

**Sustainable Competitive Advantage Through
Innovative Research Ideologies**

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*Sustainable Competitive Advantage through Innovative
Research Ideologies*



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Section A
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Abstract

Coconut palm is one of the major plantation crops in tropical areas throughout the world. The global annual production of coconut is around fifty-two billion nuts. Sri Lanka is ranked as the fourth, in terms of the contribution to the world coconut production and land extend under coconut. The most popular Sri Lankan coconut exports to the global market are desiccated coconut, virgin coconut oil and coconut water. In the Sri Lankan context, coconut is one of the major plantation crops and it covers around 410,000 ha. Coconut grows in different types of soils with diverse moisture and nutrient regions in different agro-ecological zones. The annual national production of coconut is between 2500-3000 million nuts mainly depending on the climate condition. Among these productions, 70% is being consumed domestically, and the rest is used to produce coconut-based products such as coconut oil, copra, coconut milk powder, etc. The coconut sector accounts for approximately 12% of all agricultural produce in Sri Lanka. The main coconut growing districts in Sri Lanka are Kurunagala, Puttalam, Gampaha, Hambanthota and Rathnapura. Among these districts, Kurunagala, Puttalam and Gampaha are known as the coconut triangle in Sri Lanka. Coconut yield depends on climatic and weather variables such as rainfall and, temperature and relative humidity. Many studies have confirmed that the optimum weather conditions for the growth of coconut include a well-distributed annual rainfall of about 1500 mm, a mean air temperature of 27 °C and relative humidity of about 80%-90%. This study was carried out to investigate the trends in Meteorological Drought incidence over selected coconut plantations located in the Gampaha District, Sri Lanka. In this study, 14 coconut estates were considered and GPS coordinates were taken by visiting those estates. Rainfall data were obtained for the study period from the Department of Meteorology in Sri Lanka and predicted to the coconut estate

locations by using the kriging technique. This was done by using QGIS software. Standardized Precipitation Index (SPI) was used to evaluate the drought incidence at both the short term (3 and 6 months) and the long term (12 months) time scale. In order to calculate the SPI index, for each time scale, the variability of precipitation totals was normalized and fitted into a gamma distribution. Analysis was done in different time sequences, and time duration from October to September was used as the hydrological year (SPI_{12}), and October to March and April to September were used as a 6-month time scale (SPI_6) as these periods are the cropping seasons of Maha and Yala, respectively, in Sri Lanka. October to December, January to March, April to June, and July to September were used as the 3-month time scale (SPI_3).

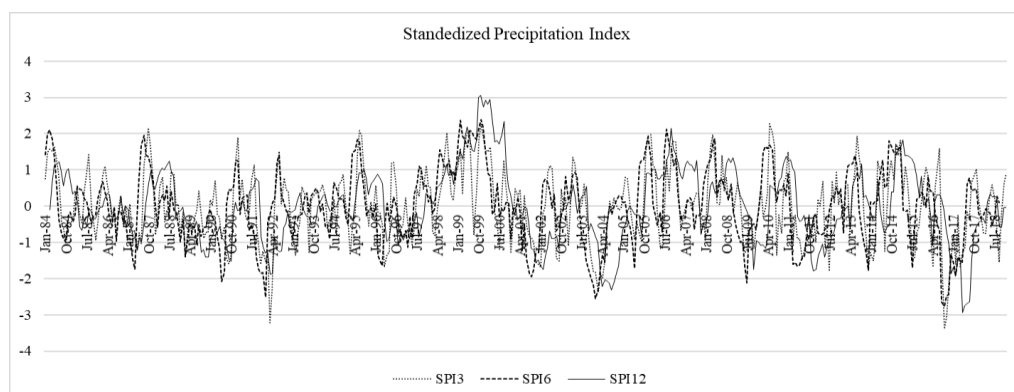


Figure 1: Temporal variation of the Standardized Precipitation Index

Calculated SPI values were compared with the SPI classification values for the dryness/wetness category to recognize the status of the drought. SPI was calculated at different time scales, but the analysis showed that more drought events had occurred at the short term time scale. According to the SPI_3 and SPI_6 values, there were moderate drought events that occurred in 1997, 2011/2012, 2015 and severe drought events had occurred in 1990, 1996, 2001/2002, 2009, 2011/2014. When considering the long term time scale (SPI_{12}), moderate drought events can be observed in 1989/1990, 2009 and severe drought events can be observed in 2011/2012, 2012. Extreme drought events had occurred in 1992, 2004 and 2017. Therefore, after these years coconut production should have to be reduced because of water stress.

Keywords: Climate change; Coconut; Drought analysis; Rainfall; SPI

Acknowledgement: This work was supported by the National Science Foundation of Sri Lanka [grant number: NTRP/2017/CC&ND/TA-02/P-02/01].

An Assessment of the Total Factor Productivity Growth in the Corporate Tea Sector: A Stochastic Frontier Approach

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Abstract

Sri Lanka's tea industry is increasingly under threat on many fronts. Among them, productivity decline is one of the key issues confronting the tea industry. Therefore, assessing the productivity of the corporate tea sector is of paramount importance since poor performance of the corporate sector aggravates the low productivity level in the Sri Lankan tea industry. Due to the limitations in the partial factor productivity measures which have been the workhorse in productivity studies, especially in the plantation sector, we used Total Factor Productivity (TFP) as a more accurate and comprehensive measurement in this study. Studies based on assessing the productivity changes in the tea sector are scarce in the literature. Therefore, this study addresses this gap by estimating the rate of growth in TFP, decomposing the TFP growth into efficiency change and technical change using a carefully collected panel data set.

This paper applied a stochastic frontier model using data from 35 tea estates relating to the period 2005 to 2019 which amounted to 4842 valid data points. A Translog Production Frontier was estimated since it was the best fit for the data. Labour (3.006) and extent (1.844) have the largest output elasticity and therefore, they can be regarded as the most important factors for tea production. However, fertilizer (0.032) and chemical (0.018) elasticities showed a value less than one, indicating an inelasticity. These low partial elasticities show that the use of these inputs has not been able to increase production at greater levels. Further, results revealed that the tea estate sector is 51.7% technically efficient which means that on average a typical tea estate had operated 48.3% below the potential output, indicating possibilities of increasing performance without any significant changes in inputs.

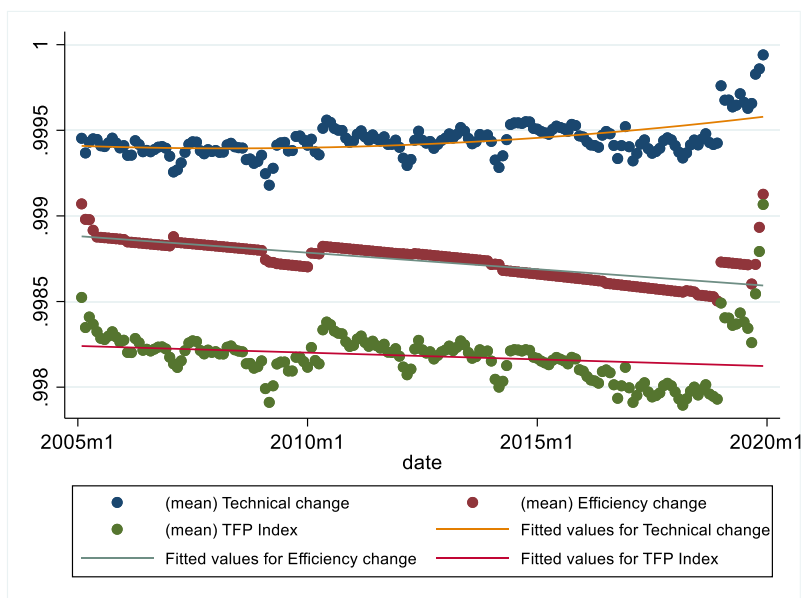


Figure 1: Technical Change, Efficiency Change, and Total Factor Productivity Change in the Tea Estates from 2005 to 2019

Further, the results revealed slight technical progress during the study period and the overall rate of technical progress was estimated at 2.00×10^{-5} percent per year. The overall rate of technical efficiency change declined, estimated at 1.19×10^{-5} percent per year. The combined effect of slow technical progress, dominated by the fall in technical efficiency resulted in the decline in the TFP at a rate of 9.18×10^{-7} percent per year (Figure 1). This net effect of declining TFP further raises serious concerns regarding the sustainability of the tea sector in Sri Lanka in the long run. The study will enable individual estates to shape their current strategies in order to succeed in the production process and also enable policy makers to identify the areas where the government should intervene and allocate resources with the intention of improving the productivity of the tea industry by utilizing the existing resources maximum. Policies to shift up the production frontier and improvements in managerial practices to combat declining efficiency levels are recommended.

Keywords: Corporate tea sector; Stochastic frontier approach; Technical change; Technical efficiency; Total factor productivity change

Application of Next Generation Sequencing to Reveal Salinity Stress Related Candidate Genes in Two Sri Lankan Rice Varieties

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Abstract

In the present world, Next Generation Sequencing (NGS) has enabled easy identification and mapping of genetic variations in whole genomes within a short period and at a relatively low cost. The rice genome has been widely used as a basis for understanding a wide range of diversity among rice varieties. Soil salinization is considered as one of the widespread problems faced by rice. Thus, NGS based molecular techniques are widely used to characterize and isolate candidate genes associated with agriculturally important traits such as salinity tolerance. So far little of the tremendous knowledge on the genetic basis of salt tolerance has been utilized for breeding purposes. Also, in Sri Lanka molecular breeding is still developing in a legging phase. Therefore, present study was planned to identify the candidate genes for salinity stress tolerance in rice, realizing the necessity of employing advanced molecular breeding techniques in Sri Lanka.

The whole genomes of At 354 (salt tolerant) and Bg 352 (susceptible) were re-sequenced using Illumina 2500 platform and mapped to two reference genomes, *Oryza sativa japonica* cultivar Nipponbare IRGSP-1.0 GenBank Accession GCA_001433935.1 and *Oryza sativa indica* cultivar Shuhui498 (R498) GenBank Accession GCA_002151415.1. Then using the gene sequences from whole genomes, the salinity related candidate genes within the salinity related Quantitative Trait Loci (QTLs - previously derived by At 354 x Bg 352 cross) were discovered based on the polymorphic genetic variations; SNPs or InDels alternatively present either in At 354 or Bg 352, using the Unipro Ugene Software version 1.29.0. To confirm the *in-silico* detected genetic variations, an

InDel marker was designed with the longest InDel present in one of the genes. Finally, the most prominent candidate genes with InDel mutations were selected and their differential expression under different ranges of salinity stress in At 354 and Bg 352 was studied. The gene expression in the seedlings grown in a hydroponics system with 12 dSm⁻¹ salinity, were assessed before salinization, 24 hours after increasing the salinity up to 6 dSm⁻¹, and then 24 hours, 48 hours, 72 hours and 5 days after increasing the salinity up to 12 dSm⁻¹.

The NGS results revealed approximately 2.4 million SNPs and 0.2 million InDels with reference to Nipponbare while 1.3 million SNPs and 0.07 million InDels with reference to R498 genome. Altogether, 1385 genes were detected within the QTL hotspots. Screening of genetic variations of these genes revealed 36 potential salinity related candidate genes containing polymorphic SNPs or InDels in the exon region between two parents. Each of these genes had either one missense or frameshift or loss of stop codon or early gain of start codon. These 36 genes contained 10 genes with polymorphic InDels and 26 genes with polymorphic SNPs between At 354 and Bg 352. The gene *Os01g0581400* associated with protein kinase activity had a long InDel with a 12bp fragment length and it was developed as an InDel marker named PKW. Out of the 36 candidate genes, five genes, *Os03g0839200*, *Os04g0117600*, *Os07g0181000*, *Os11g0655900* and *Os12g0624200* were identified as most prominent candidate genes based on their sequence alignment and gene function information. These five genes displayed differential expression either by upregulation or downregulation under different salinity stress ranges showing their involvement in response to salinity.

Keywords: Rice; Salinity; QTLs; Whole genome re-sequencing

Acknowledgement: Authors thank National Research Council for providing financial support under the research grant (NRC 16-016) and National Science Foundation for providing a postgraduate scholarship (NSF/SCH/2019/01).

Biofilm Biofertilizer Increases Soil Carbon Sequestration in Tea and Paddy Cultivations

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Abstract

Several recommended practices are currently being applied for soil carbon sequestration (SCS) and conservation *viz.* adding crop residues, planting cover crops, and growing cereals, legumes and other crops. However, increasing carbon (C) without manipulating microbes in Nitrogen (N) rich soils may naturally boost soil microbes that consume N and emit the more potent greenhouse gas nitrous oxide, potentially offsetting SCS's climate benefits. Moreover, simply adding C sources to the soil does not necessarily mean that the C is going to retain in the soil, because C deposited in the soil release back to the atmosphere by the priming effect. Therefore, microbial interventions may be required in order to stabilize sequestered C in agricultural soils. In the present study, the effect of Biofilm biofertilizers (BFBFs) on SCS was investigated in lowland paddy as well as upland tea cultivations. Two systematic extensive field experiments were carried out in 17 locations in total; Ampara (n = 3), Kurunegala (n = 3), Kegalle (n = 3) and Polonnaruwa (n = 5) for rice, and Nuwara Eliya (n = 1) and Badulla (n = 2) for tea. The BFBF practice of 50% of chemical fertilizer (CF, for rice, 225 kg CF ha⁻¹; for tea, 188 kg CF ha⁻¹) with 2.5 L ha⁻¹ BFBF was compared with 100% CF (for rice, 425 kg CF ha⁻¹; for tea, 375 kg CF ha⁻¹) practice. Three random soil samples were collected from 0 - 25 cm depth in each experimental field, and the experimental locations acted as replicates for each practice. The samples were analyzed for soil moisture, total N, total C, labile C, and stable C (difference between total and labile C). In addition, crop yield, rooting depth, tea leaf total polyphenols, and endophytic diazotrophs were also measured as plant and microbial parameters. The results showed that in addition to crop yield benefits (i.e. ca. 25% yield increases in

rice) the BFBF practice sequestered 15 t stable C ha⁻¹ season⁻¹ over the 100% CF practice in paddy cultivation (p<0.05). This was due to increased rooting depth (11.2 cm and 7.8 cm in BFBF and 100% CF practices, respectively) and C assimilation in the root-zone soil. Also in tea cultivation, SCS was higher significantly by *ca.* 100% (0.3 t stable C ha⁻¹ season⁻¹) with the application of BFBF (p<0.05). The increased SCS with BFBF application in paddy and tea cultivations was generally associated with increasing trends of endophytic diazotrophs, soil moisture and total N, and tea leaf total polyphenols. In conclusion, the BFBF practice can increase SCS while replacing bulky quantities of organic matter inputs in paddy and tea cultivations. As such, the BFBF practice would lead to economic benefits through C trading, also contributing to the "4 per 1000" initiative to increase soil C stocks by 0.4% per year. Therefore, this enormous potential of BFBF practice in SCS particularly in rice cultivation should be extended globally.

Keywords: Biofilm biofertilizer; Paddy rice; Soil carbon sequestration; Tea

Coconut Growers' Knowledge and Perceptions on Climate Change and Adaptation Strategies: Evidence from Coconut Growers in Coconut Triangle of Sri Lanka

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Abstract

Coconut (*Cocos nucifera* L.) is one of the most widely grown perennial plantation crops in Sri Lanka. Being a tropical country, impacts of climate change and extreme weather events are significantly affecting the productivity of coconut in the major coconut growing areas. This will ultimately threaten the livelihoods of coconut growing community. Thus, this study attempted to investigate the knowledge and perceptions of coconut growers in three major coconut growing districts (coconut triangle *viz.* Kurunegala, Puttalam and Gampaha) on climate change and adaptation strategies and examine the potential relationships between their knowledge, perceptions and adaptation measures.

