study, natural garnet sand, which was collected from Pulmoddai, Sri Lanka was used to synthesize nanoporous iron yttrium oxide nanoparticles as it has wide range of applications such as magnetic nanofilters and nanoabrasives. The X-Ray diffraction (XRD) analysis revealed that the garnet sand consists of almandine variety ($\text{Fe}_3\text{Al}_2\text{Si}_3\text{O}_3$). First, 5.000 g of powdered garnet sand was refluxed with 60 ml of 10 M HCl solution at 90 °C. The digested solution was filtered and 2 % NaOH was added dropwise to the filtrate until the pH becomes 14 in order to precipitate iron hydroxide and heated at 80 °C to dissolve hydrated aluminium. Then, the dry precipitate was dissolved in 10 M HNO_3 and mixed with yttrium hexahydrate trinitrate solution. Later, the mixture was mixed with citric acid and pH was controlled to 2 using aqueous ammonia. The solution was heated at 80 °C until a light brown xerogel is formed. Finally, the xerogel was calcined at 800 °C for 5 h. Synthesized nanoparticles were characterized by XRD, Fourier Transform Infrared (FT-IR) spectroscopy and Scanning Electron Microscopy (SEM) techniques. The SEM data revealed the nano-porous structure with 100 nm pore size, while FT-IR and XRD results confirmed the FeYO_3 composition of the nanomaterial. This work can be extended to study the dye adsorption of the iron yttrium oxide nanoparticles, encapsulation of the nanoparticles in the porous structure of synthesized particles and its potential applications, its magnetic property and enhancing the filtration property of the particles.

Keywords : Garnet, Sand, Yttrium Iron Garnet, Nanoporous

Optimization and Structural Analysis of a Gel Polymer Electrolyte Based on Polyacrylonitrile to be used for Na Batteries

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Today, an insurgence has arisen on non Li based batteries to meet the escalating energy demand. Na, Mg, and Zn are some of the suggested alternatives. Simultaneously, attention was focused on replacing liquid electrolytes due to their inherent drawbacks such as leakage, evaporation and high reactivity. One solution is employing quasi solid state gel polymer electrolytes (GPEs). Main objective of this study is preparing, optimizing and structural analyzing of a GPE to be used for Na batteries. GPE based on polyacrylonitrile (PAN) was prepared using the salt sodium thiocyanate (NaSCN) and the solvents, ethylene carbonate (EC) and propylene carbonate (PC). Materials were heated and the resultant was pressed between two glass plates to obtain a thin film. This procedure was repeated varying the polymer and the salt concentrations. The composition was fine tuned to obtain the highest room temperature conductivity. The structure analysis was done using X Ray Diffraction (XRD) technique. XRD measurements were carried out for two samples – with and without salt. The highest conductivity observed was 1.92×10^{-3} S cm⁻¹ from the sample 202.5 PAN: 500 EC: 500 PC: 35 NaSCN (weight basis). When the polymer concentration was increased, conductivity increased first. However, further increase of polymer reduced the conductivity. This may be a result of interplay between dissociation of ion pairs and viscosity of the medium. Similarly, amount of charge carriers and their mobility governs the conductivity and results an optimum conductivity at a particular salt concentration. XRD results clearly suggest that crystalline phase in the PAN: EC: PC structure diminishes upon addition of the salt. It implies that the GPE is in amorphous phase and based on the conductivity value, it is suitable to be employed for Na rechargeable batteries.

Keywords: Gel polymer electrolytes, X Ray Diffraction, Polyacrylonitrile, Sodium batteries

Feasibility of using industrial waste in Sri Lanka to develop composite construction material: A Review

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Sri Lanka has been facing an increasing industrialization process since free market economy in 1977. Consequently, a multitude of factories were located in highly populated urban or sub-urban areas and their improper disposal of waste has ensued environmental pollution and public health hazards. On the other hand, an excessive demand for clay bricks has arisen due to the growth of population and advancements in the construction sector in the country. A sustainable solution for both above stated problems can be derived by developing this composite clay brick using selected industrial wastes in order to achieve green economic benefits. The purpose of this paper is to review the previous literature to overlook the feasibility of utilizing industrial waste to develop a composite brick for construction industry in Sri Lanka by using clay and solid industrial waste such as ceramic, glassware and electronic waste, fly ash, rice husk ash and sugarcane bagasse ash. Clay is a non-renewable resource which was used as the main raw material in the production of the clay brick. As the first step, selected industrial waste materials were processed and mixed with clay in different weight ratios. Thereafter, the mixture was subjected to shape and press. Subsequently the firing was done in suitable temperature conditions for selected time ranges. Finally, drying process was carried out by natural or artificial methods. After the manufacturing, standard tests were done in order to examine the *compressive* strength, water absorption and bulk density of the bricks. The composite bricks that were made from various industrial wastes indicated favorable results in above tests in different clay to waste mass ratios. Despite the limitations in the research area, this brick can be used for constructions in the future through further research, development and standardization.

Keywords: Industrial Waste, Composite, Construction Material, Sustainability, Waste Management

Possibility of Using Remote Sensing Techniques as a Tool in Exploration of Marble Deposits in Sri Lanka

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Remote sensing with the aid of hyper-spectral data are widely used in mineral exploration. However in Sri Lankan context remote sensing has not been used for mineral exploration due to nonexistence of most of required data and the vegetation cover is one of the major factor that limit the remote sensing approach. From that, the study area Balangoda and Mathale consist of rapid variation in elevation that may cause shadow effect which restrict the reflection of solar radiation. This study investigates the possibility of using freely accessible multispectral data for marble exploration. Classification techniques and topographical features were used to locate calcite and dolomite occurrences in the study area. Shuttle Radar Topography Mission (SRTM) data were used for topographic feature identification and Sentinel-2 data were used for accurate classification. Anticline-syncline formations and fractured zones were identified using SRTM data. Effective classified images were obtained from Sentinel-2 and Landsat-8 data processing. Training polygons was used to extract the spectral signature in each data set. Although direct spectral signatures of calcite and dolomite are not prominent in remote sensing images, indirect indicators help in delineating possible mineralizing zones. Decision tree for each data set was used in classification process. This study proves that using relatively high resolution data acquired from Sentinel-2 can be used for more effective classification than Landsat-8 data sets in mineral explanations.

Keywords: Remote sensing, Mineral exploration, Marble, SRTM, Landsat-8, Sentinel-2.

Fabrication of Solid State Dye Sensitized Solar Cell Using Red Sandalwood as Natural Sensitizer

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Commercially available dye-sensitized solar cells contain synthetic-metal centered dyes as a sensitizer. Natural dyes obtained from plants are a cheaper alternative for high cost synthetic dyes. The Main objective of this research is extraction of a natural dye which has wide availability with minimal chemical procedure to reduce cost of production and toxicity. The study intended in developing a solid-state-dye-sensitized solar cell by sandwiching red-sandalwood pigments in between porous TiO₂ and CuI films. TiO₂ films were prepared on conducting glass substrates by using two different methods to obtain two different thicknesses and their morphologies were studied. According to the absorption spectra, presence of multiple layers increase the intensity of absorption of thicker (>10 µm) TiO₂ than thinner (<10 µm) TiO₂ film. Optical microscopic images of different TiO₂ films show that thicker (>10 µm) TiO₂ film has no cracks present. Due to the absence of cracks in thicker TiO₂ film, solid electrolyte cannot reach to glass substrate and therefore, no short current occurs. Red-sandalwood dye extracted to three different solvents (ethanol, acetone, acetonitrile) using soxhlet extraction and rotary evaporation. In each solvent three major electron transitions observe for red-sandalwood extractions. Therefore, these three solvents are acceptable for extraction of red-sandalwood to use as sensitizer. A significant red shift in the absorption spectrum can be observed after chelating red-sandalwood pigments with TiO₂ compare to that of dye in solutions. Formation of red sandalwood-Ti complex may be the reason for the observed red shift in the absorption spectrum. The bond formation between TiO₂ and natural red-sandalwood pigments was confirmed by FTIR measurements. The deposition of hole-transfer (CuI) was eliminated problems encounter with the liquid electrolyte in photovoltaic cells. The morphology of CuI layer was studied. This demonstrates that triethylamine-hydrothiocyanate can control the formation of crystals of CuI by acting as a surfactant.