Data were collected using a sample comprised of 400 coconut growers (Kurunegala, n=160, Gampaha, n=100 and Puttalam, n=140). Stratified random sampling method was used to determine the sample size. The heads of the selected households or their spouses were interviewed using a questionnaire with 10-point Likert scale to evaluate coconut growers' knowledge, perception and adoption on impacts of climate change and semi-structured questions were used to elicit information on coconut growers' socio demographic factors. Coconut growers' knowledge was quantified using 16 statements in Likert scale and each climate change dimension was measured independently, and an overall knowledge was calculated through the knowledge index. Perception level and adoption level also quantified using 31 statements and 14 statements respectively. Then perception index and adoption index were calculated. A binary correlation analysis was performed to find out the relationships in coconut growers' knowledge, perceptions and adaptation levels on climate change and correlation coefficient was calculated to determine the association between independent variables (age,

landholding size, education, farming experience, land ownership) with dependent variables (coconut growers' overall knowledge and perceptions in each district).

Results and Discussion: Study revealed that the socio-demographic profile of the growers have differential impacts on growers' perceptions about climate change and their ability to adapt to them. The knowledge level of the growers on climate change and adaptation which quantified using the coconut growers' knowledge index and the computed knowledge index values obtained for Kurunegala, Gampaha and Puttalam districts were 75.8%, 82.7% and 73.4% respectively. Further, the computed perception indices of growers in above districts were 67.8%, 74.4% and 62.1% respectively. Similarly, the level of adoption was quantified using the adoption index, and the computed index values for the same districts were 47.8%, 49.5% and 46.7% respectively.

Table 01: Relationship between Socio-demographic Characteristics and their Knowledge and Perceptions about Climate Change in three major coconut growing districts

Independent Variable	Knowledge "Spearman's rho" value for each district			Perceptions "Spearman's rho" value for each district		
	Kurunegala	Gampaha	Puttalam	Kurunegala	Gampaha	Puttalam
Age	-0.129	-0.016	0.167*	-0.007	0.002	0.001
Land Holding	0.123	0.053	-0.045	0.215**	0.092	-0.064
Education	0.590**	0.064	0.671**	0.378**	-0.086	0.379**
Farming Experience	-0.055	0.158	0.094	0.187*	0.242*	0.157
Land Ownership	-0.063	0.007	-0.007	0.055	0.084	-0.023

**Correlation is significant at 0.01 level (2-tailed), * Correlation is significant at 0.05 level (2-tailed)

Results revealed that the education level was significantly associated with both knowledge and perceptions of coconut growers on climate change in Kurunegala and Puttalam districts, however not in growers from Gampaha district. According to the results, coconut growers' overall knowledge was positively and significantly related with their perceptions in all three districts at 0.01 level (2-tailed) (0.679** in Kurunegala, 0.554** in Gampaha, 0.743** in Puttalam). Further, their knowledge was positively and significantly related with their adaptation measures (0.356** in Kurunegala, 0.303** in Puttalam), except in Gampaha (0.189). In addition, their perceptions also positively and significantly related with adaptation measures (0.504** in Kurunegala, 0.279** in Puttalam) except Gampaha (0.141).

Conclusion: The study concludes the implementation of adaptation strategies by coconut growers were less than 50% in all three districts, even though their knowledge and perceptions levels were more than 60%.

Keywords: Adoption; Climate change; Coconut growers; Knowledge; Perception

Design, Development, and Performance Evaluation of a Camera Integrated Height-Adjustable Device for Harvesting Black Pepper (*Piper nigrum* L.)

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Abstract

Black pepper (*Piper nigrum* L.) is considered as the “King of Spices”, and it is extensively used in main cuisines all over the world because of its unique fragrance. Meanwhile, Sri Lanka ranks 7th place with a share of 5.7% of the global pepper production. Consequently, about 17% share of the total export earnings from spices was contributed by pepper for the Sri Lankan economy in 2019. Therefore, black pepper is locally deemed as the second most important commodity among spices. However, peppercorn harvesting is the most labour-intensive activity in Sri Lanka, it is the costliest activity in black pepper production due to labour scarcity and uprising prices of wages. Even though several mechanical harvesters have been introduced, which are not much popular among the local farmers, due to low farmers’ satisfaction. Therefore, the objective of the present study was to develop a state-of-art pepper harvesting device to provide cost effective as well as efficient harvesting solutions for local Micro Small and Medium-scale (MSMEs) pepper farmers. The device is comprised of four main units, which are capable in integrating each other. The components are lap supported pole holder, camera integrated height adjustable pole, plucking unit with the harvesting blade, and control unit with a display. During operation, the device hangs out around the hip area of the operator with the support of belts across the shoulders of the operator. At a vertical operational height of 6 m, total weight of the harvesting device is 3.45 kg. The vertical height of the pole can be finely adjusted using the control unit via a screwdriver mechanism. The control unit also manipulates the blade of the plucking unit. With the support of additional extensions, the pole length can be further

extended as needed. The picking unit consists of a motor-operated blade to detach the peppercorn from its vine. The camera wirelessly sends video signals to the display at the controlling unit, which improves the visibility of the operator to harvest correctly matured pepper cones at unreachable heights. Just after the fabrication, the mechanical performance of the newly developed device (T1) on harvesting pepper was compared with manual harvesting by hand picking (T2) using a ladder. The data were analysed using a t-test at the significance level of 5%. According to the results, T1 (6.2 kg h^{-1}) recorded significantly higher harvesting capacity over that of the T2 (5.3 kg h^{-1}). Similarly, mechanical efficiency of T1 (77%) was also significantly higher than that of the T2 (61%). Further, both harvesting methods have caused very negligible damages to the plants and the harvests. Finally, the results clearly revealed that the newly developed harvesting device is capable in efficient operation by having 1.18-fold increase in harvesting capacity over the manual hand picking of pepper. However, before the final recommendations the study must be further extended with some more socio-economic parameters to firmly confirm whether or not the newly developed harvester could be an ideal solution for the local MSMEs pepper farmers to overcome the issues associated in manual harvesting of black pepper.

Keywords: Black pepper; Capacity; Efficiency; Harvesting device; Height adjustable pole

Development and Testing of an IoT Assisted Volumetric Soil Moisture Sensor Network as a Solution to Groundwater Depletion and Pollution Issues in Kalpitiya, Sri Lanka

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Abstract

Groundwater depletion and pollution have been identified as critical issues threatening the sustainable lifestyle for people in the Kalpitiya peninsula where groundwater is used as the main water source. Excessive groundwater extraction and excess nitrate leaching are the root causes of the highlighted issues. An irrigation system designed following the principles of irrigation scheduling reflecting an effective water application efficiency is a timely need to address the above issue. The objective of the study was to develop internet-connected state-of-art volumetric soil moisture sensing unit compatible with a cloud-based data analysis and decision-making system. The secondary objective was to do irrigation scheduling based on the real-time soil moisture value which will lead to achieving higher irrigation efficiency with low deep percolation.

In the initial phase of the study, a data logger based on Arduino MKR1310 was developed and tested under controlled field conditions. The new device was powered using a rechargeable Lithium Polymer battery and consisted of the LoRa transmitter which was capable of transmitting data to the Thingspeak Cloud Data platform through the LoRa gateway, where the start and off control signals of irrigation system were determined based on predetermined parameters relevant to soil moisture status of the experimental site. The sensing unit had three Time Domain Reflectometry (TDR) soil moisture sensors, buried at 15, 45, and 75 cm depths to find soil volumetric water content (VWC) noted as θ_v (Figure 1). The total available water (TAW) of the soil was determined using available water contents (AWC) of the 'n' number of soil layers each having thickness of 't' (Equation 1). The soil AWC was determined by taking the difference of field capacity (θ_{fc}) and wilting point (θ_{wp}) which had been determined in the

experimental site before the study (Equation 2). The effective root depth (R_d) was determined considering the peak water consumption (ET_0) of the crop at the stage with the highest leaf area index. Further, the crop-specific allowable depletion (AD) was determined by taking TAW as a portion of the maximum allowable depletion (f_{dc}). The sprinkler irrigation system could be activated when the AD equals θ_v , until the soil VWC reached up to the difference between θ_{fc} and the forecasted rainfall allowance given as r_a (Equation 3).

$$TAW = (AWC1)(t1) + (AWC2)(t2) + \dots + (AWCn) [R_d - (t1 + t2 + \dots + tn-1)] \text{ ---- Equation 1}$$

$$AWC = \theta_{fc} - \theta_{wp} \text{ ---- Equation 2, } AD = f_{dc} (TAW) = \theta_{fc} - r_a \text{ ---- Equation 3}$$

During the study, VWC (θ_v) values of the experimental site obtained from the newly developed system were compared with those of the values taken from a standard data logger (ZL6-Meter Group). A two-sample T-test was done using MS Excel to check was there any deviations found with the newly developed unit in performance over that of the standard technology used to measure soil VMC.

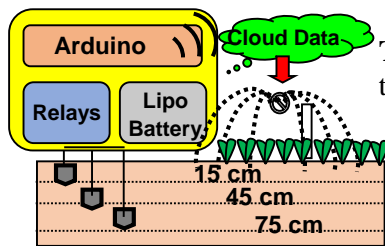


Figure 1: Design layout

Table 1: Mean VWC (θ_v) values were obtained from two different sensing devices at three different depths.

Sensing Device	Depth (cm)		
	15	45	75
ZL6 Data Logger	0.247	0.304	0.323
Arduino A2D	0.262	0.312	0.323
P Value	0.072	0.25	0.91

According to the results, the mean VMC values of the standard device (ZL6) at 15, 45, and 75 cm were 0.247, 0.303, and 0.322 respectively, while those of the newly developed sensor unit at the same depths were 0.262, 0.312, and 0.323 respectively. However, there were no significant differences among the two sensing technologies at any studied level of depth. TEROS10 VWC sensor which has been used in the study is considered a very advanced, robust, and reliable soil water sensor. Since the LoRa is used as the IoT (Internet of Things) connecting technology, farmers do not have to pay for communication subscriptions. Further, the total manufacturing cost of the newly developed sensor devices is significantly far below that of the commercially available data loggers. However, before the final recommendations, the newly developed low-cost volumetric moisture sensing unit must be checked for its reliability in data generation and resistance against corrosion. This is going to be a prioritized area in the next half of this study under the field conditions in the Kalpitiya region of Sri Lanka.

Keywords: Ground water depletion; Internet of things; Irrigation system management; Volumetric water content

Downward Movement of Nitrogen and Potential Contamination of Shallow Groundwater under Sandy Regosols in Kalpitiya: A Case Study on Red Onion Cultivation

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Abstract

Nitrogen is the most dynamic nutrient which lead to a rapid downward movement in soil. Both nitrate (NO_3^-) and ammonium (NH_4^+) forms are highly soluble and move with soil water flow. In intensively cultivated areas with frequent N application, NO_3^- -N, is leached to shallow groundwater and consequently contaminates the waterbody. Sandy Regosol (WRB, FAO legend: Haplic Arenosols) is the dominant soil type in Kalpitiya, where vegetable cultivation is intensively practiced. Leafy red onion is a popular short-term crop widely cultivated in Kalpitiya with excessive use of fertilizer. Loss of nitrogen due to leaching has become not only a critical problem in agriculture, but also a major environmental and health problem. Therefore, objective of this study was to quantify downward movement of nitrogen from leafy red onion under grower managed fertilizer practice compared to Department of Agriculture (DOA) recommendation. The study was carried out in Kandakuliya in Kalpitiya. Lysimeters with a 0.28 m^2 surface area was installed 90 cm below the soil surface prior to cultivation and allowed to settle the profile. Before planting (Variety-Jaffna local), compost (10 t/ha) was applied for both treatments. Nitrogenous fertilizer application method practice by the farmers (i.e. Four split applications of urea at 100 kg/ha, onion fertilizer (12:9:9) at 125kg/ha, blue granules (12:12:17) at 62 kg/ha and calcium nitrate at 62 kg/ha at 10 days intervals) was selected as treatment 1 (T1). DOA recommendation i.e. urea dosage (Basal dressing:68.5 kg/ha, Top dressing 1:65 kg/ha at 3 weeks after planting, Top dressing 2:65 kg/ha at 6 weeks after planting) was applied with Biochar(10 t/ha) for treatment 2 (T2). Irrigation was done twice a day and leachate samples of each replicate were collected, and leached volume was

measured at weekly intervals. NO_3^- and NH_4^+ concentrations of collected leachate were analyzed using ion selective electrodes (CPI505). Volume of the irrigation water applied and its NO_3^- and NH_4^+ concentrations were also measured. Input-N for both treatments were calculated. The crop was harvested 48 days after planting and weight was recorded. Analysis of variance followed by Tukey's test ($p < 0.05$) was used to analyze the data using R statistical software. Both fertilizer and irrigated water were considered as input source of nitrogen. The concentration of NO_3^- and NH_4^+ in irrigated water was 6.88ppm and 1.80ppm respectively. The concentration of NO_3^- in leachate were ranged from 35.1 mg/L - 160 mg/L in T1 and 37.4 mg/L – 131 mg/L in T2 which were high than the WHO permissible level of NO_3^- (50mg/L) for drinking water. There was a significant difference ($p < 0.05$) in mean cumulative leached NO_3^- between T1 and T2. The leached NO_3^- throughout the season from T1 and T2 were 33.46 g/m² and 24.14 g/m² respectively whereas leached NH_4^+ throughout the season from T1 and T2 were 0.46 g/m² and 0.61 g/m² respectively. There was no significant difference in cumulative leached NH_4^+ between T1 and T2. Total input nitrogen amount for T1 and T2 were 63.03 g and 73.03 g respectively. Even though there was no significant difference in total leached nitrogen, there was a significant difference ($p < 0.05$) in nitrogen leaching percentage. 90.4% of input nitrogen was lost from T1 while 58.5% of input nitrogen was lost from T2 throughout the season. The harvested crop yield from T1 and T2 were 18,727 kg/ha and 15,581 kg/ha respectively. This study revealed that NO_3^- load in leachate is significantly higher in T1. This may be due to the intermittent application of fertilizers during the season. Although the total input nitrogen amount was higher in DOA recommendation, the NO_3^- leaching recorded for T2 was less than T1. Application of Biochar with DOA recommendation may have caused a slow releasing effect of urea which increases the nitrogen use efficiency while reducing the groundwater contamination with NO_3^- . Even though there was no significant yield difference reported between treatments, it was evident that the DOA recommendation with Biochar has been able to reduce nitrogen leaching losses. However, both treatments showed higher concentration of nitrate levels in leachate indicating the high risk of groundwater contamination in this cultivation system.

Keywords: Groundwater contamination; Nitrate leaching; Nitrogenous fertilizer; Sandy regosols

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Enhancement of Soil Chemical Properties and Crop Performance by N-enriched Co-compost Pellets in Maize (*Zea mays* L.) Cultivation

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Abstract

Co-composting of organic municipal solid waste (MSW) and dewatered fecal sludge (DFS) is supposed to be an appropriate approach to ensure nutrient and organic matter recovery. This study was conducted with the objective of enhancing the nutrient composition of compost by producing co-compost pellets (CCP) and studying the impact on plant growth and yield when co-compost is added as a 100% organic and combinations with mineral fertilizer. For co-compost production, initial mixing ratio of feedstock was 70% MSW and 30% DFS. Chemical properties {N, P, K, Ca, Mg, organic carbon (OC) content, heavy metal content, pH and Electrical Conductivity (EC)}, and biological properties (faecal coliform and salmonella) were tested during the co-composting process (SLS 1246:2003). Sieved co-compost powder was used to produce CCP. Biochar derived from oil palm (*Elaeis guineensis*) empty fruit bunches and mineral fertilizer were used as additives during pelletizing. Resulted CCP were tested with maize (*Zea mays* L.) variety MI Hybrid Maize 02 using five treatments (T1- Mineral fertilizer recommended by the Department of Agriculture Sri Lanka (control), T2- CCP, T3- Biochar+ CCP, T4- Urea+ CCP, T5- Biochar+ urea+ CCP) in a Randomized Complete Block Design with four replicates at the Center of Excellence for Organic Agriculture (IL1a), Makandura, Gonawila (NWP) from May to September 2018. Plant vegetative and reproductive data were collected. Soil samples were collected at

monthly intervals and tested for total Nitrogen (%), available Phosphorus, available Potassium, OCC, pH, EC.

Results revealed that, during composting process composition of Nitrogen, Phosphorus, and Potassium were changed with time. Initial Nitrogen value was 1.04% by mass and finally it was recorded as 1.27% by mass. Phosphorus changed from 0.65 to 0.86% by mass. Potassium value was increased from 0.56 to 0.65% by mass. Organic carbon and Organic matter content were increased from 6.24% and 12.29% to 7.90% to 15.80% respectively by mass with the increase in compost age. According to the results, produced co-compost was free from heavy metals, fecal coliform and *Salmonella*. Soil chemical properties during the tested period under maize cultivation showed a significant difference among the control and co-compost pellets treatments. T3 recorded the highest pH value (5.69) and OC (1.32%) while control treatment showed the lowest pH (5.23%) and OC (1.01%) when compared to the other treatments. Significantly ($p < 0.0001$) highest plant height and yield were recorded in T2 compared to the control (Table 01). These results conclude that biochar+co-compost pellets help to improve soil chemical properties compared to the mineral fertilizer application and act as a soil amendment. Co-compost pellets produced from MSW and DFS can potentially be used in better crop growth and yield enhancement.

Table 01: Mean values of vegetative and reproductive parameters

	Plant height (cm)	Chlorophyll content (SPAD)	Leaf area (cm²)	Root fresh Mass (g)	Yield (g m⁻²)	Pod diameter (cm)
T ₁	98.59 ^d	51.68 ^{ab}	136.5 ^a	131.75 ^b	443.94 ^b	4.18 ^{ab}
T ₂	136.50 ^a	43.36 ^c	130.7 ^a	137.25 ^b	501.97 ^a	4.25 ^{ab}
T ₃	116.76 ^{bc}	45.32 ^{de}	161.7 ^a	148.75 ^{ab}	417.43 ^{bc}	4.33 ^a
T ₄	82.75 ^e	48.07 ^{bcd}	156.3 ^a	184.00 ^a	232.49 ^e	4.25 ^{ab}
T ₅	95.66 ^d	46.55 ^{cd}	116.3 ^a	125.00 ^b	323.28 ^d	4.00 ^b
P	<0.0001	0.0025	0.12	0.0437	0.0001	0.0012

Keywords: Biochar; Co-compost; Liquid and solid waste; Pellets

Enhancing the Awareness and Perception in Smallholder Rubber Farmers towards Recommended Technologies: Evidences from Four Rubber Growing Districts

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Abstract

Farmer awareness and farmer perception are two important intrinsic factors that determine the level of adoption of recommendations in any cropping system. Meanwhile, in rubber cultivation, these factors lead to a high adoption level ensuring sustainable cultivation. Awareness, in other words, is knowledge and it is the first requirement to start the adoption process. Further, higher knowledge on a particular factor would lead to a high adoption rate. Farmer perception plays a key role in adoption, as suggested by the perception-adoption paradigm. According to the literature, both awareness and perception are influenced by different types of extrinsic factors. With this background, this study was carried out to identify the factors affecting farmer awareness and perception in the smallholder rubber sector in Sri Lanka. A pre-tested semi-structured questionnaire survey was carried out to collect information from rubber farmers in four rubber growing districts: Gampaha, Kegalle, Kurunegala and Kandy. The sample size was 350, and the sampling was done using a two-stage stratified sampling scheme. Both awareness and perception were measured using twenty-three statements regarding the recommendations in agronomic practices. Binomial responses were taken for the awareness: if a farmer was aware of the statement, stated as yes and if the farmer was unaware of the statement, stated as 'no'. Four points Likert scale was used to assess the perception regarding the statements: 0 – no idea, 1 – not important, 2 – important and 4 – very important.

Principle Component Analysis (PCA), which is a multivariate technique used to reduce a high number of correlated variables into a low number of uncorrelated variables, was carried out for the awareness and perception data separately. The

first principal components (PC1), which explain the highest variation, were obtained as awareness and perception indices. Regression analysis was conducted with the PC1 to identify the factors affecting awareness and perception. Attending training programmes, education level and land extent showed significant impact on both awareness and perception with the expected positive sign. Membership of rubber related society has a positive relationship with both awareness and perception. However, a significant impact was only observed with perception. Contacts with extension officers significantly enhanced farmer awareness; however, its impact on perception is not significant (Table 1).

According to the results, conducting training programmes is important to enhance both farmer awareness and perception. Establishing and promoting rubber related societies will help to improve the farmer perception while providing a platform to share their experience and knowledge. Strengthening existing rubber extension service will help to improve farmer awareness.

Table 01: Factors affecting awareness and perception with respective coefficients and p values

Variable	Awareness		Perception	
	Coefficient	P value	Coefficient	P value
Attend training	0.7790	0.017*	0.8740	0.023*
Membership in rubber society	0.0318	0.903	0.6873	0.027*
Land extent	0.1694	.0.002*	0.1867	0.005*
Contacts with extension officers	1.2759	0.002*	0.1405	0.775
Education Primary	2.1045	0.054	2.1970	0.082
Level Upto O/L	1.7472	0.091	2.8347	0.018*
Upto A/L	1.9417	0.064	3.5582	0.004*
Higher education	2.6822	0.020*	3.5978	0.008*
Constant	-4.7566	0.000	-4.6849	0.002

* significant at 0.05 level

Keywords: Awareness; Perception; Rubber; Smallholder; Sri Lanka

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Formulation of a Commercializable Stevia Incorporated Herbal Tea Using Superior Quality Stevia Leaves for the Benefit of Diabetic Patients

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Abstract

Stevia rebaudiana Bertoni, an ancient perennial herb of South America, produces diterpene glycosides that are low calorie sweeteners, about 300 times sweeter than sucrose due to the presence of steviol glycosides (mainly stevioside and rebaudioside). Stevia extracts, besides having therapeutic properties, contain a high level of sweetening compounds known as steviol glycosides, which are thought to possess antioxidant, antimicrobial and antifungal activity. *S.rebaudiana* is widely used as a sweetener around the world and is safe for diabetics. Even though this plant has been studied extensively by other nations, studies have not been conducted in Sri Lanka. Therefore, the current study was carried out to develop some agronomic practices and formulate stevia based herbal tea for the benefit of diabetic patients.

Field experiments were conducted at the research plots at Laksakanda Estate, Kuruwita, Sri Lanka. Plants were established under three shade levels (0%, 50%, and 80%). Growth data on number of leaves, plant heights, number of shoots, plant spreading were collected weekly. Leaves were harvested and analyzed for the mineral content and steviol glycosides, and finally formulated a stevia incorporated standardized herbal tea using the leaves obtained from the superior quality stevia leaves. Results revealed that plant growth was significantly higher in plant maintained under zero shade level (0%). The higher stevioside content was observed in plant growth under 50% shade level. The herbal tea developed with Stevia leaves harvested from 50% shade level were

subjected to phytochemical properties (total polyphenolic content, levels of catechins and proximate values such as calorie, fat, crude protein, carbohydrate, fiber, fucose, glucose and fructose) and sensory evaluation by trained sensory panel. Finally, intellectual right of prepared stevia-based tea was protected by applying for Sri Lankan patent (Patent No LK/P/20379). Commercialization of stevia incorporated tea is in progress.

Keywords: Herbal tea; Natural sweetener; Shade levels; *Stevia rebaudiana*; Stevioside

Genetic Diversity within *Saccharum officinarum* Accessions Collected in Sri Lanka

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Abstract

The sugarcane variety improvement program is focusing the enrichment of *Saccharum* germplasm through exploration, collection, evaluation and utilization of genetic-resources. Variety importation and local expedition are important in enrichment of *Saccharum* germplasm. The main purpose of local expedition is to collect samples from genetic resources found in home gardens and jungles. The modern- sugarcane cultivars are derivatives of *Saccharum spontaneum* and *S. officinarum*. The high sucrose levels in modern cultivars are mainly derived from the species *S. officinarum*, also known as the ‘Noble cane’. It is the backbone of the sugar industry in the tropics and major source of germplasm for high sugar content in modern hybrid sugarcane breeding. *S. officinarum* is characterized by having high sucrose levels, low fibre levels, thick stalks, poor ratooning ability, and $2n=80$ chromosomes. This research was conducted to characterize the *S. officinarum* accessions collected through local expedition for breeding purposes.

Eighty *S. officinarum* accessions collected through local expedition during 1987, 1992, 2010, 2012 and 2013 from Nuwara-Eliya, Colombo, Matale, Kandy, Galle and Matara districts and one accession imported from Australia (Badila, $2n=80$) as a reference for *S. officinarum* were subjected for this study. The total DNA was extracted from young leaf samples of the accessions using modified CTAB protocol. The quantity of extracted DNA was measured by nano-drop spectrophotometer. Twenty-three highly polymorphic SSR markers were selected from ICSB. PCR amplification was performed in a total of 15 μ l reaction containing 2 μ l of 90-100 ng/ μ l DNA. 3 μ l of 5 x PCR buffers, 25 mM, 1.5 μ l of $MgCl_2$, 10 mM, 1.5 μ l of each forward and reverse primer, 10 mM, 0.5 μ l of dNTP mixture, 0.1 μ l of taq DNA polymerase and 4.9 μ l distilled water.

Amplified products were visualized by silver staining in PAGE gel. Bands were scored for the presence (1) or absence (0) in all 81 genotypes and the distance matrix was used to construct phylogenetic tree by using Unweighted Pairwise Group Arithmetic Mean (UPGMA) using the software NTSYS pc 2.2.

Out of 50 SSR primers, 23 primers produced highly polymorphic bands. A total of 233 loci was generated for 81 genotypes. The similarity coefficient measures genetic identity and genetic distance between accessions were estimated. At the genetic similarity coefficient of 69%, the accessions were classified into five major clusters. Most of the accessions collected from Matale, Kandy and Nuwara-eliya districts included into cluster 1. The grouping pattern of the 24 accessions in cluster 1 based on the genetic similarity coefficients showed that sugarcane accessions from the same geographical regions tend to cluster with the same group. Out of the 81 *S. officinarum* accessions, 51 were clustered into cluster 2 with Badila (2n= 80) imported from Australia and stripe cane (pure *S. officinarum*) SLC 92 72 collected from Sri Lanka. The accession Badila has been confirmed as *S. officinarum* which has the chromosome number 2n= 80. Therefore, based on the observations, 31 accessions in sub cluster 2b can be identified as pure *S. officinarum* which has the chromosome number 2n= 80. The highest genetic similarity 86.7% was observed within the accessions in this cluster. It was observed between SLC 13 68 and Badila.

The lowest genetic similarity (54.5%) was observed among genotypes between the SLC 12 34 and SLC 13 19 that are in clusters 1 and 4, respectively. These two genotypes differ from each other and easily distinguishable among the genotype based on the morphology, SLC 13 19 is a maroon colour stripe cane collected from Galle and SLC 12 34 is yellow in colour collected from Nuwara-Eliya. Since these two accessions were adapted to completely different geographic areas, the chromosome makeup of these two accessions should differ from each other to some extent.

The results revealed that there are five divergent groups between 81 *Saccharum officinarum* accessions tested and sugarcane accessions from the same geographical regions tend to cluster with the same group. Therefore, some selected accessions from each group could be used for inter-specific crossing programs expecting more variability in the resulting progenies. Most of the accessions collected through local expedition were clustered with Badila confirming that Sri Lanka is enriched with pure *S. officinarum*.

Keywords: *Saccharum officinarum*; Similarity coefficient; SSR

Interrelationships between the Operational Context of Key-Performance Indicators and Performance of a Research Institute: Evidence from the Commercial Agriculture Sector in Sri Lanka

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Abstract

Performance management is key to induce organizational research practice, and there is no exception with regard to the development of the commercial agriculture sector. Key performance indicators (KPI) is a tool in a guise of a smart indicator that could be used to measure the performance of research developments towards innovative commercial agriculture. However, KPI adoption in research institutes has so many weaknesses that hinder the obtaining the true benefits out of them. This study was aimed, in the light of this and on the understanding that there is little empirical research has been carried out, to explore the potential interrelationships between the contribution of KPI connected with the key performance drives (KPD) and research culture of a research institute with a particular focus on Sri Lankan context.

The study was conducted using in-depth interviews with key informants who have high degrees of knowledge about KPIs, their uses, and have experience in managing KPIs and their adoption within the research organizational structure. On the assumption that those key informants are also more or less influential in KPI formulation and make informed decisions in the research development towards innovative commercial agriculture, the decision-makers on organizations' research work covering the commercial agriculture sector of Sri Lanka (n=10) were selected. They were contacted by way of an in-depth personal interview supported by a semi-structured interview schedule operated through an Online Video Conferencing facility. The interview schedule contained 15 inquiries covering multiple dimensions with respect to KPI

formulation, establishing, measuring, reporting, and making decisions and was validated by a 6-person expert panel.

A thematic analysis of the opinions of respondents was taken into account of the context, policy attributes, enablers, and organizational benefits of a well-thought performance management system. It was found that the majority of institutional leadership did not practice KPIs in its decision-making process at a matured level in the organizational structure of the research institute. Despite this, a wide range of KPI-related benefits in organization culture such as improved efficiency in decision-making, improvements in team morale, collaboration, and collective learning were identified at the onset of this survey. Further analysis is in place to explore the practical implications of understanding the context, redressing the imbalance between using and practicing those KPIs, and role-playing by organizational leadership. Some implications for future research, including the extent to which psychological aspects of practicing KPIs in organization design affect different organizational relationships and how KPIs are differently shaped in organization design at the hands of leaders from different categories are also deliberated.

The outcome of the analysis facilitates developing a KPI-KPD framework to guide the organization's thinking towards building the research capacity of a research institute. It shall be instrumental in achieving the organization's vision and mission through good-fit commercial agriculture research evaluated based on informed decisions acquired by KPI data and information.

Keywords: Commercial agriculture development; KPI; Organizational leadership; Research institutes

Morphological Variation of Arrowroot (*Maranta arundinacea*) from Six Geographical Locations of Sri Lanka

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Abstract

Arrowroot (*Maranta arundinacea*; Family Marantaceae), also known as “Hulankeeriya” or “Aerukka”, is an underutilized tuber crop in Sri Lanka. It is a perennial herb which grows as a shrub with clusters of erect, tended, cylindrical stems. The starch obtained from the rhizome of arrowroot is gluten free, easily digestible and nutritious starch with numerous health benefits. Local root and tuber crops are an economically beneficial solution for the food security in developing countries. However, morphological characterization is a prerequisite for selection, improvement and effective utilization of the crop. The present study investigated the morphological variation of arrowroot based on plant populations in six geographical locations representing four agro-climatic zones of Sri Lanka. The snowball sampling method was employed due to the rareness of populations. Samples were collected from areas namely, Deraniyagala, Gannoruwa, Hakgala, Mahara, Matara and Welimada. Five shrubs at the harvesting stage were used from each location. Thirteen morphological traits were measured according to a developed plant morphology descriptor list. Statistical analysis was done using Analysis of Variance (ANOVA). Seven out of 13 morphological traits were significantly different indicating the diversity of arrowroot across the geographical locations (Table 1). Strong positive correlations were present between total leaf area per hill and total biomass above ground per hill ($r = 0.828$; $p < 0.05$) and between number of harvested tubers and total weight of harvested tubers per hill ($r = 0.804$; $p < 0.05$). Number of leaves per hill had a strong positive correlation with the total leaf area per hill ($r = 0.932$; $p < 0.05$). Total number of harvested tubers per hill positively effects on total yield per hill.