Key words: Red-sandalwood, Solid-state dye sensitized solar cell, TiO₂, Soxhlet extraction

Development of Heat Insulating Paint Using Rice Husks and Kaolin

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The global warming scenario increased demands for the heat insulator material, especially in the construction sector. The present day popular roofing materials are asbestos and metal sheets. These have poor shield to outside temperature, thus have relatively high indoor temperatures compared to clay tile roofs. This study focuses on development of a roofing paint with heat insulating properties to reduce indoor temperature. Here primers paint was modified adding different percentage of kaolin and rice husks. Percentage of kaolin and rice husks added in to primers paint was 5% (w/w) for each. In both cases, particle size of kaolin and rice husk was 150 μm . A small metal piece coated by the paint that has additives were tested for heat insulating properties with the consistence of silica according to the Fourier law. The loading paint content on a piece of metal square was varied according to the number of coatings applied. The thickness of the paint coat and weight of the paint per square centimeter were recorded for each sample. Each sample was prepared in triplicate for analysis. The temperature difference between top and bottom of the metal sheet was evaluated using a custom made apparatus using thermocouples under insulating conditions from the surroundings. The heat transfer rate was calculated using the Fourier law assuming the thermal conductivity of the metal sheet has the value of steel due to the fact that very thin coating was applied. The results reveal that the average heat transfer rate decreased with the increasing number of coatings applied and relatively faster decay of heat transfer rate was observed for kaolin and rice husk containing paints than primers paint only. However, the greater temperature difference between top and bottom of the metal piece was observed for primer paint with 5% kaolin loading. The average temperature difference of paint with kaolin is 9.67 with 12 number of coatings. This results conclude that addition of rice husk or kaolin to a primer paint can enhance the heat insulating properties.

Keywords: Insulating paint, Fourier law, Heat transfer rate, Kaolin, Rice husk

Ascertain an Optimum Temperature and Soaking Time to Enhance the Colour of “Maangu” Tourmaline

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“Maangu” is untagged stone in tourmaline group. The large amount of “Maangu” stones are found in Sri Lanka than other tourmaline verities. Since “Maangu” have less transparent appearance, they are seldom in jewellery items or any other decorative items. Investigatig the enhancement of colour or change of colour of “Maangu” by heat treatment was the objective of this research. Heat treatments were done by using “Lakmini” furnace and electrical furnace, to identity appropriate furnace for industry scale operations. Samples were heated at 650 °C, 680 °C, 710 °C, 750 °C, 850 °C and 900 °C for 2 to 4 hours in oxidation condition to discover the temperature changes and corresponding colour changes. Results were remained unchanged after heating at 650 °C. A slight colour enhancement appeared in 680 °C. Slight brown colour enhancement appeared in 750 °C. The Brown colour started decreasing in 900 °C. Brown colour visually appeared in two samples at 850 °C. X-ray Fluorescence Spectrometry shows that “Maangu” contain Silicon, Aluminum and Magnesium as major elements ranging 12-68%, 7-35% and 2-9.5%, respectively, while Titanium, Iron, Vanadium, Chromium, and Manganese recorded as trace elements. Final results show that no any significant change before and after the heat treatment with to Fourier Transform Infrared Spectrometer. As a conclusion, optimum temperature and soaking time to improve the hue, saturation and tone of the stone is 850 °C in more than four hours.

Keywords: Maangu, Tourmaline, Heat treatment, Chemical analysis

Recycling of Cathode Ray Tube Glasses and Utilizing the Waste Glasses in the Roof Tile Industry of Sri Lanka

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With the development of the technology the Cathode Ray Tube (CRT) monitors are being replaced by modern Liquid Crystal Display (LCD) or Light Emitting Diode (LED) display screens, transforming the used CRT monitors into a major e-waste. CRT glasses contain lead (Pb) as a constituent to an extent of 18% - 22% w/w. The emission of lead to the environment causes numerous harmful effects to the living beings. Sri Lanka has a burden of nearly 140,000 Mt of CRT glasses as e-waste and appropriate measures should be taken to dispose or recycle CRT glass waste. Current study proposes to utilize CRT waste in the roofing tile industry as a glaze or body mix. CRT glass powder was directly mixed with red clay in a range of ratios, while examining the modulus of rupture, water absorption, shrinkage and the amount of lead leaching of the glass powder and red clay mixture. The red clay was procured from the silt deposits in irrigation tanks in North Central Province of Sri Lanka. The best percentage of CRT glass powder, which was added to red clay was determined as 15%. The lead leaching rate of the material corresponds to that ratio of 15% CRT powder into red clay, retained at a rate of 0.94 ppm implying that rate of releasing lead is considerably low and it would not emerge harmful causes to the environment. The addition of CRT glass powder exhibited relatively better vitrification and finishing, depicting the potential to utilize the application in the commercial glass industry. It can be concluded that the waste CRT glasses can be utilized economically as an eco-friendly material in a novel technological way, where findings of the application of waste CRT in Roof Tile Industry.

Keywords: CRT glass, Lead, Modulus of Rupture, Red Clay, Glaze, Recycle

Increasing the Purity of Graphite Samples Taken from the Under Flow of the Froth Flotation Process Using a Gravity Separation Method

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Graphite is one of the main exporting mineral commodities in Sri Lanka which is found as flake graphite, vein graphite and, amorphous graphite. *Kahatagaha, Bogala* and *Ragedara* mines produce world's best quality graphite with a Carbon grade over 90%. Quartz, pyrite, chalcopyrite, feldspar, calcite etc. are the associated trace minerals with the graphite. Froth flotation is one of physio-chemical separation technique. Nevertheless, it cannot be considered as an eco-friendly and a cost-effective method, since chemicals used for froth flotation of graphite are toxic and expensive. Moreover, froth flotation does not provide the optimum separation and about 37% of graphite get mixed with the underflow. In this research Humphrey Spiral was used as the gravity separation technique to process the under flow taken from froth flotation. Flow rates, splitter distances and particle sizes were taken as the parameters. Particle size of the sample tested were from 50-500 μm . The results concluded that under the flow, graphite can be processed up to 80% or higher grade from an initial grade of 37.89% with flow rate of 888 ml s^{-1} , splitter distance at position 3 and for particle size between 300-500 μm . To obtain the optimum grade, particle size distribution, percentages of mineral in relation to the particular particle size should be studied and suitable flow rate chose accordingly. Further, splitter distance should be narrowed down the area of tailing conduit to attain an optimum grade.

Keywords: Graphite, Graphite Processing, Gravity Separation, Spiral

Removal of Iron Impurity from Vein Quartz by Acid Leaching

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Vein quartz is the major source of silicon for manufacturing of solar cells, computer chips, and silicon carbide. Nevertheless, high-tech applications of vein quartz do not apply in industries due to iron impurities that is the major problem in the quartz processing industries in Sri Lanka. The aim of the investigation was to enhance the purity of exporting semi processed vein quartz by acid leaching. Particle size reduction processes crushing, grinding and milling increase the amount of iron in the quartz and this secondary iron concentration needs to be removed to produce more purified quartz. Thus, in this research quartz was obtained using raw quartz near Badulla area. Raw quartz was processed using primary and secondary crushers and then it was separated into four size fractions (125 µm, 500 µm, 1 mm, and 8 mm). The acid leaching was employed for iron removal. Atomic Absorption Spectrophotometer (AAS) was used to measure iron content before and after the leaching. As preliminary studies, Hydrochloric acid and Nitric acids were employed for the leaching and Liquid-Solid ratio was 5:1. According to the results which were observed as preliminary study, HCl was chosen for the leaching and effect of the HCl for the removal of iron was examined. The particle size of the quartz, leaching time, concentration of the reagents were used as parameters. Leaching was done under normal atmospheric conditions (25 °C, 1 atm). The acid leaching of vein quartz resulted in a reduction of 60 – 65% Iron from the original natural state. Since iron dissolution is a photochemical reaction experiment was conducted in controlled conditions (250 – 500 lux). A progressive amount of leaching (60 – 65%) of iron from quartz was obtained under following conditions, a higher concentration of HCl (5M), smallest size fraction (0-125 µm), and 60 hrs. leaching time. Under these conditions, a higher purity of quartz powder can be achieved.