Table 1: Variation in morphological traits of arrowroot plants from different geographical locations

Morphological Trait	Location					
	DR	MH	GN	MT	WL	HK
No. of stems per hill	8.00 ± 2.35 ^a	3.40 ± 0.55 ^b	5.00 ± 2.35 ^{ab}	5.00 ± 3.08 ^{ab}	4.20 ± 1.30 ^{ab}	3.40 ± 0.55 ^b
Depth of root system (cm)	29.64 ± 3.27 ^a	24.50 ± 4.64 ^{ab}	25.40 ± 3.65 ^{ab}	25.74 ± 0.49 ^{ab}	19.80 ± 4.97 ^b	23.40 ± 2.70 ^{ab}
Total leaf area per hill (cm ²)	6962 ± 1700 ^a	3002 ± 1413 ^a	6962 ± 3403 ^a	6108 ± 3294 ^a	5874 ± 2888 ^a	4109 ± 680 ^a
No. of tubers per hill	11.4 ± 2.97 ^a	8.60 ± 0.89 ^{ab}	7.00 ± 1.58 ^{ab}	5.20 ± 2.39 ^b	9.00 ± 4.85 ^{ab}	11.0 ± 4.30 ^{ab}
Total above ground biomass per hill (g)	281.0 ± 124.4 ^a	157.4 ± 32.9 ^a	603.0 ± 231.0 ^a	606.0 ± 339.0 ^a	585.0 ± 341.0 ^a	594.8 ± 132.4 ^a
Total weight of tubers per hill (g)	463.8 ± 217.6 ^a	256.2 ± 91.9 ^{ab}	176.4 ± 59.8 ^b	254.1 ± 119.4 ^{ab}	237.8 ± 113.6 ^{ab}	424.8 ± 201.9 ^{ab}
Length of rhizome (cm)	22.94 ± 2.06 ^{ab}	14.92 ± 2.19 ^c	15.56 ± 2.28 ^c	24.48 ± 3.80 ^a	16.4 ± 2.14 ^c	18.3 ± 2.23 ^{bc}
Width of rhizome (cm)	2.64 ± 0.23 ^a	2.14 ± 0.19 ^a	2.46 ± 0.37 ^a	2.32 ± 0.28 ^a	2.46 ± 0.37 ^a	2.32 ± 0.26 ^a
Maximum height of stem (cm)	53.72 ± 6.88 ^b	103.0 ± 19.24 ^a	89.1 ± 18.57 ^{ab}	106.4 ± 30.80 ^a	96.8 ± 25.00 ^a	70.4 ± 7.83 ^{ab}
Stem diameter (cm)	1.60 ± 0.41 ^a	1.64 ± 0.54 ^a	1.74 ± 0.23 ^a	1.38 ± 0.37 ^a	1.76 ± 0.64 ^a	1.48 ± 0.34 ^a
No. of leaves per hill	31.4 ± 14.29 ^a	31.6 ± 15.52 ^a	44.2 ± 17.82 ^a	40.8 ± 28.90 ^a	44.0 ± 25.60 ^a	39.2 ± 9.91 ^a
Length of first mature leaf from top (cm)	33.0 ± 2.32 ^a	33.5 ± 2.45 ^a	33.0 ± 2.57 ^a	28.94 ± 7.05 ^a	32.2 ± 2.80 ^a	32.06 ± 2.33 ^a
Width of first mature leaf from top (cm)	7.34 ± 0.55 ^a	8.74 ± 1.54 ^{bc}	11.06 ± 1.32 ^a	9.20 ± 1.22 ^{abc}	9.28 ± 0.85 ^{abc}	9.80 ± 0.55 ^{ab}

Values are Mean ± SD; n = 5. The same superscript letter in each row represents values not significantly different from each other at p = 0.05.

DR – Deraniyagala, MH – Mahara, GN – Gannoruwa, MT – Matara, WL – Welimada, HK – Hakgala

Keywords: Arrowroot; Comparison; Correlation; *Maranta arundinacea*; Plant morphology; Traits

Morphometrics and Species Limits of Ornamentally Important Aquatic Genus *Lagenandra*

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Abstract

The genus *Lagenandra* is known for its ornamental value in aquarium industry and hence often extracted from nature. Illegal collections and habitat degradation due to anthropogenic activities have placed this genus in a vulnerable position in the wild. Therefore, this taxon has been classified as a high conservation priority. In this backdrop, a field-based taxonomic study was initiated to elucidate the species limits. Field work was carried out, especially in the Wet zone of the country during the period 2018 to 2021. The collected specimens were tentatively identified based on published literature and referring to herbarium specimens. The plant specimens were studied in detail and morphological characters, both vegetative and reproductive, were coded into a data set. At least three mature individuals were coded from a population. The data set was subjected to a multivariate analysis using Past software (version 2.15). Hierarchical Cluster Analysis was carried with the data collected from hundred and sixty populations employing 92 qualitative and quantitative characters. The cluster solution was selected from the best suitable algorithm where, Gower Distance was used to calculate the similarity measures with the 'paired group' (UPGMA) option and the Single Linkage Algorithm with the highest Cophenetic Correlation Value.

The Hierarchical Cluster Analysis resulted in 15 phenetic groups, of which ten phenetic groups corresponded to already described species. The most contributing characters for the grouping based on the SIMPER analysis were the petiole length followed by leaf length, spathe length and length of the cataphylls. Of the ten phenetic groups, seven corresponded to species that were described

during the revision of the Flora in 1986; *L. bogneri* de Wit, *L. erosa* de Wit, *L. jacobsenii* de Wit, *L. koenigii* (Schott) Thwaites, *L. lancifolia* (Schott) Thwaites, *L. ovata* (Linnaeus) Thwaites, *L. praetermissa* de Wit and *L. thwaitesii* Engler. Meanwhile, three corresponded to new species; *L. wayambae* Madola, K. Yakandawala, D. Yakandawala & Karunaratne, *L. kalugalensis* Madola, D. Yakandawala & K. Yakandawala and *L. srilankalensis* Madola, D. Yakandawala & K. Yakandawala described during recent studies. The phenetic groups corresponding to *L. koenigii* and *L. praetermissa* encompassed three and two sub-groups respectively within the large phenetic group of the taxa. However, all the populations enclosed within the large phenetic groups of each of these species possessed diagnostic features indicating the morphological diversity of the two species. None of the phenetic groups corresponded to *L. erosa*, a species, which is assumed to be “Extinct from the Wild” (CR[PE] in the present National Redlist 2020). The detailed character comparisons of the five other phenetic groups revealed that three phenetic groups were distinct from the species of *Lagenandra* described to date and to be possible new species. The other two phenetic groups had morphological features that overlapped with the taxon forming broader phenetic group, indicating a possible hybrid taxa, which needs further study. Identifying new taxa would enhance the species limits of the genus *Lagenandra* and contribute to uplift the biodiversity richness of the country and the globe.

Keywords: Aquatic ornamental; Biodiversity; Conservation; Multivariate analysis

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Multispectral Imagery Assisted Drone Technology to Measure Leaf Chlorophyll Concentration in Rice (*Oryza sativa* L.) Crop Field in Sri Lanka

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Abstract

Rice (*Oryza sativa* L.) is the most economically important cereal crop in Sri Lanka. Assessing rice crop performance at the field level is an important task to manage resources efficiently and obtain high yield sustainably. Usually, farmers assess crop greenness by human eyes as an indication of crop condition associated with leaf chlorophyll concentration but that is subjective, late indicative, and poorly representative of crop physiological status. Furthermore, leaf color chart (LCC) though offers a scoring system to assess greenness, are challenging in assessing every single crop in the field. As an alternative this study was aimed to evaluate the feasibility of using multispectral imagery assisted drone technology to measure chlorophyll content, remotely in rice crops at the field level.

The study was carried out at the rice fields maintained by the Rice Research and Development Institute (RRDI), Bathalagoda, Kurunegala, Sri Lanka. The most widely grown 3 months rice variety Bg 300 was established in April, 2021 under four levels of Nitrogen (N) fertilizer treatment plots as 0% (0 kg/ha), 50% (112.5 kg/ha), 100% (225 kg/ha), and 150% (337.5 kg/ha) of Department of Agriculture, Nitrogen fertilizer recommendation. Plots were maintained with all necessary agronomic practices until harvest in July, 2021. Drone imagery of the field at the booting stage (6 weeks after planting) which is the maximum vegetative stage of the crop was captured at 45 m height during 10:00 h to 11:00 h. The commercially available P4 Multispectral (DJI Technology) drone was used mounted with multispectral camera sensors for wavebands in blue: 465–485 nm, green: 550–570 nm, red: 663–673 nm, red edge: 712–722 nm, and near-infrared: 820–860 nm to capture images. Mission planning was conducted using the DJI GS Pro app and the images were improved into Pix4Dmapper.

Before drone flying ground sampling areas were demarcated on a field with 1 m² white styrofoam rectangular boundaries where on-ground measurements: leaf

greenness and leaf chlorophyll concentration were conducted with a SPAD-502 chlorophyll meter and LCC respectively. Derived Normalized Difference Vegetation Index (NDVI) values from the drone imagery in the sample rectangular boundary areas were analyzed with the ground-truth data i.e. chlorophyll content and leaf greenness to establish a co-relation fit. The result suggested that NDVI was strongly co-related with chlorophyll content ($R^2=0.97$) and leaf greenness ($R^2=0.96$). Based on the result spatial distribution of chlorophyll content in the rice field was able to map using QGIS version 3.20 as shown in Figure1. Mean SPAD value of 39.59, 37.54, 37.11 and 34.51 were indicated by mean NDVI values from 0.792, 0.718, 0.646 and 0.498 depicted in green color intensities, for corresponding fertilizer levels 150% (337.5 kg/ha), 100% (225 kg/ha), 50% (112.5 kg/ha), and 0% (0 kg/ha) and, respectively (Fig.1).

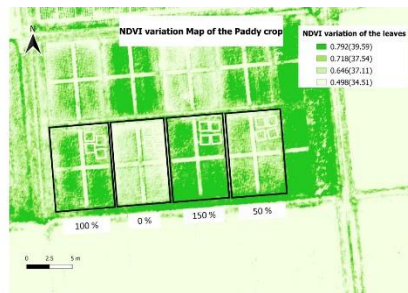


Figure 1: NDVI zonal map indicating leaf chlorophyll distribution in rice field

Nitrogen fertilizer is a key nutrient for the development of chlorophyll and maintaining its active functionality in plant. Different levels of N status in rice plants resembles varying chlorophyll contents and greenness, thus resulting in varying photosynthesis activity in leaves. During photosynthesis activity plants absorb and reflects wavebands in proportionate to the available active chlorophyll content causing the spectral reflectance of rice plants. Due to that when the rice plant spectral reflectance were measured as a fraction of NDVI; which could be used to identify rice crops' health characteristics instead of on-ground conventional crop assessment methods, those were able to relate to known N fertilizer levels throughout the field.

The findings suggest that drones are capable of monitoring the chlorophyll content in rice field with high accuracy and assess the Nitrogen level in rice plants. Therefore, in this study it can be concluded that, for Bg 300 rice variety canopy NDVI values ranging from 0.373-0.623, 0.521-0.771, 0.593-0.843 and 0.667-0.917, are highly indicative of Nitrogen fertilizer levels 0%, 50%, 100%, and 150% respectively. The findings are also encouraging the use of smart crop remote sensing techniques in future rice cultivation at the local, region, and country levels.

Keywords: Chlorophyll content; Drone; Multispectral imagery; Normalized difference vegetation index; QGIS

Odoriferous Compounds of *Vanda tessellata* (Roxb) Hook. f. ex D.Don. and Their Possible Ecological Role in Attraction of Pollinators

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Abstract

Vanda tessellata is an indigenous orchid species in Sri Lanka which consists of a wide range of flower variations. This species is protected under Fauna and Flora Protection Ordinance and listed as a threatened species under the Endangered (EN) category of the National Red List 2020 of Sri Lanka. This plant has high ornamental and medicinal value, thereby causing serious threats due to over-exploitation. Present habitat destruction has increased the threats faced by *V. tessellata*. Therefore, sound knowledge on pollination biology is an important fact in the conservation and propagation of the species. A total of sixty numbers of fresh flowers of the species were collected at different time intervals; before the opening of the flowers, after the opening of the flowers at 0300 hr, 0600 hr, 0900 hr, 1200 hr, 1500 hr, 1800 hr, 2100 hr and 2400 hr time intervals. After collection the flowers were inserted into poly bags immediately and stored in a cool place (26 C⁰). A poly-bag without a flower was sealed as a counter sample. Gas chromatography-mass spectrometry (GC-MS) analysis was used in the analysis. The gas Chromatograph was fitted with a fused silica HP-5MS capillary column (30 m× 0.25 mm; film thickness 0.25 µm). The oven temperature was programmed to range from 60- 280°C at 4°C/min. Helium was used as the carrier gas at a flow rate of 2 ml/min. The gas chromatograph was coupled to a Hewlett-Packard 6890 mass selective detector. The ionization voltage, was set up as 70 eV, along with ion source temperature as 200 °C. To record pollinators, 60 flowers were tagged, and pollinator visitation was

observed for 24 hr for five days. Using a hand net, pollinators were captured, preserved in 70% alcohol and identified at the Department of Zoology, University of Peradeniya.

The detailed GC-MS resulted in 65 volatile compounds. Around 10 chemicals were emitted by 0300 hr and denoted the peak around 0900 hr by emitting 15 chemicals. Subsequently, it reduced to 8 chemicals by 1200 hr and which reduced further gradually. Particular chemicals, p-vinylphenol (8.9%), 4-ethoxymethylphenol (39.6%), Methyleugenol (6.6%), N-dimethylhydrazine (4.7%), Phenylmethyl encyclopropane (6.8%), Tripropargylamine (7.3%), Methyl pentacyclododecane-8-carboxyloate (8.2%) and Phthalic acid (18.2%) were emitted at high concentrations around 0600 hr. Meanwhile, Cyclohexasiloxane (20%), 1,2-Benzenedicarboxylic acid (15.8%) were detected around 0900 hr. Main chemical compounds found in the evening and night were, 2- methyl-octadecyne (28.5%), Octadecamethyl-cyclononasiloxane (16.3%), Tetracosamethyl-cyclododecasiloxane (12.2%), 3-ethyl-3methylheptane (33.2% at 18.00 hr and 12.2% at 21.0hr), Tricosamethyl-cyclododecasiloxane (16.3%), Hexadecamethylheptasiloxane (10.1%), Pipertone(15.2%), Eugenol (7.4%), Dococene (4.1%) and linalool(2.9%). The pollinator visitations of *V. tessellata* flowers and the intensity of floral odour were correlated well. The diurnal pollinator, *Xylocopa tenuiscapa* (Carpenter Bee) visitation was frequent during 0730 hr to 1130 hr. It is a solitary bee species which travel long distances for foraging. The chemicals emitted during the evening and night was heavier, waxy, less volatiles with antioxidant, antimicrobial properties. These chemicals are responsible for attracting *Daphnis nerii* (Olender Hawkmoth), a nocturnal pollinator moth species, to *V. tessellata* flowers. Especially, 2- methyl-octadecyne detected in high concentration (28.5%) during the analysis is a Lepidopteran pheromone. The results prove the ability to attract both diurnal and nocturnal pollinators in successful pollination in *V. tessellata* flowers.