Key Words: Quartz, Leaching, Quartz impurity removal

Optimization of Mixing Parameters using Mooney Viscosity of Top & Bottom Profiles in Off-the-Road Rubber Track Compounds

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Rubber tracks are used in off-the-road heavy duty vehicles. The tread of tracks consists of two layers namely top profile and bottom profile. Rubber Compound ATR 6112 (A) & Compound ETR 5271 (B) are used to manufacture top profiles, while Compound TR 5237 (C) is used in bottom profile. The high Mooney viscosity of such compounds leads to reject the batches of compounds. Therefore, compound mixing parameters were optimized during the study using Mooney Viscosity (MV). Also cure time, scorch delay & hardness of compounds were evaluated. Mixing cycle (s) defined as time for pre-mastication & mixing of curatives and number of mill turns were selected as the major parameters and assessed separately for compounds. Number of mill turns was varied as 3, 2 & 1 for all three compounds. Mixing cycles are Compound A (40,60), (20,60), (0,50,50) & (30,70), and Compound B (20,90), (40,60), (0,50,50) & (30,80), while Compound C at (20,80), (30,70), (0,50,60), & (40,60). Complete Randomized Design with 10 replicates were used. Compounds A and B with the mixing cycle of (0,50,50) where mixing of curatives and rubber compound together, used internal mixer without allowing pre-mastication time. The best mixing cycle was achieved at (30,70) for Compound C with a lower MV. The number of mill turns has not significantly affected on MV, scorch delay, curing time and hardness of all three compounds. The scorch delay was affected by mixing cycle only in Compound B. The curing time was affected by mixing cycle in only Compound A and C. The hardness of the compounds has not significantly affected by mixing cycle. Finally, better cure characteristics of the compounds could be obtained along with reduced Mooney Viscosity by adjusting the mixing cycle.

Keywords: Mixing cycle, Mooney viscosity, Mill turns, Rubber track compounds

Effect of Technically Specified Rubber (TSR) Variations on Rheological Properties of Soft Compound of Solid Tires

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The soft compound of solid tires is used to produce the middle section (cushion) of the solid tires which enhanced to provide the cushioning effect. Medium hardness, low heat buildup, high elasticity and high resilient are the most expected characteristics from the soft compound. TSR from different suppliers may lead to unexpected deviations in the rheological properties of the soft compound produced. Such deviations in the rheological properties significantly affect the performance of soft compound. The objectives of this study were to investigate the effect of TSR variations of suppliers on rheological properties of soft compound and identify the raw rubber property or properties which cause such variations. Rheological properties such as t_{s2} (Scorch time) and t_{c90} (Optimum Cure time) of soft compound produced from TSR supplied by three different suppliers (thirty samples each) were measured to check the effect of TSR variation of the suppliers on rheological properties of soft compound. Raw rubber properties such as dirt content, ash content, volatile matter content, nitrogen content, Wallace plasticity (P_0) and Plasticity Retention Index (PRI) of three samples of TSR from each supplier were measured to identify the cause of the TSR variations. The results revealed that the rheological properties of the soft compound are significantly affected by the TSR variation of the supplier ($p < 0.05$). Dirt content, ash content, volatile matter content, nitrogen content were having a significant effect for the resulted variation of TSR ($p < 0.05$). Findings of this study will be useful in selecting the best TSR supplier to produce best soft compound in solid tire manufacturing.

Keywords: Rheological properties, Soft compound, Solid tires, Technically Specified Rubber

Development of a pH Responsive Ceramic Material

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Food spoilage is a big problem in the food industry which cannot be overcome, but able to be controlled or ways of detection can be developed. In the food industry, identification of food quality minimize health problems and avoid wastage. The objective of this research is to introduce a pH sensitive smart bottle cap. When the pH is going to change the ceramic pallet placed in the cap will change color. When some food item such as milk is being spoiled, there will be lactic acid, which reduce pH, produced. Because of acidic condition pH will be reduced. This pH variation can be identified by pellet. Kaolin is the ceramic material used in this research. Here it is used due to its non-toxicity and chemical inertness. The kaolin based material was prepared in a way it can absorb a dye material to obtain clear view of color change. This research used four types of dye materials. Two of them are anthocyanin containing plant based dyes and other two are commercial dyes. Anthocyanin can undergo molecular rearrangement due to polyphenolic groups and extended conjugation of double bond depending on pH of the medium. Also in methyl orange and methyl red, they show different colors in acidic and basic conditions. Other important thing is those dyes exhibit low toxicity and may not affect to the taste of food item. The air stability of those four dye materials have been checked by the UV visible spectrometer. For the purple cabbage, there were increased of absorbance gained after 72 hours. The pH reduction average is 34.04% after 72 hours. Same as the Hibiscus dye also shown, a increase of absorption and reduction average of pH 25.35% after one day. Same as methyl red dye, it shows 11.7% increase of absorption after one day. Also it shows 20.05% of pH reduction after one day. In methyl orange, it shows 67.67% of absorbance increase and 19.3% of pH reduction. Purple cabbage absorbed pellets show yellow color for the 1.0 M NaOH and pink color for the 1.0 M H₂SO₄. For spoiled milk, blue color pellet turned into the purple. Same results were obtained for the Hibiscus dye. It shows brownish color for the spoiled milk as well. It shows brown color with the spoiled milk. Therefore, it is clear that these ceramic pallets have the potential to be used as smart caps for spoiled food detection.

Keywords: Food soilage, Kaolin caps, Ceramic cap, Commercial dyes, Pit change

Use of Coir Fibre Waste as an Effective Raw Material for Fibre Boards Reinforced with Natural Rubber Latex Compounds and Phenol-Formaldehyde Resin

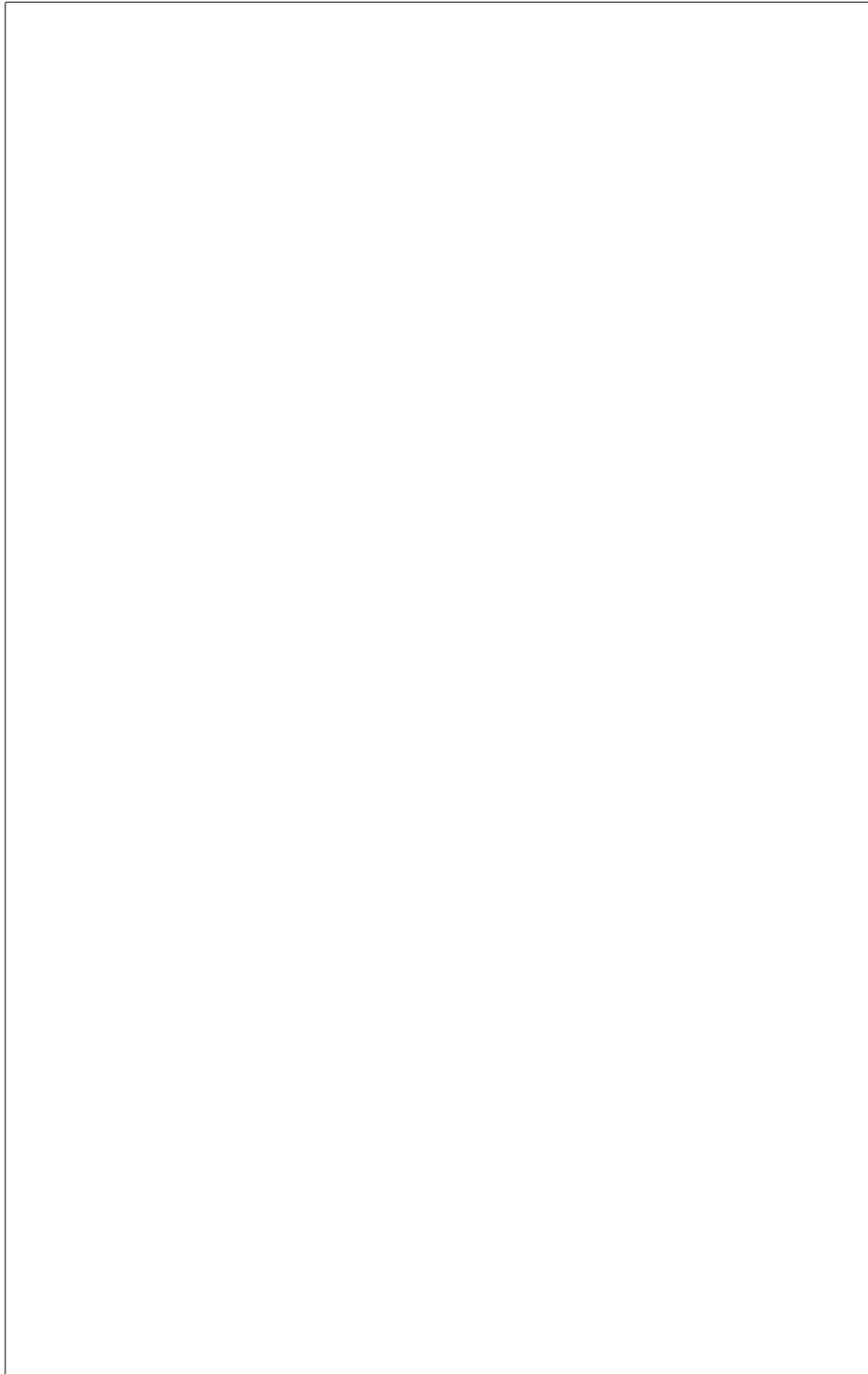
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Coir pith is a by-product resulted in extraction of coir from coconut husks. Small fibre particles namely “*Kātu*” (~5 mm) are accumulated during coir pith extraction process as a waste material, which has been an issue in the production process. There is a potential to utilize “*Kātu*” as an economically viable raw material to manufacture coir boards (CBs). CBs can be used as alternative source for Hard & Particle Boards and other Synthetic Boards. An effort was made to develop a CB as an alternative to the above boards evaluating the basic parameters. Processing was undertaken using a coir cutter machine and then it was developed into CB. Each CB (15 x 15 x 0.5 cm) was prepared using 35 g of “*Kātu*” changing the mass of Natural Rubber Latex Compounds (NRCL) and Phenol-Formaldehyde Resin (PFR). Mass of NRCL in CBs varied as 30, 40 and 50 g and the PFR as 5, 10, 15 and 20 g. Having moulded, vulcanization was carried out at 120 °C for 20 min. For the CBs, moisture content (%), density (kg m^{-3}), water absorption (%), swelling and physico-mechanical properties such as maximum force at break (N) and maximum elongation (%) were evaluated according to ASTM and IS standards. Tests were carried out at 27 °C temperature. CBs were prepared successfully by optimizing the composition. The density of CBs was within the acceptable range: 465.8 - 653.61 kg m^{-3} , which is close to the density of ‘Hard Boards’ and ‘Particle Boards’. Moisture content, water absorption and swelling properties were up to the standards. The force at break and maximum elongation showed an increase when the amount of NRCL and PFR was increased. In conclusion, “*Kātu*” can be used as an effective raw material for manufacture of CBs reinforcing with NRCL and PFR for the use of other boards given above.

Keywords: Coir fibre board, Natural rubber, Phenol-formaldehyde



Mechanical Engineering and Mechatronics

- Agricultural Machinery and Engineering
- Digital Electronics and Embedded Systems
- Mechanical Engineering
- Mechatronics and Robotics
- Electrical and Computer Engineering

RFID Based Smart Personal Baggage System

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Advances in the RFID technology over the last three decades have revolutionized the field of engineering. The technology has been applied to an enormous number of applications where contactless identification is required. The rate of adoption of the technology keeps increasing due to the relatively low cost of the modern RFID based systems. Personal asset tracking is becoming more and more important since people tend to forget their belongings due to their hectic schedules and the increased number of personal gadgets in use. In this paper, a method of using RFID based system to track the personal items and their safety during travel has been introduced. The system is designed in such a way that it is embedded into a backpack, a handbag or a traveling bag. With the help of the area tagging and the pre-programmed schedule, the customized RFID reader system is capable of real-time tracking, managing the integrity and providing anti-theft capabilities to the personal belongings while traveling. Then, the system integration method and the special strategies of controlling the RFID system with a constrained environment inside a baggage have been elaborated in detail. In addition, we introduced a dynamic transmit power controlling algorithm to maintain the tracking perimeter to be restricted only to the baggage, even when the items inside the baggage are changing and the signal attenuation is changed. Furthermore, we discussed a patch-antenna, which is designed to use with the specific application requirements and space constraints in detail. The integration and research results have been successful and based on that, future improvements to the system with technology advancements have been discussed along this paper.

Keywords: RFID, Personal-assets, Smart-baggage, Anti-theft, Patch-antenna

Autonomous Baby Care System

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Baby nets are important for protecting babies from mosquitoes and insects, and give a good sleeping experience. Baby cradles, which are currently available in the market do not give any extra level protection to babies. Existing systems do not have the interaction with mothers as they cannot be with their babies all the time. Therefore, in order to ensure a baby's safety in all aspects, the main objective of this study is to produce an Autonomous Baby Care System to provide an extra level of protection to babies with alert message system. In some cases, if a mother is not in the close proximity to her baby and the baby is awakened from sleep and crying, the situation can be identified using sound sensors and then the system will sing a lullaby and swing the baby cradle to make the baby sleep. And also if the baby has urinated, it can be identified using humidity sensor and alert the mother with a buzzer sound along with the LCD display message to change the diapers. In addition, the system will continuously monitor the weather around the baby and according to the temperature, it will control the fan speed. Arduino is the main control unit of this system. Arduino gets the input signals from the sensors attached to the baby net, process it, and gives output signals to take necessary actions, such as controlling the fan, playing a lullaby, and swinging the cradle. Also it will send the status to mother's receiver panel. The system successfully identifies the input signals from Sound sensor, Temperature sensor and Humidity sensor and results desired actions from 94% of the outputs. As a future improvement and for commercial use, Artificial Intelligent (AI) techniques can be used to improve the accuracy of the output of the sensors.

Keywords: Baby Cradle, Baby Care, Arduino, Humidity Sensor, Temperature Sensor

Development of a monitoring device for fermentation stage of black tea manufacturing

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Tea is one of the popular industries around the world for its social influence. Taste, tea colour and odor are the ways to measure the quality on the final product, but Theaflavins/Thearubigins ratio is accepted as 1/10 for a high quality. In general factory officers estimate the optimum fermentation time visually. However, optimum fermentation time might depend on humidity, temperature, moisture content of leaves, which are processing on a particular day. Thus, there is a need for a system independent from human decision. An electronic device was developed, in order to determine the optimum fermentation time for the black tea. A set of sensors such as humidity, moisture and temperature were attached to the device to store the physical environment data of the fermentation bed. Colour changes during the fermentation were monitored using an iPhone 6s camera, which have 12 mega pixels. First set of tea particles from a batch of fermentation was selected for the research. This device was allowed to collect data until the factory officer asked to stop the fermentation according to his own decision. A sample of each monitored batch was collected after firing to measure percentage of Theaflavins. Tea infusion was monitored using Ultraviolet spectrophotometer. Finally, data were analyzed statistically. Theaflavins content decreases with the fermentation time which is the trend expected. The average temperature, temperature difference and average room temperature are statistically significant with fermentation time at 0.05 level of significance and percentage of variance is 96.6. Moisture content is constant because this is expected as we focused on dry season leaves. Finally, study confirms the importance of measuring physical parameters when monitoring fermentation stage to obtain quality tea. Some advanced test has to be done on the fermentation tea colour in future.