Keywords: Gas chromatography; Odoriferous compounds; *Vanda tessellata*; Volatile compounds

Optimization of an *in vitro* Clonal Propagation Technique for Mass Cultivation of *Stevia rebaudiana*

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Abstract

Stevia rebaudiana is a perennial herbaceous plant in family Asteraceae, commonly known as sweet herb in presence of several sweet tasting diterpenoid glucosides in its leaves. Recently, utilization of stevia in food and medicinal industries as a substitute for cane sugar has been started to rise globally as a preventive measure of type-II diabetes and obesity. Stevia is a potentially suitable crop for cultivation in wide range of tropical and sub-tropical agro-ecological regions in Asia. Hence, there is a high potential to cultivate stevia commercially in Sri Lanka as well. *In vitro* clonal propagation is identified as a viable solution to overcome limitations encountered with conventional propagation methods for many plant species. For stevia also, availability of such a protocol is very much advantageous in mass production of clonal planting material. Hence, the purpose of this study is to optimize a micropropagation protocol for *S. rebaudiana*.

The experiments were carried out to identify the best explant type, and surface sterilization, *in vitro* multiplication, rooting and acclimatization procedures. Mature plants of *S. rebaudiana* were maintained as the mother plant stock in a plant house. Shoot tips collected from healthy looking mother plants were excised into shoot tips with two leaf primordia, shoot tips with two leaves and nodal cuttings (single and double) after the surface sterilization which were used as different explant types. The pH of the culture media were adjusted to 5.8, gelled with 8 g/L of agar and autoclaved at 1.5 kg/cm² at 121°C for 20 min. Aseptic conditions were maintained as required throughout the study. Cultures were incubated at 25 ± 2°C, 65- 70% relative humidity and 16 h light/ 8 h dark photoperiod with 3000 lux light intensity provided by cool white florescent tubes. As experimental designs, Completely Randomized Design (CRD) and factorial CRD were practiced, where each treatment consisted 10 replicates. The

experiments were repeated three times. The data were analyzed using Statistical Analysis Software and means were compared by Least Significant Difference test ($p \leq 0.05$). Data recorded as percentages were normalized using arcsine transformation prior to analyze.

Among the surface sterilization procedures tested, the given procedure (Figure 01) was the best to avoid contaminations (05%) and browning (00%) of explants that may occurred during four weeks of culture establishment period in Murashige and Skoog medium (MS) fortified with 2.0 mg/L Benzyl Amino Purine (BAP).

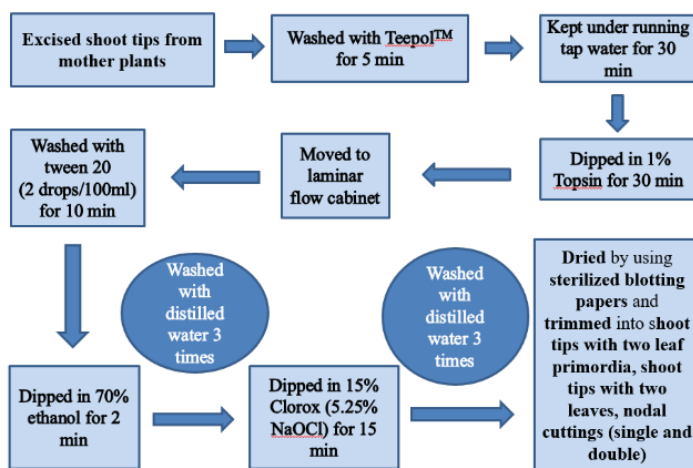


Figure 01: The best surface sterilization procedure

Single nodal cuttings were identified as the best explant type with highest mean shoot proliferation of 44.9 shoots/ explant in modified MS medium fortified with 0.3 mg/L BAP and 0.3 mg/L Kinetin (Kin) where four weeks' sub culturing was practiced. Synergetic effect between BAP and Kin was promoted shoot proliferation in absence of auxins. The highest mean number of roots per shoot (8.35) was produced within six weeks in $\frac{1}{2}$ MS medium. In presence of Indole Butyric Acid, number of roots formed were decreased and calli were observed. During eight weeks of acclimatization under shade, 90% survival rate was resulted by plants in planting trays filled with sterilized sand: coir dust (1:1). The developed micropropagation protocol needs to be standardized prior to commercialize.

Keywords: Explant types; Micropropagation; Proliferation; *Stevia rebaudiana*

Performance Evaluation of a Sub Surface Drip Irrigation System in a Coconut Cultivation

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Abstract

Rainfall is one of the most important factors affecting on the yield of coconut having a daily crop water requirement of about 80 litres. The pattern and the frequency of rainfall are changed due to climate change. Therefore, coconut production has been declined significantly during past few years (annual average production of 2500-3000 mn nuts to 2200 mn in 2017). Irrigation has been proven its positive impact on quality and quantity of coconut yield. Surface drip irrigation systems (Surface DIS) are commonly practiced in coconut lands because they have less deep percolation losses and evaporation losses. In Surface DIS, laterals are laid at either side of a coconut palm and emitters are connected within the manure circle (2 m). It has been observed that the concentration of roots concentrates in one side of the ball of the palm where the emitters are located. The damages by rodents and some interruptions due to cultural practices (weeding), harvesting and intercropping are the major field problems associated with the surface DIS. A high cost is spent for maintenance of traditional surface DIS, for annual replacement of system components due to the damages. It can be reduced by subsurface placement of the system because sub surface components are permanently installed about 60 cm below the soil surface. Major concern in subsurface DIS is its performance and uniformity of the lateral lines. It is difficult to measure the system's flow rate, pressure and uniformity in subsurface DIS because the drippers are placed below the soil surface. In subsurface DIS either continuous laterals or discrete laterals can be used. Further, in this irrigation technique as a novel installation, a circular loop of inline lateral could be connected to a linear lateral. The major design criterion of a drip irrigation system is reducing its flow variation along lateral lines. But the flow variation has to be kept within an acceptable level under given operational pressure. Uniformity of the laterals is important when obtaining the

maximum lateral length (MLL). Pressure and MLL are the two most important factors useful to achieve an acceptable uniform pattern in irrigation. On that context, a limited hydraulic data is available on the water application uniformity of subsurface DIS. Therefore, a hydraulic study was conducted to determine the water application uniformity (lateral flow variation of 10% and 20% as preferable and acceptable respectively) of subsurface DIS with continuous and discrete lateral designs in a coconut cultivation. The spacing of coconut palms was 7.5 m approximately. Volumetric discharges of 20 emitters rated as discharge of 1.6 L/h installed at 40 cm spacing along 8 m loop around the coconut palms were collected during a period of 24 minutes. The pressure head was maintained at 3.4 bar in the mainline at the water pump end. Accordingly, the total discharge per palm per hour was calculated. The Emitter flow variance (q_{var}) along the discrete and the continuous laterals was evaluated ($q_{var} = (q_{max} - q_{min}) / q_{max}$) to determine the MLL and the emission uniformity (E_u); ($E_u (\%) = q_{25\%}/q \times 100$). Since all coconut palms in a row were subjected to record data, mathematical computations were done to obtain q_{var} and E_u . The continuous lateral design reached to a maximum lateral length (MLL) of 50 m at 10 % flow variance and 70 m at 20 % flow variance. In discrete lateral design, the MLL is only 34 m at 10 % flow variance (preferable range) and 70 m at 20 % flow variance (acceptable range). However, according to another previous study in a different experimental site, MLL was found as 112 m under 10% flow variance and 192 m under 20% flow variation in a continuous lateral design of a surface DIS, but the results of the present study, the MLL has declined under the subsurface DIS. Further, in this study, the emission uniformities of both designs are almost equal. Therefore, continuous lateral designs could be recommended for achieving higher water application uniformity in subsurface DIS with extended MLL.

Keywords: Emitter discharge; Emitter performance; Subsurface drip irrigation, uniformity coefficient

Raising Effective Use of ICTs in Agricultural Extension: Technology Stewards' Responses to Stewardship Training Programme in Sri Lanka

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Abstract

Extension training and professional development are priorities in small-scale agriculture wherein Sri Lankan context the adoption and use of information and communication technologies (ICTs) remains a high priority. Specifically, the introduction of digital skills into professional practice is viewed as a crucial step toward pervasive digitalization in agriculture. Moreover, low-cost ICT-based services like text messaging, social media, and user-generated content can even contribute to knowledge mobilization within the agriculture sector. This study investigates agricultural extension practitioners' response to an in-service training program offered by the Postgraduate Institute of Agriculture, the University of Peradeniya in collaboration with the Wayamba University of Sri Lanka intended to raise effective use of ICTs through a technology stewardship approach.

This study reports on participants' (Technology stewards) responses (n=43) to an in-service training program on technology stewardship. Data were collected employing a pre-course survey, formal course evaluation, classroom observation, and semi-structured interviews with participants. Kirkpatrick's four-level evaluation model was used to structure the analysis of the results. The results of the study show high levels of friendliness to the technology stewardship training program, that learning objectives of the course are achievable when offered as an in-service training program. And also 65% of the participants indicated an intent to use their learning in a very post-course

activity. We noticed relatively low completion rates (37%) of the individual action plan (IAP) assignment, which can indicate the requirement to produce better post-classroom support for participants. Further, it's essential to provide more support to participants in finishing up their capping project assignments by raising the awareness of the technology stewardship concept among senior decision-makers and extension administrators. Further, this study raises a variety of considerations for future course design and institutional policy so as to raise support technology stewardship in practice. The stewardship training shows promise as a leadership-oriented approach for expanding the effective use of ICTs among communities of practice for agricultural extension within the country and elsewhere.

Keywords: Agricultural extension, ICT, Knowledge transfer, Technology stewardship

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Recreationalists' Willingness to Pay (WTP) for Conservation: Implications for Sustainable Management of Marine Resources

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Abstract

Marine parks are major tourist attractions that can encourage sustainable development. Well-managed coastal resources can act as revenue generating entities with a significant economic contribution. Hikkaduwa coral reef is the first Marine National Park and first official marine protected area in Sri Lanka. Hikkaduwa marine park offers several recreational benefits for both local and foreign tourists such as glass bottom boat touring, scuba diving, snorkeling and surfing. Both local and foreign visitors pay different prices for these activities. The prices nor the current entrance fee reflect the actual resource value. This could lead to resource degradation and exploitation as well as loss of tourism revenue in the long run. Environmental economics literature finds that society's contribution through a payment in any form can be a sustainable way of natural resource management.

According to environmental economics literature, the price a visitor is willing to pay as the entrance fee can be considered as a conservation fee. This study therefore, employs an environmental economics tool; a Contingent Valuation Model (CVM) to estimate the recreationalist's willingness to pay (WTP) for recreational activities provided by the park and to compute an entrance fee for the park.

Face-to-face interviews were conducted with a sample of $n = 180$ randomly selected local and foreign visitors using a structured questionnaire. The Probit model was estimated to derive the willingness to pay values for recreational activities in the Hikkaduwa national park such as snorkeling, glass boat tour, surfing. In addition to that, marginal Willingness to Pay values were derived to estimate the entrance fee from both local and foreign visitors.

Results show that respondent's income had a significant impact on willingness to pay (WTP) for snorkeling. Results further reveal that majority (> 80%) of the local and foreign visitors are willing to pay an increased entrance fee for the conservation of the park for the future generations. Local visitors were willing to pay Rs. 30 as an entrance fee while foreign visitors were willing to pay USD 4 as the entrance fee for the park, both of which are higher than the current fee. Findings further show that local visitors' willingness to pay for recreational activities such as snorkeling, glass boat tour and surfing are Rs. 757, Rs. 1,638 and Rs. 1,292 respectively.

The foreign visitors' willingness to pay for these activities are USD 16, USD 29 and USD 17 respectively. Majority of the foreigner visitors also expected that their contribution would support the local community and improve beach facilities. However, over 30% of respondents did not believe in government having the sole responsibility of conserving the park. Taking the right management actions to develop these subsectors can therefore be prudent for improving the tourism sector, increased social benefits, economic gains and reducing the anthropogenic impact on the marine and coastal resources.

Keywords: Contingent valuation; Marine park; Recreational activities; Willingness-to-Pay

Screening Antibacterial Activity of Fresh Leaves of Selected Fruit Trees Grown in Dry Zone in Sri Lanka

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Abstract

Using fruits other than for nutritional purposes is a growing concern. In fact, medicinal use of fruit plants is a common practice and many researchers have discovered medicinal properties of fruits and fruit plants. Fruit trees with less commercial value are underutilized and their leaves are mostly not utilized. Multi Drug Resistance (MDR) is considered as the next global predicament and already has an immense impact on global health and economy. Plant derived mild antibacterial agents are considered as an ideal solution for MDR. Combining these two aspects of underutilized fruit trees and the requirement of plant derived antimicrobial agents, it is highly important to screen underutilized fruit trees for antibacterial properties as an initiative.

Sampling: Eleven species of fruit trees were used in this study. Plant materials were collected from two locations of dry zones in Sri Lanka. Mature plants were deposited in the National Herbarium as voucher specimens. Different fruit trees selected under various plant families are as follows; Family Myrtaceae; *Syzygium caryophyllatum* (L.) Alston, *Syzygium samarangense* (Blume) Merr. & L.M.Perry, *Syzygium jambos* (L.) Alston and *Psidium guineense* Sw. Family Oxalidaceae; *Averrhoa carambola* L. Family Annonaceae; *Annona muricata* L. Family Salicaceae; *Flacourtia indica* (Burm.f.) Merr. Family Rutaceae; *Atalantia ceylanica* (Arn.) Oliver and. *Limonia acidissima* L. Family Solanaceae; *Solanum americanum* Miller. Family Malvaceae; *Grewia tiliifolia* Vahl.

Preparation of plant extracts: Freshly plucked first four leaves were cleaned in 0.5% bleach solution and macerated using a mortar and pestle. 20 g of fresh leaves were extracted in 5 ml of distilled water, filtered with 0.46 microliter syringe filter and used immediately. Determining the antibacterial activity: Antibacterial activity of the leaf extracts was determined against *Staphylococcus*

aureus (ATCC 25923), a clinical sample of *beta-hemolytic Streptococcus* as Gram-positive bacteria, while *Escherichia coli* (ATCC 25922) and *Pseudomonas aeruginosa* (ATCC 27353) were used as Gram-negative bacteria.

Agar well diffusion test was conducted to screen the antibacterial activity of the selected plant species against four different types of bacteria and results were observed quantitatively by measuring the diameter of the Zone of Inhibition (ZOI = D) in millimeters. One-way ANOVA was conducted to show the effectiveness of the plant extracts towards controlling the tested bacterial species.

Antibiogram analysis: Antibacterial activity against *Staphylococcus aureus*. The antibacterial activity of the selected fruit leaves against *S. aureus*. Only *S. caryophyllatum* and *P. guineense* showed higher diameter of inhibition than cloxacillin which is an existing antibiotic. *S. samarangense*, *S. jambos*, *A. carambola*, *S. americanum* and *G. tiliifolia* showed positive results. *S. caryophyllatum* is a commonly used in Ayurveda medicine. This study has obtained similar result for *S. caryophyllatum* same as previous species.