Keywords: Black Tea, Optimum fermentation time, Theaflavins, Tea quality, Electronic eye

Obstacle Avoidance System For A Quadrotor UAV Using Over Head Mounted Camera, Based On Image Processing Technique

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An obstacle avoidance system for a Quadrotor UAV using overhead mounted camera is based on image processing technique. Current robots use various sensors to obtain the locations of obstacles and navigate without colliding. Here, the robot uses an overhead camera to detect obstacles for safe navigation. For this method, the robot does not need to use any additional sensors to detect obstacles. Here, the method uses an image processing technique. The images from overhead web camera are converted to grayscale images and filtered to remove noise and then converted to black and white binary images by using MATLAB software package. Then, objects in the images are identified and centroids are drawn, and a square is drawn around the robot to distinguish in-between. Thereafter, the pixel location of each object is taken from the centroid pixel location and the area of the object is also taken into the algorithm. The navigation is done with the aid of the “depth first search” algorithm. It uses the location of the robot to navigate to the desired node in the image binary matrix. The results of this project were successful. Navigation of a mobile robot using overhead mounted single camera without using additional sensors were done successfully. For Quadrotor, this algorithm was simulated on Robotic Operating System and Dronekit Simulation platform. These platforms were built on Ubuntu operating System and a Python script was used to connect the MATLAB program. Simulation successfully detected the obstacles and had a safe navigation. The conclusion of the research is that, this method is suitable for applying for any mobile robot for a specific range and the method can be used for Quadrotor by defining same parameters as for the mobile robot.

Keywords: Obstacle Detection, Quadrotor, Image Processing, MATLAB, Dronekit

Object Sorting System Using Affordable Robotic Manipulator

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In modern world, automation and robotic are at a high demand as both directly affect the rapid development in various industries. Also, quality and flexibility of products are becoming significant criteria. Robots will be the best solution for substitution of cost of labor wages and higher customer demands. Automation is the most preferred technique to replace the human labor that perform complex tasks in complex and risky environments. Pick and place operations are required in many of manufacturing processes, and it can be automated. Therefore, this study aims to sort and place different objects according to their shape and color using image processing techniques. The main objective is to provide a solution for any manufacturing process which require sorting based on shape, color or their combination. In this study, low cost, servo motor controlled, CNC machined 5 DOF robotic manipulator with electromagnetic end effector is used for the object sorting. The shape detection and color detection algorithms were implemented using MATLAB 2016 and a high-quality USB web camera. The robotic manipulator is controlled through an Arduino Mega via serial connection to MATLAB. Since, higher processing power is required for the algorithms, a computer was used. A graphical user interface was developed with customization options. Objects were successfully detected based on shape and color and sorted using the robotic manipulator.

Keywords: MATLAB, Arduino, Color, Shape, Sorting

Vision Based Guiding System for AGV Using Robot Operating Systems

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An automated guided vehicle or automatic guided vehicle (AGV) is a mobile robot that is most often used in industrial applications to move materials or goods around a manufacturing facility, warehouse or stores. This research is based on making a vision based guiding system for AGV instead of follow markers, wires in the floor or magnets. For this task here used “rviz” and “Gazebo” visualizing interfaces in ROS (Robotic Operating Systems). In this guiding system, the initial map was generated of the working environment manually. Then, in this mapped environment AGV can navigate autonomously avoiding obstacles. To obtain a 3d and 2d map of the navigating environment, AGV used *ROS RTAB map* (real-time appearance based mapping) packages. Video cloud of the environment was obtained by Xbox Kinect 360. For communicating with Kinect video cloud, *ROS freenect-openni* package was used. The AGV model was designed by *URDF* (unified robot designing format). This model is designed to its real dimensions through URDF. For first map generation, AGV moved manually in the working environment. Manual Navigation of the AGV achieved by *ROS keyboard teleop* packages. These navigation commands pass to motors of AGV through Arduino board. For communication between Arduino and ROS, “*rosserial*” packages were used. This system can identify obstacle through video cloud with a small delay. The laptop was used as ROS working environment and also to monitor and mark the destination point of AGV. It is possible to use wandboard, Raspberry Pi board instead of laptop and HMI (Human Machine Interface) instead of the laptop monitor. AGV can identify its current position through ROS localization packages and use wheel encoders to obtain traveled distance accurately, while navigation to the given destination.

Key Words: AGV, ROS (Robotic Operating Systems), RTAB Map

Computerized Motor Spare Parts Identifier

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The use of image processing for physical characteristics identifier for auto spare parts selling industry systems was the aim of this research. Furthermore, this research is to develop an identifier of physical properties, which are altered in used spare parts and identify the correct spare part that should be used to replace. In Sri Lankan scenario, a replacement of a spare part is done by hand measurements and selection through manuals. An automated system could reduce time consumed in this process. The images were taken from the *USB2.0 HD UVC WebCam* and the images were processed using *MATLAB R2016a* software. *Arduino Mega 2560* development board was used to control the hardware. Moreover, the system is programmed to check the availability of the spare parts through the already established data base. *MySQL* database managing software is used to develop the database manipulation. Presently, the system can identify oil seals. Further a robotic arm and Auto Guided Vehicle to deliver the suitable part to the consumer via the fully automated process is expected to develop.

Keywords: Image processing, Spare part identifier, Automated system

Finite Element Analysis of Tyre-Rim with Different Nave Thicknesses

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The local industries often use manual calculations in the rim design and manufacturing process. The accuracy of these calculations has a significant effect on final products. With the help of modern computational power, the rims can be analysed to a greater depth at an early stage and product quality can be substantially enhanced. This work was initiated to analyse a rim and optimize the nave thickness allowing the rim to withstand higher loads even at lowest material requirements. As the first step, geometries of two rims with different naves (9 mm and 10 mm) were created as 2D surface geometries, in order to get an effective stress distributions. After modelling, material was assigned for different sections. Subsequently, boundary and loading conditions were applied. All displacements and rotations were set between the tire outer surface and a virtual road layer. At the beginning, the road layer was moved to 10 mm towards the tire and all other displacements and rotations were fixed. In the second step, all the displacements and rotations were fixed except the displacement in vertical direction. The virtual road layer causes to generate the pressure between tire and the rim. As a result of that stresses are generated within the tire and the rim components. At the end, stresses generated in four different points were compared with original rim of 10 mm nave and optimized rim of 9 mm nave. The results of the Finite Element Analysis (FEA) show that the maximum stress variation percentage is 15.62% and, the maximum stress generated in the optimized rim lies below the yield strength of the steel. Thus, it is verified that 9 mm nave thickness can replace 10 mm nave thickness. Although this is a single millimetre thickness reduction, it can save cost in large amounts at mass production. Therefore, it can be concluded that use of FEA techniques to optimize the rim nave thickness could bring distinct benefits in the rim manufacturing process.

Keywords: Design, FEA, Nave, Rim, Thickness

Autonomous Guided Vehicle for the local market

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Autonomous transport vehicle for factory with auto charging dock-using Proportional, Integral and Derivative (PID) controlling falls under the autonomous guided vehicle (AGV). The intention of this research is to develop fully functional AGV with added functions like battery level indication, automatic docking, intelligent steering drive method using (PID), low-cost ect. Furthermore, this project aims to implement the PID algorithm, control the movement of the AGV by proper tuning of the control parameters, an optimized drive system to suit with the rough industrial environment, the affordable price tag for Sri Lankan market and deliver better performance. AGV mainly used magnetic line following method and the vehicle battery is charged automatically in specific charging dock (charging area). A PLC is used control of the AGV and implement PID algorithms for motor speed control, which governs the robot to smoothly travel along the line. Drive system used brushless direct current motors (BLDC) with the embedded gearbox. This BLDC motor and gearbox combination gives more robust operation compare to chain drive system. An 8-bit magnetic sensor used as the main sensor for the navigation. The end product of this research is to build up “mouse” type affordable AGV platform which can use in Sri Lanka Industries. Future developments will be focused to change the magnetic based guidance system to vision based guidance system and an auto charging system.

Keywords: PID, AGV, BLDC, Dock

Unique Object Following Robot

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In rapidly moving robotic world, leader following robots have been researched and developed by many researchers worldwide, because it is advantageous. These leaders following robots make a good interaction between a leader and a mobile robot. This interaction was made with the help of several technologies by many researchers. Those techniques are ultrasonic wave transmitting and receiving technology, radio frequency identification technology, Infrared waves transmitting and receiving technology, using stereo camera, KINECT module, laser range finder technology, and image processing technology. In this research image processing technology was used to track and follow a leader uniquely. Through image processing technology, a unique object in the leader's body is tracked and according to the tracking, the leader is followed. The image processing task is processed by camera module and with the Raspberry Pi board, the Raspbian operating system was installed and open cv program was installed to the raspberry pi board to carry out the image processing part. The Arduino board was serially connected with the Raspberry Pi board. According to the image processing information, the Arduino board is used to control the motors of the robot and through that, the mobile robot is able to follow the leader in a straight line and also to follow the left-right movement of the leader. The Algorithm used was found in the OpenCV library and the language used to program was Python. Low lighting conditions and less processing power affect the accuracy of the robot. The motors should have the power to gain sudden acceleration and to maintain the speed to follow the leader if leader walks fast.

Keywords: Raspberry, Object follower, Man follower, RFID, IR

A portable gas sensing Device Based on Imageprocessing

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There are various kind of gases that evolving from common applications in the industrial, automotive, medical, laboratory and environmental areas. Most of the gases are hard to identify due to the location they release and difficult to capture them. Any gas released is inconvinient to carry them to a laboratory for identification. Currently available laboratory devices that used for gas sensing are expensive due to their advanced technology. Therefore, a cost effective special instrument consists with simple technology is require as a solution. This research will be helpful to fulfil above requirements. The device is especially designed for the industrial and laboratory purposes. At the beginning, system was developed to detect Ammonia gas. Concentration series of 25 ml sample solution were made by adding 1 ml of Nessler (mercury II Chloride 2.5%) with different Ammonia volume. Colour changes of Ammonia gas with Nessler solution were monitored by an image. Images were captured using Y3-Huawei phone camera, which have 480×854 screen resolution with 5 mega pixels. RGB measurement of images were obtained using the MATLAB 2014a Software. UV spectrometer data of the same samples were obtained at same time. RGB Values and UV spectrometer data were analyzed statistically. Minimum detection level of Ammonia gas was found as 0.091 ppm. The average Absorbance with Concentration (mol dm^{-3} , Ammonia) are statistically significant with absorbance at 0.03 level of significance and percentage of variance is 96.5%. The average Red colour with concentration (mol dm^{-3} , Ammonia) are statistically significant with average red colour 0.012 level of significance and percentage of variance is 91.1%. Green and blue Variance are lower than red. Compared to three colours, red colour was best for the Ammonia gas Analysis. This research can be extended later for other gases, which give colour changes with chemicals such as CO_2 , SO_2 with potassium dichromate (VI), and H_2S gas with lead acetate etc. Also, as an extra application this research can be extended for any colour measurement application like tea, paint, and dye colour analysis.

Keywords: Image processing, automotive, RGB, pixels, Absorbance

Haptic Teleoperated Steering System for Unmanned Ground Vehicles

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The teleoperation of Unmanned Ground Vehicle places high demands to its steering system. The main objective of this research was to design and introduce a haptic teleoperated steering system. While turning the steering wheel into desired angle, master controller detects the signal and transmit it to slave controller through wireless communication module. Then, it drives the slave motor. If there any disturbance torque on the slave motor, armature current changes proportionally to that torque. The change in armature current was sensed by a current sensor connected to the slave controller. Then, that data transmits to the master controller. After that, master controller regenerates a haptic feedback current signal and sends it to the feedback motor driver. Then, the relationship of master and the slave motor responses was obtained. Whenever the slave side feels any force, the current drawn by the slave motor was increased from its normal value. This current regenerates the proportional torque on the master side. Control scenario was evaluated with control systems applications. By the use of a PID controller allowed more precise control of position and thus, faster achievement of a stable position. The design was simulated in Simulink software and control algorithm was tested for prototype model. The system is settled within 8.4 s for the given angle inputs and disturbances. The system responded to each force acting on the slave end according to a specific program, which was coded and installed on a microcontroller. The results proved the model can generate haptic feedback on the teleoperator. Further development of enhanced performance of the system in wireless network environment is intended.

Keywords: Haptic Feedback, Steer By Wire, Teleoperation, Unmanned Ground Vehicle

GSM, GPS and Facial Recognition Based Vehicle Security System

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This study is focused on developing an improved version of vehicle security system for a bearable price. In this study GSM, GPS, facial detection and recognition technologies are used to overcome liabilities in the existing vehicle security systems. In the proposed system, the real time image processing user authentication is done by comparing a freshly taken photo of the driver with an existing database. Whenever the driver sits on the seat a hidden camera established inside the vehicle turns on and captures a photo of the driver. Cascade Object Detector and Fisher vector features of MATLAB software is being used for facial detection and recognition. Captured image of the driver is compared with the images in the database of authenticated drivers using the above mentioned features and verify the authentication. The GSM technology build up the communication between the vehicle and the owner and it provides the control of the vehicle to the owner's mobile phone. The GPS technology provides the access to gain the co-ordinates of real time precise location of the vehicle. The system consists of a vehicle lock down system that provides owner the facility to lock down the vehicle using a simple text message. Whenever the owner received the security alert he can reply with the predefined text message to activate the lock down system. The lock down system consists of a relay switch system and a fuel supply control valve. When the lock down system initiate it breaks the fuel supply and electric supply to the vehicle. A microprocessor based control system processes the functions of this security system. This well improved vehicle security system provides efficient security for the vehicle.

Keywords: GPS Technology, MATLAB, Facial detection, Detector, GSM Technology

An innovative Fixing Solution for holding Complex Shaped Components

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Manufacturing industry faces several challenges when fixing complex shaped components, especially in the aerospace industry. The aerospace industry uses various types of dedicated fixturing systems to handle these components, but lacks a universal method of fixing. A complex shaped component does not have any symmetric lines or parallel surfaces, which makes it difficult to fix in manufacturing processes such as machining, finishing and inspection operations. A pin type fixturing system is the dominant and reliable design used in such applications to fix complex shaped components. In pin type fixturing systems, force is applied via a point contact to the workpiece. This can cause structural and/or surface damage to the component. To overcome this, a fixturing system based on jamming of materials with negative pressure is used to improve conventional pin type. A flexible diaphragm filled with jamming materials is used to increase the area of contact. By changing the diaphragm properties, it is possible to improve the quality of workpiece fixing. This work studies the effect of the diaphragm properties on fixing quality. Series of experiments were carried out to decide the best suited diaphragm properties in terms of highest holding force with best adaptability to a given complex shape. According to experimental results, increasing the thickness of granular jamming membrane has provided higher fixturing force for complex shaped components.

Keywords: Aerospace, Complex shapes, Fixtures, Granular Jamming, Work holding devices.

A Controller for Assistive Devices using Eye Movement and Electroencephalography

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Assistive technology is adapted or specially designed technology for improving the functioning of people with disabilities. However, access to assistive technology is limited in Sri Lanka. The high cost of assistive technology development has put them out of reach of most of the disabled Sri Lankans. Therefore, low-cost equipment to read signals from patients with limited abilities will lead this technology development to next level. This research presents the development of a low-cost system which acquires and process brainwaves and eye movements of individuals. These signals are processed for controlling few assistive devices. Further, the research explores methods for using the system in aids with the brain's ability to undergo plastic changes for the recovery of function and to ensure patient's safety. Experiments in this project revealed different ways of brainwave processing and meaningful brainwave output frequencies to identify more emotions and motives of human brain like levels of concentration and drowsiness. The tests were performed on different subjects and revealed many new useful results such as suitable positions to place the electrode, variations in results when the subject gets familiar with the system. Hough transformation based eye tracking system is developed to detect iris position. Initially, it is implemented in MATLAB to detect three iris positions, left, right and center within 4-5 seconds. Later, the system is implemented on Raspberry-Pi using Open CV and Python with less than 3 seconds detection time. Finally, this research concludes that incorporating eye iris movement tracking with brainwave can be used as a novel low-cost approach. This combination allows developing a simple real time assistive device controller. This system can be used as a solution for connecting physically disabled individuals in developing countries to smart assistive devices.