Based on the above research work, it can be concluded that the leaves of the fruit trees specifically *Syzygium caryophyllatum* (L.) Alston, *Psidium guineense* Sw. and *Solanum americanum* Miller can be used as potential new antibacterial agents for *Staphylococcus aureus*, *beta-hemolytic Streptococcus* and *Pseudomonas aeruginosa*. *Syzygium caryophyllatum* (L.) Alston, *Psidium guineense* Sw. are on par with the recommended antibiotic, Cloxacillin against *Staphylococcus aureus*. However, none of the selected plant extracts showed any activity against *Escherichia coli*. Further research with different extraction methods should be conducted to confirm the results of this study. This study shows the potential of developing herbal products to control pathogenic microbes using underutilized fruit trees.

Keywords: Antibacterial activity; Multi drug resistant; Underutilized fruit

Acknowledgement: This study was funded by the University Research Grant, Wayamba University of Sri Lanka (WUSL) (Refer page 157 of the appendix for further details) and conducted collaborating with the Department of Material and Nanoscience Technology, Faculty of Technology, WUSL. I would like to pay my special gratitude to Prof. CAN Fernando and laboratory staff in the Department of Material and Nanoscience Technology, and the Department of Horticulture and Landscape Gardening for the valuable support given. I also would like to deliver my sincere thanks to Dr. Sanjeewa Bowatte, Dean, Faculty of Medicine, WUSL for providing equipment. My special thanks should go to Mr. Chithrananda, the Registrar and administration staff of WUSL for providing accommodation during research period.

Screening for Cyanotoxin Producing MC Genes in Cyanobacteria Species Inhabiting in Paddy Fields and Wastewater Ponds

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Abstract

Microbial-based fertilizers or biofertilizers present a promising strategy to reduce the dependency on agrochemicals and they are considered as a significant component in sustainable agriculture. Cyanobacteria species have been identified as biofertilizers for paddy cultivation because of their ability for nitrogen fixation and plant growth promotion. Cyanobacteria or blue green algae are photosynthetic unicellular or multicellular prokaryotic organisms present in diverse terrestrial and aquatic habitats. Despite of their many applications other than biofertilizers e.g. wastewater treatment, some cyanobacteria species are known to produce secondary metabolites known as cyanotoxins, which cause adverse effects in humans and other organisms.

Microcystins (MCs) are the most prevalent cyanobacterial toxins and belong to the complex group of cyclic heptapeptide hepatotoxins. Therefore, cyanobacterial inocula should be screened for their potential to produce cyanotoxins prior to their use as biofertilizers and in other applications. This study aimed at screening the potential for cyanotoxicity in ten cyanobacteria species which were isolated from selected paddy fields (n=23) and wastewater ponds (n=3) in different districts of Sri Lanka and available at the culture collection at the Department of Biotechnology, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka using molecular approaches.

Genomic DNA from morphologically identified ten cyanobacterial species, *Chroococcus*, *Synechococcus*, *Synechocystis*, *Oscillatoria*, *Lyngbya*, *Leptolyngbya*, *Anabaena* (Green), *Anabaena* (Brown), *Nostoc*, and *Phormidium* were extracted using the Wizard® Genomic DNA Purification Kit. PCR amplification of DNA obtained from pure cultures with cyanobacterial specific primers; forward primer (CYA 359F) and reverse primers [CYA 781R (a) and

CYA 781R (b)] was carried out for molecular identification of cyanobacteria species. Cyanobacterial cultures were screened for the presence of MCs producing genes, *mcy A*, *mcy B* and *mcy E* specific primers. Forward primer mcyAF 47 and reverse primer mcyAR 19 were used for the screening and the preliminary results revealed that all the studied species were lack of *mcy A* gene hence potential for producing cyanotoxins. Further screening is carried out using *mcy B* and *mcy E* gene primers.

Keywords: Biofertilizer; Cyanobacteria; Cyanotoxicity; Microcystins; Rice, Wastewater

Study of Anthocyanin, Proanthocyanidin Content and Antioxidant Properties of Traditional Red Rice Varieties

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Abstract

Rice grains with red pericarp are usually rich with phytochemicals such as phenolic acids, flavonoids, anthocyanins, proanthocyanidins, tocopherols, tocotrienols, γ -oryzanol, and phytic acid compared to white rice varieties. Black and red rice usually have a strong antioxidant capacity as they contain a high amount of anthocyanin and proanthocyanin. The present study mainly focused on assessing variation of anthocyanins, proanthocyanidins content along with the antioxidant content in the four selected traditional red rice varieties namely, *Pachchaperumal*, *Kaluheenati*, *Suduheenati* and *Madathawalu*. Soluble and bound phenolic fractions were extracted using 1 g of rice bran from each variety and total phenolic content, DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity, total proanthocyanidin content, total flavonoid content and total anthocyanin content were analysed. Total phenolic content was analysed in both soluble and bound fractions using the Folin–Ciocalteu’s method. DPPH radical scavenging activity from bound fraction was assessed using 0.1 mM DPPH solution. The results were analyzed using One-Way Analysis of Variance followed by Turkey’s pair-wise test as the post-hoc analysis. According to the results, mean soluble and bound phenolic contents of rice varieties ranged from (39.72 ± 2.01) to (54.49 ± 2.01) and (18.03 ± 0.78) to (24.31 ± 0.24) mg of GAE (Gallic acid equivalent) per 100 g of bran respectively. The phenolic content of the soluble fraction is higher compared to the bound fraction. Total phenolic content in both soluble and bound forms among rice varieties was significantly different ($P < 0.05$) from each other. *Kaluheenati* variety exhibited the highest

values for both soluble (54.49 mg of GAE/100 g) and bound (24.31 mg of GAE/100 g) total phenolic content, while *Pachchaperumal* showed the lowest soluble (39.72 mg of GAE/100 g) and bound (18.03 mg of GAE/100 g) total phenolic content. *Kaluheenati* showed the significantly highest value ($p < 0.05$) for total proanthocyanidin content (138.15 mg catechin equivalent (CE)/100 g). *Madathawalu* showed the highest DPPH radical scavenging ability (73.52%), while *Pachchaperumal* exhibited the lowest in the bound-phenolic extract (51.66%). Anthocyanin content of four red rice varieties varied from 17.97 to 24.57 mg cyanidin-3-glucoside equivalents (C3GC)/100 g. Of them, *Madathawalu* exhibited the highest total anthocyanin content (24.57 mg C3GC equivalents/100 g). The highest value for total flavonoid content was observed in *Pachchaperumal* and it was 183.59 mg quercetin equivalents/100 g. With respect to all these parameters, both *Kaluheenati* and *Madathawalu* exhibited the highest overall antioxidant properties than the other tested rice varieties. In addition, *Pachchaperumal* exhibited the highest flavonoid content, although it exhibits lower antioxidant properties. Accordingly, it could be speculated that *Pachchaperumal* may contain a higher amount of other flavonoids compared to anthocyanins. Present results also indicated the promising contribution of total anthocyanin content and proanthocyanidin content for higher antioxidant activity. Results of the present study could be useful in future rice breeding programmes targeting the enhancement of nutritional quality in rice grains and the determination of genetic determinants responsible for improving antioxidant capacity in rice.

Table 1: DPPH radical scavenging activity of selected Sri Lankan traditional rice varieties

Variety	Free Radical Scavenging Ability %
<i>Pachchamerumal</i>	51.66 \pm 0.94 ^c
<i>Suduheenati</i>	63.47 \pm 0.97 ^b
<i>Kaluheenati</i>	64.38 \pm 1.38 ^b
<i>Madathawalu</i>	73.52 \pm 0.38 ^a

Results presented as mean \pm standard deviation ($n=3$) on a dry weight basis. Mean values in a row superscripted by different letters are significantly different at $p < 0.05$.

Keywords: Antioxidant; Phytochemicals; Red rice

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The Influence of Socio-Demographic Factors on the Maintenance Quality of Urban Residential Gardens in Gampaha District

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Abstract

The land and other ecological resources in cities have tended to be consumed rapidly due to urbanization, which causes many environmental issues associated with the reduction of green spaces. Under such a scenario, the ecological roles of urban green spaces are quite apparent. The residential gardens are the largest single land use category in urban areas and a major component of urban green spaces. This direct living environmental component provides significant biodiversity benefits, while positively impacting the wellbeing of urban citizens. Recognition of the key roles played by urban residential landscapes in urban green space conservation remains far behind in Sri Lanka. Therefore, the present study was conducted to investigate the socio-demographic factors responsible for the designing and maintenance of residential gardens among the urban community of the Gampaha District.

Hundred and fifty households in the three highest populated Divisional Secretariats (DS) in Gampaha District *viz.*, Gampaha, Mahara and Negombo were selected for the study. At the DS level, 50 home gardens, located within a radius of 2 km from the center of each city, were selected. A single cluster consisted of 10-15 households. The socio-demographic details, garden management practices and the perceptions of the residents were accessed using a pre-tested interviewer administrated questionnaire. Quality of the garden, in terms of garden design characters and level of maintenance, was evaluated through a garden survey. Considering the socio-demographic characteristics of the respondents, the majority of the respondents were females (72%), wherein the Sri Lankan context, women are mostly engaged in gardening. Respondents belonging to the age category of 36-50 years dominated (40%). All the respondents had attained higher education levels, while completion of Advanced Level qualification denoted the highest frequency (54%). Meanwhile, 32% of the respondents were occupied in private sector organizations, followed by retired household heads (28%). Monthly household income ranged from LKR 40,000 to >LKR 200,000, where the highest

fraction (33%) of the respondents received a monthly income ranging from LKR 81,000 to LKR 120,000.

The majority (65%) of the respondents indicated landscaping as gardening for beauty, even though it is a broad concept including functional and environmental conversation aspects. There are many sources of information on gardening, where the electronic media and social media were the top ranking sources of information, which accounted for average mean scores of 4.10 and 4.02, respectively. With respect to the mode of garden designing, the highest fraction of the residential gardens was self-designed (49%), while 22% were designed using self-generated ideas together with the advises of a professional designer. According to the score given to individual gardens, 43% gardens were of average quality, while 14% were considered to be of 'high quality' in terms of the design and overall maintenance practices. Only 13% could be considered as 'poorly designed and maintained'. However, people in the study population valued residential gardens with respect to different socio-cultural services, where stress release/health benefits, aesthetic value of plants/flowers, and pollution control were ranked as the highest benefits of residential gardens, with mean scores of 4.86, 4.84 and 4.74, respectively.

A complex interaction of socio-demographic factors governs the perceptions of urban residents and appears to be important in residential garden management. According to the Chi-square test of association, the level of education ($p=0.003$) and the monthly household income ($p=0.009$) significantly influenced on the mode of garden designing. While the attitude towards landscaping was significantly associated with age ($p=0.014$), monthly household income ($p=0.001$) and mode of garden designing ($p=0.026$). The overall quality of the studied residential gardens were found to be significantly associated with several factors such as education level ($p=0.050$), occupation ($p=0.008$), income ($p=0.050$), ownership of the household ($p=0.028$) and the mode of garden designing ($p=0.010$). Meanwhile, only land area ($p=0.048$) was significantly associated with the attitudes of the respondents towards the socio-cultural services of the residential gardens. Residential gardens possess high spatial heterogeneity due to diversified factors, including socio-demographic factors where, the level of education and income are having greater prominence. In Gampaha district, electronic media (mass and social) is the highly influencing information source for gardening. The influence of the socio-demographic variables and associated knowledge generated during the present study could be used in urban green space planning within the Gampaha district, to assure the quality of direct living environments of the urban residents.

Keywords: Gampaha; Residential garden; Socio-Demographic factors; Urban

Acknowledgements: Authors would like to thank the support from the Wayamba University Research Grant-SRHDC/RP/04/19-02 for the financial assistance. Refer page 160 of the appendix for further details.

Section B
Applied Sciences

A Novel Method to Find the Principal Square Root of any Perfect Square

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Abstract

Square root is a very useful and necessary operation in scientific computations, and there are a lot of applications of it in real life. It is very difficult to find the principal square root when the number of digits of a perfect square increases. In this study, it is mainly focused on discovering the new method for finding principal square roots by studying the patterns of perfect squares and their principal square roots.

In the literature it can be found a method to find a perfect square of a positive integer ends with 5. For instance, to find the perfect square of 25, first the square of five, 25, is written down and it is considered as the last two digits of the required perfect square. Then the first digit of the given number, 2, is multiplied by its successor, 3 to get 6 as the first digit of the required perfect square. Therefore, the perfect square of 25 is 625. If the converse process of this concept is considered, it can be found 25 as the principal square root of 625 as follows: First, if the last two digits of the prefect square are 2 and 5 in order then the last digit of the principal square root is 5. Next, the remaining digit of the perfect square, 6, can be obtained by the product of two consecutive positive integers, namely, 2 and 3. When smallest positive integer is taken as the first digit of the principal square, the principal square root of 625 is 25. To generalize this idea to any perfect square end with 5, the process is divided into two parts: Obtaining the unit's digit of the principal square root and obtaining the first digits of the principal square root. In the first place, it is obvious that the last digit of the principal square root is 5. As the next step, a quadratic equation is obtained by equating the product of two consecutive integers to the remaining first digits after removing last two digits, 25, from the perfect square. Then by solving the equation, the positive integer solution is chosen as the first digits of the principal

square root. Combining results of the steps mentioned above, the principal square root of any perfect square ending with 5 can be obtained.

It can also be developed novel method to find a principal square root of any perfect square with some modifications to the aforementioned method after categorizing them based on the unit's digit of the perfect square, namely, 0, 1, 4, 6 and 9 and analysing own patterns of the structures of perfect squares and their principal square roots. There are two unit's digits for principal square roots derived from perfect squares. For instance, a perfect square end with 1 has two corresponding unit's digits in the principal square root, namely 1 and 9. To obtain principal square root ending with 1 the following method is used. First, to find first $n-1$ digits of the principal square root, N_{n-1} , quadratic equation obtained from pattern study, $N_{n-1}^2 + \frac{N_{n-1}}{5} - \left(\frac{C_1}{5} + (N_n^2)_{m-2}\right) = 0$ is used. Here, $C = \frac{b_{m-1}}{2}$. Moreover, $N_n = (a_1 a_2 \dots a_{n-1}, a_n) = (N_{n-1}, a_n)$ and $(N_n^2)_m = (b_1 b_2 \dots b_{m-1} b_m)$ denote the principal square root with n digits ending with 1, the perfect square with m digits ending with 1, respectively. There exist two roots for the quadratic equation mentioned above. Since the coefficient of N_{n-1} of the quadratic equation is positive, definitely one root is negative. If the other root is a positive integer, it is chosen as the N_{n-1} . Consequently, the required principal square root is $(N_{n-1}, 1) = N_n$. If a positive integer root, N_{n-1} , cannot be obtained from the above equation then it can be concluded that the unit's digit of N_n is 9. To obtain required N_{n-1} , quadratic equation $N_{n-1}^2 + \frac{9}{5} N_{n-1} - \left(\frac{(1-C)}{5} + (N_n^2)_{m-2}\right) = 0$, where $C = \frac{b_{m-1}}{2}$ is used. Consequently, the required principal square root is $(N_{n-1}, 9) = N_n$. For the other cases, similar kind of equations can be used by coupling the unit's digits of the principal square root as follows: 2 and 8, 3 and 7 and 4 and 6. In the case of the perfect squares end with 0, first the last two digits, 00, is removed from the given perfect square. And 0 is considered as the unit's digit of required principal square root. Then the principal square root of the first digits of the perfect square is obtained by using the proposed methods. Finally, combining the results mentioned above, the required principal square root is obtained. Further, an *MATHEATICA* program was also developed for this method and the verification of the results was done by the existing *MATHEMATICA* command for finding square roots. Through this research study, hidden beauty of some mathematical concepts could be revealed.