Keywords: Brainwaves, Eye movements, Hough transformation, Assistive technology, Electroencephalography

Development of Specific National Energy Benchmark Model for Sri Lankan Apparel Industries

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The development of specific national energy benchmark model for apparel industries is a fundamental requirement for efficient assessment and monitoring of energy consumption of the Sri Lankan apparel sector. Thus, this model could be used as a base for the energy labelling and energy star programs, which would be implemented for the apparel sector in the near future. In the context of this study focuses on analysing the energy consumption data of significant number of reference apparel industries have been analysed in order to construct a relationship between the energy consumption and the significant factors, which would affect to the final energy consumption. The total energy consumption of the apparel sector does not only depend on its total production (output) and/or operating hours, but also several other factors such as age of the building or factory, the outside weather conditions, number of floors, occupants' behaviour, general maintenance, etc. The mostly used simple benchmarking method, which is normalized by means of the total production and/or operating hours, is not adequate in the process of effective recognition of the energy efficient apparel industries. Hence, the regression model developed with the above explanatory factors is necessary for identifying the energy performance. The final model developed with the above explanatory factors facilitates to determine whether an apparel industry uses energy more efficiently than other similar industries. And also the model could be used to encourage the poor energy performers in the apparel sector to improve their efficiency.

Keywords: Energy benchmark, Energy efficiency, Apparel industry

Pneumatic Rotary Turret Feeder

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Part orientation, sorting and feeding in highly inflammable chemical manufacturing situations can only use pneumatic powered automated systems instead of electro powered or hot steam powered automation systems, because electric charges and temperature increment can be a cause of ignition. A rotary turret feeder consists of two base mechanisms; having an oriented cylindrical bowl wall with a rotatable turret, which has specific shape cut at the edge. In the fabrication process, turret feeder was mounted within the bowl by an incline about 45 degrees from the horizontal axis. The incline of the feeder was determined, in order to increase the effect of the gravitational force on the caps. As a result of this, unstable caps re-enter to the sorting process. The torque generated by the pneumatic motor, which was mounted to the bowl with the same orientation, enables the rotary movements of the turret directly connected to the bowl. The rotary movement of the turret feeder is influenced for orienting bulk volumes of caps. The feeding turret includes specific shape carvings at its edge, which has inverse orientation geometry, needed as output orientation of the sorting item. Relevant orientation is the only stable orientation on the turret halls. Stable orientations of caps are taken out from the opening of the bowl wall by using an angular barrier. Barrier pushes the caps into the roughly finished angular surface. Due to the frictional force, pushed caps rotate into final desired orientation and slip through a guided fence as the output. As the results, low weighted side of the cap comes down as the output cap orientation and maximum feeding speed is 38 caps per minute. It can be acceptable for highly inflammable chemical manufacturing system's cap sorting situations as a safe, low cost, reliable and easily maintainable device.

Keywords: Pneumatic, Rotary oriented, Turret, Cap sorting

Raw material stored location Identification in the Garment Factory using RFID Technology

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RFID is a technology for automated identification of objects, which different applications were used successfully with two distinct advantages; uniqueness and automation such as animals in farm, containers, humans, etc. In the Apparel Industry, it is difficult to finding the raw materials rolls, which have certain meters in a large pallet. Due to that case, raw material waste is higher than consumer. This process was developed to solve such cases and reduce waste percentage and time management. This research aimed to approach with factors which resulting in efficiencies and labour savings, do away with manual case counting, Reduce negotiations with retailers over missing roll, lower overall inventory levels. As initial process, details of rolls were computerized in database by GUI interface. Entered details of raw material were automatically updated database of MySQL workbench. Tags were attached to the rolls and noted which rolls have which UID No.: Read data was displayed in LCD panel such as UID No., roll No., rolls type or yardage etc. It was given easy as solution of find roll which determined meters. Location of rolls was given by GUI interface with respect to entered details. Readers were attached in precise points to cover areas. Mapping system is useful at the inspection, because it was given what are the available rolls in its certain areas by comparison of the given data and entered data missing rolls can specify. Wired communication was used, because wireless communication is not allowed to access in intern. Angle of sense range was adjusted to 90°, because same details were given more than one RFID reader due to reason of sensing ranges are overlapping. Pallets arranging can be follow as an option of 5S and LEAN to avoiding sensing range overlapping. Inability of using long-range distance RFID readers and its suitable tags better communication was not updated details automatically.

Keywords: RFID, GUI-interface, Lean, MySQL-workbench, LCD

Eye Blink Detection by Image Processing to Prevent Vehicle Accidents

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Deaths and injuries due to road traffic accidents are extremely high in Sri Lanka. Detecting the drowsiness of the driver is one of the surest ways of measuring driver's fatigue. Driver's drowsiness is one of the major reasons which leads to these mishaps. This research describes 'Real Time Drowsiness Detection System', which could determine the level of drowsiness of the driver. This system considers both the closing of eyes and opening of the eyes. The eye blink of the driver is detected. If the driver's eye remains closed more than a certain period of time, the driver is said to be drowsy and alarm is sounded. Viola Jones Algorithm and Hough transformation algorithm are used for iris detection. Primary attention is given to faster detection and processing of data.

Keywords: Drowsiness, Hough transformation algorithm, Viola jones algorithm, Eye blink

Portable Charger Powered by Piezo-electric Crystal Vibration

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With the increment of the world population, world has faced a huge problem in terms of generating the required power necessity. Due to the rapid industrialization, the world is expecting more and more power. In present, numbers of power sources could be seen both non-renewable and renewable. However, due to increasing usage, a lot of energy resources have been exhausted and wasted. Also, there can be identified another huge problem arising when generating power that is environmental pollution. Piezo-electric material can be identified as an alternative eco-friendly method for power generation. Piezo-electric materials have the unique ability to interchange electrical and mechanical energy. Because of this property, piezo-electric plates can be used to absorb the mechanical energy and transform it into electrical energy. Usually, the ambient vibration or pressure will act as the mechanical energy source. A small amount of piezo plates is not capable of generating much energy. Therefore, methods of accumulating and storing of energy generated until sufficient power is captured were developed. The research was carried out by combining several piezo electric plates serially and parallelly with the use of rectifying filters. Small vibration motor was used as the energy source to generate vibrations. It is observed that serial combination of three plates gives sufficient voltage to charge a battery. This stored energy is intended to use. In everyday life, as it can be identified some instances, where small-scale power necessities arise. As examples mobile phone charging, lighting a table lamp, charging rechargeable batteries. As a future development, the device will be tested in real-world applications such as harness energy from human walking and vehicle vibration.

Keywords: Power, Piezo-electric plate, Vibration, Energy, Charging

Solving Poisson's equation with Dirichlet boundary condition using Henstock-Kurzweil integral

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The Poisson's equation is an elliptic type second order partial differential equation, which has several applications in theoretical physics, chemistry and engineering. There are a few approaches to solve the Poisson's equation such as the Green's function, Dirichlet's principle, layer potentials, L^2 estimates, energy methods, etc. However, in most cases it is difficult to find an analytical solution. HK-integration has more powerful results such as: convergence theorem, Fundamental theorem of calculus with full generality, integration over unbounded region, integral containing parameters, etc. It would be a good idea to find an analytical solution to Poisson's equation with Dirichlet boundary condition for general setting with more advanced integral like Henstock–Kurzweil integral (HK-integral). We use the Green's function to obtain a general representation formula for the solution of the Poisson's equation. For this, Green's function G needs to exist. Moreover, it is difficult to calculate an explicit formula for G. Thus, we need a new technique or method to evaluate. So we use HK-integration to find G and a representation formula for the solution. HK-integration is very simple to describe as the Riemann integral, which possesses all the advantages of the Lebesgue integral and even more. Moreover, any Riemann or Lebesgue integrable function is HK-integrable. Therefore, the set of all HK-integrable functions is larger than those of the set of other integrals. So, using HK-integral, one can find an analytical solution to the Poisson's equation with Dirichlet boundary condition, where the case Riemann or Lebesgue integration does not work.