Keywords: First digits; Perfect square; Principal square root; Unit's digit

Analysis of an Electrochemical Double Layer Capacitor with 1-butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide Based Gel Polymer Electrolyte and Natural Graphite Based Electrodes

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Abstract

In the segment of energy storage devices, supercapacitors are a familiar generation of devices that has drawn considerable interest owing to its higher energy and power densities. Supercapacitors can be classified into two major types and one of them is electrochemical double layer capacitors (EDLCs) where electric energy is stored via reverse adsorption of ions on electrode and electrolyte interface. Many EDLCs employ solid polymer electrolytes with wide operating temperature range, low volatility, high energy density and negligible vapor pressure. This study is based on fabrication and analysis of an EDLC fabricated using an ionic liquid (IL) based gel polymer electrolyte (GPE) and natural graphite/ polyvinylidene fluoride (PVdF) electrodes to produce a reliable and cost efficient energy storage device.

To fabricate the electrolyte, poly(vinylidene fluoride-co-hexafluoropropylene) (PVdF-co-HFP) was dissolved in acetone and the salt, zinc trifluoromethanesulfonate ($\text{Zn}(\text{CF}_3\text{SO}_3)_2$, ZnTf) was then added to the solution. The IL, 1-butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide was added and continued stirring to obtain a homogeneous mixture. The resultant was poured into a well cleaned glass petri dish and allowed formation of a thin electrolyte film.

To fabricate electrodes, natural graphite was sonicated with acetone to form a homogeneous paste. Then, PVdF was added to the paste and the mixture was heated to 50 °C for better dissolution. Thereafter, the paste was applied on two well clean Cu plates within a surface area of 1 cm². Then, the EDLC was fabricated with IL based GPE sandwiching within a pair of natural graphite/ PVdF electrodes and characterized using electrochemical impedance spectroscopy (EIS) technique and cyclic voltammetry (CV) test.

Impedance measurements showed that the bulk electrolyte resistance (R_b) was 4.7Ω and the charge transfer resistance (R_{ct}) was 5.0Ω . The maximum single electrode specific capacitance (C_{sc}) was found to be 7.2 F g^{-1} . A drastic drop of C_{sc} upon increasing frequency and eventually reaching to zero is observed. From the CV measurements, it is possible to see a deviation of the pattern after reaching the maximum potential of 0.7 V . This confirms the safe and preferable operation window of the EDLC is $0.1 \text{ V} - 0.7 \text{ V}$. The optimum scan rate for the continuous CV test was chosen as 10 mVs^{-1} considering the durability of the device. Cyclic voltammograms from continuous cycling shows a near rectangle shape conferring the fact that charge storage mechanism continuously takes place only at the interface. Initial C_{sc} of the EDLC was 16.4 F g^{-1} and it decreased with the cycle number. After 230 cycles, it was about 11.0 F g^{-1} . However, after reaching 232nd cycle, the rectangular shape changed, showing the destruction of the device. Results of the study are encouraging for further improvements of the device mainly in terms of durability. Further modifications of the system are in progress.

Keywords: 1-butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide; electrochemical double layer capacitors; gel polymer electrolytes; natural graphite electrodes; poly (vinylidene fluoride-co-hexafluoropropylene)

Awareness of the Right to Information Act (RIA) among the University Students in Sri Lanka: A Case Study

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Abstract

Right to information is a basic human need of any nation in the world. The ultimate objective of Right to Information is to ensure transparency of the government transactions, and accountability of the government authorities, minimizing the corruptions. Realizing this need of the citizens, the Parliament of Sri Lanka passed the Right to Information Act (RIA) No. 12 of 2016 in order to make the government institutions more transparent of their activities.

The objective of the survey was to study the awareness about RIA among the University students. The University students in Sri Lankan context seem to play an active role in various political and higher educational issues.

The present research study employed descriptive survey method with the help of both primary and secondary data. Primary data were collected through a structured questionnaire. Secondary data has been collected from published and unpublished reports on the RIA.

A sample comprised 100 undergraduates studying in Wayamba University of Sri Lanka were selected by following stratified random sampling method. Difficulty of contacting students from other Universities due to the Covid 19 pandemic situation was a limitation for this research and the students from the Faculty of Applied sciences were selected since the other students were not available at this time due to the same situation of Covid 19. Gender equality were not applicable and more female students were selected for the sample since the number of female students were high in number of students of the Faculty.

According to the findings 69% of the respondents are female and remaining 31% of the respondents are male. All the participants were from the Faculty of Applied Sciences. The majority of the participants are not aware of the RIA.

However, 38% of the respondents who were aware of the Act suggests that the contents of the RIA have not sufficiently reached the public. Majority of the participants had obtained information about RIA from other sources.

The RIA is an important legal avenue that allows Sri Lankans to scrutinize their government more closely, and to effectively participate in decision-making, and exercise active citizenship beyond elections. Since majority are not aware about RIA, there should be a mechanism to aware the general public with the involvement of different strata of society including the community of academics, library staff, legal and media personals.

Keywords: Right to information, Transparency, Accountability, Corruptions

Continuous Cycling Performance of a Mg Rechargeable Cell with a Natural Rubber Based Electrolyte

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Abstract

Natural rubber (NR) is grown in Sri Lanka at small, medium and large scales. It has been one of the major export crops since time immemorial. Other than exporting, a small amount of local rubber production is being used for some local industrial purposes. However, it is regretted that Sri Lankan NR has not been investigated for its candidacy in any application in the power and energy arena. Most of the other countries where rubber cultivations are available have deeply explored the applicability of NR as a polymer in electrolytes. Due to insulating properties of NR, suitable modification approach is essential for NR to be used in electrolytes. Such modified NR based electrolytes have exhibited very interesting performance in devices like rechargeable cells and super capacitors. This study is focused on fabricating a Mg rechargeable cell using a modified Sri Lankan NR based electrolyte.

Required amount of modified NR was dissolved in tetrahydrofuran first. The salt, magnesium trifluoromethane sulfonate was mixed with the same solvent and the two mixtures were stirred using magnetic stirring. The weight ratio of NR and salt was 1 : 0.8. After about 24 hours, it was possible to obtain a homogeneous mixture which was then poured into a glass petri dish. Electrolyte film formation took place via traditional solvent casting technique. A circular shape electrolyte sample was taken for cell fabrication. Magnesium was used as the anode. Natural graphite was mixed with activated charcoal and polyvinylidene fluoride in the weight percentage of 80 : 10 : 10. The resulting slurry was coated on a stainless steel dice to be used as the cathode. A cell of the configuration, Mg / NR based electrolyte / natural graphite was assembled. Continuous cyclic voltammetry test was done in the potential range of 0.4 V – 2.8 V and at the scan rate of 5 mVs⁻¹. Cell was cycled 500 times to evaluate the variation of the specific capacitance (C_{sc}) upon continuous charge and discharge

cycling using a Metrohm 101 potentiostat. At the beginning, the value of C_{sc} was rather low. But, it increased with continuous cycling. Scan rate plays a great role in governing the rate of charge discharge procedure of any device. Due to that reason, the scan rate of 5 mVs^{-1} may be a small value for the cell to initiate complete charge discharge operation at the beginning. Hence, a small C_{sc} could be accepted. However, upon continuous operation, cell gains maturity and as a result, an increase of C_{sc} is possible. After about 50th cycle, C_{sc} started to fluctuate upward and downward. This might be due to some reversible reactions taking place in between electrode-electrolyte interfaces and/or in electrodes and the electrolyte. A sharp drop of C_{sc} occurred around 400th cycle. But, even after that, the variation of C_{sc} was very small. This is an indication for the absence of many parasitic reactions in the cell that would totally destroy the operation if they were present. Results clearly spotlight the promising nature of the materials mainly the NR based electrolyte to serve in rechargeable cells.

Keywords: Cyclic voltammetry; Mg rechargeable cell; Natural rubber

Cyclic Voltammetry Study of Exfoliated Graphite/Polyaniline based Solid State Hybrid Capacitor

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Abstract

Polyaniline (PANI) is a promising pseudocapacitive electrode material. However, its structural instability leads to low cyclic stability and limited rate capability which hinders PANI's practical applications. Therefore, to avoid limitations and improve the electrochemical performance of electrodes, PANI can be incorporated with a carbonaceous material. Graphite is one such abundant carbonaceous material in Sri Lanka. Few layers of graphene sheets-exfoliated graphite (EG) could be obtained by a low cost method. In this study, EG/PANI composite electrodes with different PANI thicknesses and a gel polymer electrolyte (GPE) were used in supercapacitors (hybrid capacitors) and their electrochemical properties were investigated using cyclic voltammetry (CV) technique.

Graphite was exfoliated using a surfactant mediated liquid phase exfoliation method and prepared EG was deposited on conducting fluorine doped tin oxide (FTO) glass strips using doctor blade method. EG/PANI electrode series were prepared by varying PANI film thickness (0.5, 0.75, 1.0, 1.25, 1.5 μm) using galvanostatic electrochemical polymerization. Thickness was controlled by the polymerization time. GPE was prepared using polyacrylonitrile (PAN), ethylene carbonate (EC), propylene carbonate (PC) and magnesium chloride (MgCl_2).

With the CV test, optimum potential window was identified as -1.6 V to +1.8 V and the optimum scan rate was recognized as 10 mV s^{-1} . Cycling stability of the electrochemical devices was evaluated through continuous cycling for 500 cycles at the selected potential window and scan rate. From the results of the CV test, single electrode specific capacitance (C_{sc}) values were calculated.

Cyclic voltammograms obtained for hybrid capacitors reflected the features of both electric double layer capacitance and pseudo capacitance (faradic

capacitance). The presence of redox peaks on cyclic voltammograms indicates the existence of the faradic processes within the electrochemical device. Hybrid capacitors rely more on faradaic reactions associated with doping and de-doping of ions than electrostatic interactions to store charges.

For EG/PANI (0.5 μm) / GPE (PAN: EC: PC: MgCl_2) / EG/PANI (0.5 μm) hybrid capacitor, initial C_{sc} was about 38.2 F g^{-1} and it was gradually decreased with continuous cycling. The C_{sc} calculated at the 500th cycle was around 29.9 F g^{-1} which gives a capacity retention of about 78.3 % from its initial value. Degradation of the PANI on the EG surface upon continuous cycling could be the reason behind this behavior.

Table 1 shows the C_{sc} variation with thickness of PANI electrodes obtained from continuous cycling. Initial C_{sc} value was increased when PANI thickness was increased. Hybrid capacitor with 1.5 μm PANI thickness demonstrated the highest C_{sc} (75.7 F g^{-1}). Although, a high initial C_{sc} can be achieved by increasing the PANI thickness, it was unable to maintain the same pattern in capacity retention of each device after 500 cycles. All devices degrade with cycling, but the degradation rate is increasing with the thickness resulting low C_{sc} values for higher thicknesses after 500 cycles.

Table 1: C_{sc} variation with thickness of PANI obtained from continuous cycling

PANI thickness (μm)	C_{sc} (F g^{-1})			Retention after 500 cycles (%)
	1 st cycle	100 th cycle	500 th cycle	
0.50	38.2	35.3	29.9	78.3
0.75	54.6	53.5	41.7	76.2
1.00	62.9	58.7	42.9	68.2
1.25	74.3	47.6	20.4	43.0
1.50	75.7	31.6	7.70	10.1

In conclusion, obtained results showed that initial C_{sc} increases with the thickness of the PANI layer confirming that the thickness plays a major role in determining the charge storage. Additionally, modifications are required to improve capacity retention before industrialization.

Keywords: Composite electrodes; cyclic voltammetry; exfoliated graphite; hybrid capacitor; polyaniline

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Design and Simulation of a Printed Dipole Antenna with double T-match structure for Passive UHF RFID Tags

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Abstract

Radio Frequency Identification (RFID) is a well-known and reliable technology for the automatic identification of objects using radio waves. In a passive system, which operates in Ultra High Frequency (UHF) band, the tag antenna harvests the energy from the reader and supplies power to turn on the RFID chip. To maximize the power transfer from the antenna to the chip, thereby improving the system performance, the input impedance of the antenna should be the conjugate of the chip impedance. The objective of this work is to design a tag antenna of which the impedance is matched with a commercially available UHF RFID chip. The simulations were done in ANSYS HFSS 10 (High-Frequency Structure Simulator).

The latest commercially available UHF RFID IC, i.e. Farsens Rocky100, with the impedance of $64 - 469j$ at 868 MHz was selected for the design. Designing an antenna with a high inductive impedance that is conjugate of the chip impedance is a challenging research task. The design was started by simulating a conventional dipole and the best possible level of matching was achieved by modifying the geometrical parameters (Design 1). The resulting input impedance is $64 + 26j$ at 868 MHz. There is very little improvement in the reactance and more inductance has to be added to match the impedance.

Hence, a T-match impedance matching network which is a combination of series and shunt inductors that boost the inductance was added to the conventional dipole (Design 2). In this method, a second, shorter dipole to which the chip is attached at the center, was connected to the main dipole at a smaller distance (s) forming a loop structure. The lengths of the dipole connected to the chip are realized as the series and shunt inductors. Hence, the geometrical

parameters of the two dipoles and the separation distance s can be adjusted to match the impedance. In this design, these parameters were optimized using parametric optimization, and the resultant input impedance after adding a single T-match structure is $64.84 + 122.72 j$. The reactance was improved up to a certain extent, but was not closer to the required reactance demonstrating that a single T-match structure is inadequate for achieving the expected high input impedance.

Hence, as the next approach, the design was modified by implementing a double T-match structure (Design 3). Figure 1(a) illustrates the equivalent circuit of a double T-match structure and the proposed antenna is shown in Figure 1(b). Parametric optimization was performed on this design and as a result, the input impedance of the antenna could be matched (i.e. $64.36 + 466.32 j$ at 868 MHz). The size of the antenna was also reduced with the implementation of the double T-match structure.

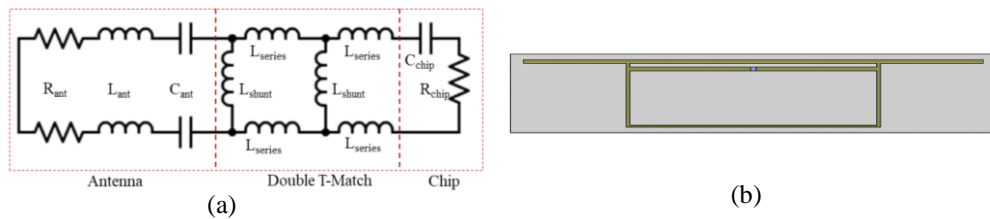


Figure 1 (a): Equivalent circuit model of double T-match structure, **(b):** Proposed antenna with double T-match structure

Performance comparison of the three designs is depicted in Table I. The optimized antenna with a double T-match structure shows good performance in terms of the power transmission coefficient, return loss and read range as well.

Table 1: Performance Comparison of Antenna Design 1, 2 and 3

Parameter	Design 1	Design 2	Design 3
$Z_{in} (\Omega)$	$64 + 26j$	$64.84 + 122.72 j$	$64.36 + 466.32 j$
Power Transmission Coefficient (τ)	0.077	0.125	0.998
S_{11} at 868 MHz (dB)	-1	-5	-55
Gain at 868 MHz (dB)	2.6	2.3	1.8
Maximum Read Range (m)	0.7	1.2	2.4
Overall Size (mm ³)	$152 \times 7 \times 1.6$	$140 \times 13 \times 1.6$	$130 \times 21 \times 1.6$

Keywords: Double T-Match; Passive RFID; Printed dipole

Design of a Low Power and High Efficient Rectifier Circuit for Microcontroller Based RFID Application

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Abstract

The Radio-frequency identification (RFID) is one of the fastest growing technologies in wireless communication. RFID has a wide range of applications in areas such as automated data management, tracking of objects, manufacturing process, and highway toll collection.