Keywords: Poisson's equation, Dirichlet boundary condition, Henstock-Kurzweil integral
Green's function

Study the Effect of Far Infrared-Withering on Black Tea Manufacturing

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Withering is the foundation step of black tea manufacturing which directly influences the quality and the cup characteristics of the made tea. This stage consumes 49% of the total electricity required for the production process and use of dendro thermal power releases CO₂ to the environment causing environmental pollution. Far infrared (FIR) withering may be a good alternative to overcome these problems. Therefore, this study was conducted to identify the essentials for developing a withering trough using Far-infrared as the heating source for black tea production and to analyze its performances. Plucked tea leaves with an initial moisture content of 43±1% were withered using Far-infrared panels, by changing the treatment combination of Far-infrared power (650, 1300 and 1950 W), exposure times (4 hr, 4.15 hr and 4.30 hr) and the leaf weight (400 kg, 425 kg and 450 kg). Temperature and the relative humidity of plenum chamber and withered leaves were measured using DHT11 sensors to maintain the conditions uniformly throughout the study. The samples were dried and *Theaflavins (TF)* *Thearubigins (TR)* ratio was measured and organoleptic parameters such as aroma, flavor and colour were tested. It was found that there is a significant interaction effect of Far-infrared power, exposure time and leaf weight on “*Theaflavins/Thearubigins*” ratio and organoleptic properties ($p<0.05$). The optimum combination of Far-infrared power, exposure time and leaf weight were 1950 W, 4.30 hours and 400 kg, respectively based on “*Theaflavin/Thearubigins*”(1:10), high score for *organoleptic* properties and low energy consumption. Therefore, it can be concluded that FIR withering has high potential in black tea manufacturing. Further studies are needed to improve the precision of the prototype to develop it as an industrial level withering trough.

Keywords: Black tea manufacturing, Far- infrared withering, Sensory evaluation, Theaflavins, Thearubigins

Automatic Sun Tracking Solar Panel

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People are considering to use alternative energy sources due to impending scarcity of nonrenewable resources. From all other resources available, solar energy is the most abundant and it is relatively easy to convert to electric energy. Using solar panels to convert solar energy to electricity is very popular, nevertheless fixed solar panels cannot generate optimum energy due to the east-to-west transition of the sun. To maximize energy, the solar panel must be perpendicular to the sun's rays. If it deviates from this optimum angle, the energy generation efficiency from the panel decreases. The active tracker relies on the detection circuit to detect the light intensity and align the panel as the sun using a motor. This project was designed and implemented for a polar single axis solar panel tracker. It has a fixed vertical axis and an adjustable horizontal motor control axis. The tracker actively tracks the sun and changes its position to maximize energy output. This system solves the problem by arranging solar panels to track the sun. This tracking movement is accomplished by using a servomotor on the solar panel so that the panel always keeps its face perpendicular to the sun to generate maximum energy. This is accomplished by using a programmed Arduino board according to the light sensor (LDR) signal, the servo motor sends a signal to rotate the attached panel as needed. Subsequent, the interface with the sensor, the control of the motor, and the power supply function are performed by the energy generated from the solar panel. This is a far more cost effective solution than purchasing additional solar panels when dealing with large panel arrays. This project develops an automatic tracking system which will keep the solar panels aligned with the sun in order to maximize efficiency, which is capable of enhancing production of power by 20-30%. It has been estimated that the use of a tracking system, over a fixed system, can increase the power by 30-60%.

Keywords: Arduino, Solar Energy, Servo motor, LDR

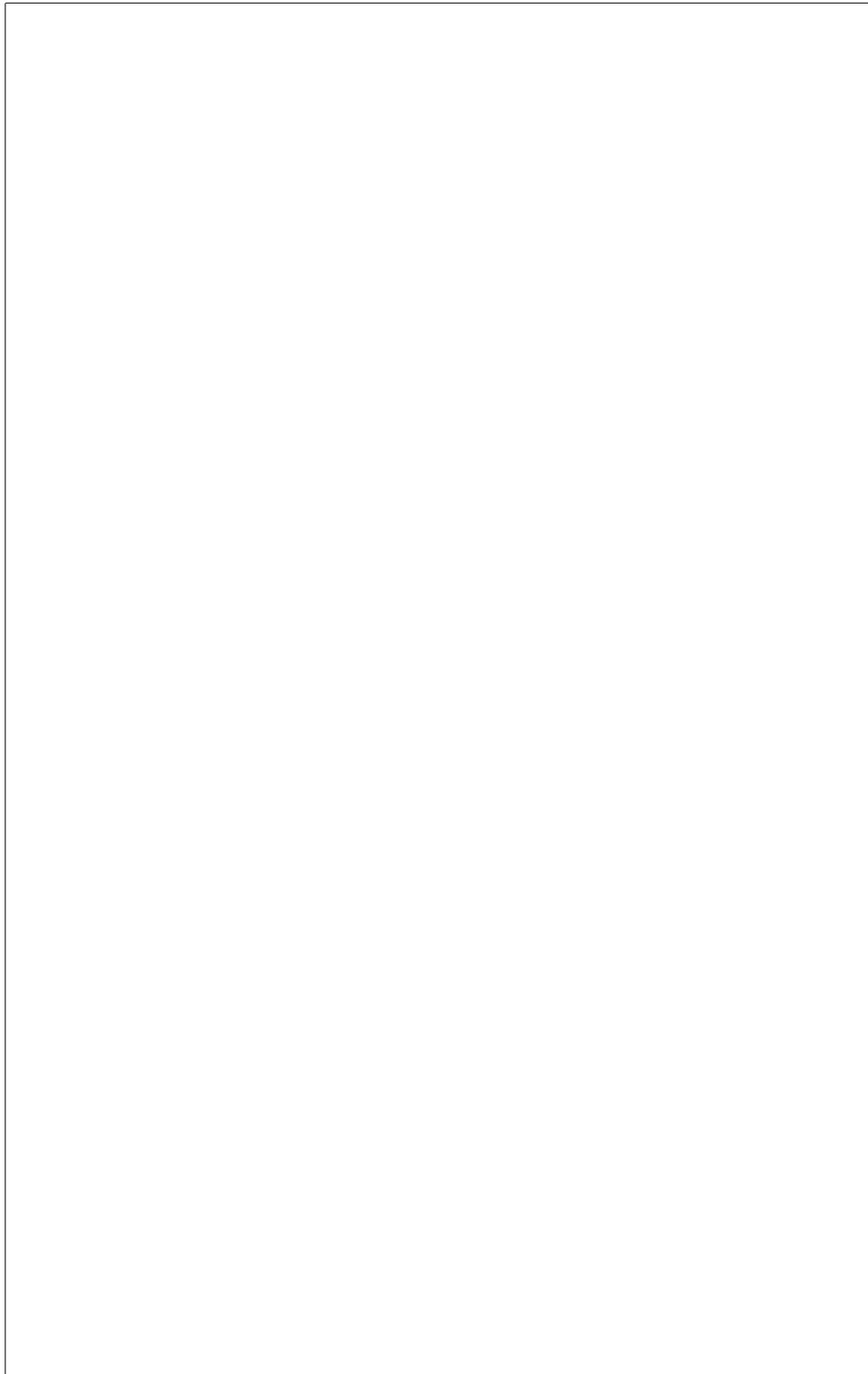
An Automated Reconfigurable Supporting Structure for Aeronautical Applications

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Reconfigurable tooling/supporting structures are needed for aircraft manufacturers and Maintenance Repair and Overhaul (MRO) facilities to increase their production rates to meet the growing demand and to switch rapidly and effectively between operations within optimal aircraft variant-mixes while minimizing resource wastage. Dedicated tooling is expensive, difficult to use with different aircraft sizes, require long manufacturing lead time and setup time, skilled workforce and occupy floor space during use. Overcoming these drawbacks, reconfigurable supporting structure should be reusable so that it enhances the operational flexibility, ensures rapid response to production/maintenances-schedule changes and reduces development costs and setup time. Furthermore, having lesser footprint is a value adding attribute for the structure. In this research, a reconfigurable supporting structure is developed for MRO operations. A platform mounted on a scissor, with sections of platforms which extend further provide safe and easy access to the aircraft. It has the flexibility to cater different applications in aircraft manufacturing, assembly and MRO facilities. The whole support structure can provide autonomous/semi-autonomous mobility by being mounted on an automated guide vehicle (AGV). Proposed design can cater to multiple airframe sizes by being able to easily modify height and orientation providing increased reconfigurability. Furthermore, increasing the number of modules in operation ensures the flexibility for different applications ranging from inspection, installation/removal of equipment etc. depending on the type of maintenance.

Keywords: Aeronautical, Aircraft maintenance, Automated support structures, Modular, Reconfigurable



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