The objective of this research work is to design a low power and high efficient RF-DC rectifier circuit for microcontroller based RFID application. The RF-DC rectifier, also called as energy harvester, rectifies the incident RF signal and increases the amplitude to the desired voltage level.

This circuit was designed to operate in the Wi-Fi band around 900 MHz. A five stage RF-DC rectifier circuit was designed after doing design simulations in the NI AWR Design environment. There is a practical limitation on the number of stages that can be implemented, whether the cascading multiple stages of the RF-DC rectifier increases the output voltage of circuit. Therefore, the use of an ultra-low power boost converter to achieve the required voltage is proposed as a practical solution, as it will offer additional functionality of controlling the output voltage.

Many specific design considerations must be taken into account when designing the layout of the energy harvesting circuit working in high-frequency signals. Therefore, the rectifier circuit was designed using low turn-on schottky diodes (D_1, \dots, D_{10}), Ceramic Capacitors (C_1, \dots, C_{10}), load capacitor (C_L), and transmission lines. The gerber file layout generated by NI AWR software was crucial for the success of the circuit because any additional parasitic inductances introduced by the traces will alter the performance of the rectifier circuit. The five stage rectifier circuit layout is shown in Figure 1 and the component values are shown in Table 1.

The output voltage of the simulated circuit was 2.3 V and it was not enough to turn-on the low power MSP430-F1232IDW Microcontroller circuit. Therefore, a boost converter circuit needs to be used to achieve the desired output voltage of 3.2 V to turn-on the microcontroller application.

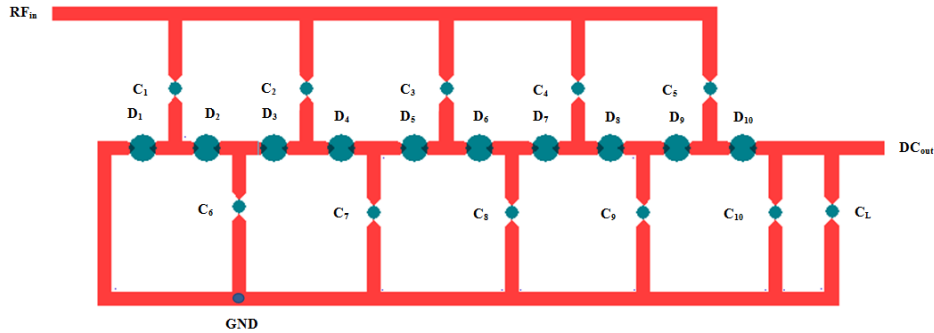


Figure 1: 5 stage RF-DC rectifier layout

The final stage of the energy harvesting circuit is a DC-to-DC converter which is a booster circuit. In order to achieve the required output voltage for the microcontroller application, a boost converter is utilized to increase the voltage level. The booster converter bq25504, (figure 2) was used as it is ideal for energy harvesting applications due to its low turn on voltage, high conversion efficiency, and power management. The boost converter has a cold-start voltage of 330 mV, and once started, can be operated at input voltages as low as 80 mV, making it ideal for low power applications.

Table1: RF-DC Rectifier circuit components

Component Name	Value
D ₁ – D ₁₀ (Schottky Diodes)	SMS7630-079LF, Max. forward voltage = 0.24V
C ₁ – C ₁₀ (Ceramic Capacitors)	10pF
C _L	1000pF

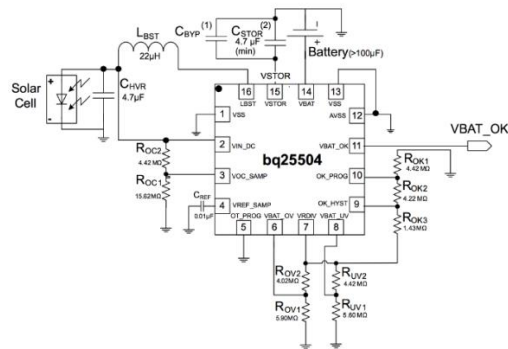


Figure 2: bq25504 Ultra Low-Power Boost Converter

Keywords: bq25504 boost converter; RFID; RF-DC rectifier

Performance of Linear Regression Estimators in the Presence of Multicollinearity and Autocorrelated Errors: A Simulation Study

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Abstract

Multicollinearity and Autocorrelation among error terms are two common problems in linear regression model fitting that leads to adverse effects on the properties of the Ordinary Least Square estimator (OLS). The OLS coefficients may be statistically insignificant, have a high variance, and become particularly sensitive to small changes in the data points due to multicollinearity among explanatory variables. This would lead erroneous results on regression estimators. Several techniques and biased estimators have been developed in the literature to overcome the effects of multicollinearity. This study intended to compare the performance of such biased estimators, namely, the r-k Class Estimator, Almost Unbiased Ridge Estimator (AURE), Liu Estimator, Almost Unbiased Liu Estimator (AULE), and r-d Class Estimator when the error terms are autocorrelated. A Monte Carlo simulation study was conducted using the R software by generating standardized correlated explanatory variables and the predictor variable in which the error term is autocorrelated with AR (1) process. Four different autoregressive coefficient values ($\rho=0.1, 0.3, 0.7, 0.9$) were chosen along with three different noise levels ($\sigma = 0.01, 1, 9$). In addition, nine different values (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9) were selected for the shrinkage parameters (k/d) of the estimators. The experiment was repeated 2000 times with a sample size of $n=30$ and the Mean Square Error (MSE) was calculated. Furthermore, the simulation was repeated by choosing an optimal value for the shrinkage parameter using the 10-fold cross-validation, and the performance of the five estimators was compared by varying the error variance and the level of autocorrelation.

Results revealed that when the error variance is less as 0.01, AULE is the best estimator within the considered shrinkage parameter range for low autocorrelation values. In the same instance, the MSE values of the AURE estimator were higher than those of the other estimators. However, with the shrinkage parameter k/d increased, the AURE performed better than the other four estimators under moderate autocorrelation. The r-k and r-d class estimators, on the other hand, outperform other estimators for high autocorrelation values. The r-d class estimator performed better when the shrinkage parameter $k/d > 0.05$. Regardless of the extent of autocorrelation, the r-k and r-d class estimators beat other estimators when the error variance was as high as $\sigma = 1$ or 9. And among the two, the r-d class estimator showed better performance where the shrinkage parameter, $k/d > 0.5$. Furthermore, in every case where the shrinkage parameter has an optimal value, the r-k class estimator and r-d class estimator performed the best. The results conclude that for low error variances, the performance of the estimators is subject to the level of the autocorrelation and the value of the shrinkage parameter. But in the instances where the noise level is high and has an optimal value for the shrinkage parameter, r-k class and r-d class estimators outperform all the other estimators. Finally, when dealing with multicollinearity and autocorrelation at the same time, this study suggests that the level of autocorrelation, error variance, and shrinkage parameter all play a role in identifying the best biased estimators among the examined estimators.

Keywords: Autocorrelation; Bias estimators; Mean squared error; Multicollinearity

Section C

Livestock, Fisheries, and Nutrition

An Alternative Approach to Simplify the Traditional Purification Step of Collagen Extraction Protocol

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Abstract

Collagen, the major structural protein of connective tissues, has been widely utilised as a material for food, medical, cosmetic, and pharmaceutical applications. By now, 29 types of collagen have been identified and among those, type-I collagen has a greater scientific and industrial interest. Recently, wider scientific attention had been gained by fish collagen as traditional mammalian collagen is reported to be having zoonotic diseases. However, complicated and expensive extraction processes of fish collagen have hindered its wider industrial usage.

One of the main drawbacks associated with the conventional fish collagen extraction process is its complicated, lengthy and costly purification step which involves dialysis. Modification of the purification step has been given only a little consideration among researchers, therefore the focus of this study was to modify the purification step for a simple and cost-effective alternative.

Skin off-cuts of yellowfin tuna (*Thunnus albacares*) obtained from a seafood processing plant in Ja-Ela was used to modify the purification step. The methods described by Nagai and Suzuki (2000) and Muralidharan et al., (2013) were used as the reference methods to extract the collagen. The purification step in these methods was replaced by the purification technique proposed by Tan and Chang (2018) with slight modifications. In this way, 24 – 48 hours dialysis step proposed by Nagai and Suzuki (2000) was replaced by the 4-6 hours washing step with cold distilled water. The main purpose of the purification step is to remove residual sodium chloride (NaCl) and acetic acid in increasing the quality

of extracted collagen. At the washing step, the effectiveness of the washing to remove residual NaCl was evaluated by measuring the NaCl concentration of the final washed water using a refractometer. The effectiveness of removing acetic acid residues was confirmed by analysing the Fourier transform infrared spectroscopy (FTIR) spectra. Furthermore, yield estimation and Scanning electron microscopy (SEM) images were used to compare the quality of final products from the two methods.

The percentage of collagen yield from the dialysis and washing steps was 63.06% and 64.83% respectively on a dry-weight basis. The FTIR results proved that the extracted collagen from both methods was type-I and preserved the characteristic native triple helical structure of collagen. The SEM images confirmed the pore structure of collagen with the coil-like fibrils from resulted from both techniques. The zero refractometer reading indicated the absence of NaCl in the final washing water. The absence of carbonyl and methyl functional group of acetic acid represented by the absence of C=O stretching peak in between $1700 - 1725 \text{ cm}^{-1}$ and CH_3 asymmetric stretching peak in between $2952 - 2972 \text{ cm}^{-1}$ in FTIR analysis using the collagen extracted by both purification techniques, confirmed the purity of extracted collagen concerning the acetic acid.

This study indicated the possibility of using the new cheap washing step effectively to remove NaCl and acetic acid. However, a scale-up study is needed to develop for the industrial level.

Keywords: Dialysis; Fish skin; Method modification; Purification; Type-I collagen

Acknowledgements: *This work was funded by the development-oriented research grant (AHEAD/DOR-80/AQF/WUSL) through AHEAD grant scheme.*

An Approach to Minimise Energy and Chemical Usage in Chitosan Extraction

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Abstract

The shellfish processing industry adds a higher amount of waste as it contains only relatively less amount of edible meat. However, the non-edible shell portion contains valuable bioactive compounds which have been subjected to many studies for decades. Shell biorefinery is one such approach in which shellfish are fractionated and various compounds are extracted to upgrade into value-added products.

Taken into that concept, shrimp, a popular shellfish, waste is now being utilized worldwide for chitosan extraction. However, in most developing countries, high energy and chemical usage for the extraction process limits its industrial applicability. Thus, the present study tried to minimise the chemical and energy usage in the well-established heating extraction method. Shells of *Litopenaeus vannamei* (whiteleg shrimp) were used for extracting chitosan by using the method we modified and its efficiency was compared with the established heating extraction method described by Yen et al (2008) with respect to quantity and physicochemical quality of extracted chitosan.

In the modified method, whiteleg shrimp shell waste was first demineralised using 1 M HCl at room temperature for 6 hours. After neutralisation, the shells were filtered out and soaked in 40% NaOH solution at 1:15 (w/v) ratio for 24 hours to facilitate deproteinization and decolourisation of pigments. After 24 hours the same solution was subjected to 2 hours of heating at 100 °C to facilitate deacetylation. Finally, oven drying was used instead of freeze-drying for the

recovery of chitosan. Physicochemical properties were then characterised at Attenuated Total Reflectance (ATR)-FTIR, X-ray diffraction (XRD), Scanning electron microscopy (SEM), and Thermogravimetric analysis (TGA).

The yield of chitosan extracted from the established and the modified methods was respectively 33.53% and 33.34%. Both the methods showed similar band patterns and peaks in FTIR, and XRD spectrum confirming the unaltered structure of extracted chitosan. The degree of deacetylation (DDA) of the established method was 80.43% while for the modified method it was 80.22% revealing that the modifications had not been affected the DDA value of chitosan. The XRD patterns show only two characteristic broad diffraction peaks at (2θ) 9.92 and (2θ) 20.05, for chitosan extracted with the modified method, which are typical fingerprints of semi-crystalline chitosan. Chitosan from both methods showed similar porous structures in their SEM image at 5.00 K x magnification may be due to the removal of calcium carbonate during the demineralisation step in the extraction process. The apparent viscosity of the modified method was higher ($554.83 \text{ cP} \pm 1.04$) than that of chitosan extracted from the established method (435.87 ± 1.02) ($p=0.000$). The ash content of chitosan was slightly less than that of the established method ($0.95\% \pm 0.82$) than the modified method (435.87 ± 1.02), ($p=0.796$).

Results revealed that the extraction protocol modifications have not adversely affected the ultimate quantity and quality of extracted chitosan. The modified method reduces the heat and chemical requirement respectively by ~60% and ~6%. Hence the modified simple method would be a promising chitosan extraction method for future industrial usage.

Keywords: Chitosan; Extraction; Method modification; Shrimp shell waste

Acknowledgements: *This work was funded by the development-oriented research grant (AHEAD/DOR-80/AQF/WUSL) through AHEAD grant scheme.*

Changes in Carbohydrate Composition and Functional Properties of Three Millet Species; *Panicum millaceum*, *Paspalum scrobiculatum* and *Setaria italica* as Affected by Germination

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Abstract

Food security is an important fact that needs to ensure for maintaining proper global nutritional and health status. It is required to make food more available, accessible and affordable for people. Thus, the interest in underutilized or neglected food crops has been raised. There are several number of underutilized food crops available in Sri Lanka. *Panicum millaceum* (Proso millet), *Paspalum scrobiculatum* (Kodo millet) and *Setaria italica* (Foxtail millet) belong to the family Poaceae and are considered underutilized cereal crops. Improving the nutritional and physicochemical properties of food crops is very important similar to introducing novel food sources to food industry. Thus, germination is an effective and inexpensive technique that may improve the nutritional value of cereals while altering functional properties. The objective of this study was to evaluate the effect of germination on carbohydrate composition and functional properties of selected three millet species and discuss the potential of incorporating them in functional food formulations.

Selected millet grains were soaked in distilled water before being kept in a dark environment for 72 h for germination. Flour preparation and starch isolation were done from germinated and non-germinated millet grains and stored at -20°C until further analysis. Total starch, amylose, amylopectin, total dietary fiber (TDF), resistant starch (RS) were analysed for carbohydrate composition and water holding capacity (WHC), oil holding capacity (OHC), swelling power, water solubility and gelatinization parameters were analysed under functional properties. All analyses were conducted according to standard analytical methods. Statistical analysis was done using SPSS 16 software.

A significant decrease ($p < 0.05$) in the total starch content was obtained after germination of all three millet species. Starch content of *P. millaceum*, *P. scrobiculatum* and *S. italica* were decreased from 70.9 ± 1.3 to $60.8 \pm 0.67\%$, 63.5 ± 0.7 to $56.2 \pm 1.2\%$ and 61.7 ± 1.2 to $53.4 \pm 1.6\%$, respectively. Amylose and amylopectin are the main biopolymers of starch and they were significantly ($P < 0.05$) decreased upon germination. The reduction of total starch, amylose

and amylopectin contents in germinated millet grains occurred may be due to increase of α amylase enzymatic hydrolysis on starch to form simple and more absorbable sugars in respiration metabolism to provide energy for germinating seedlings. TDF was significantly ($p<0.05$) increased in all three species of germinated flours and they increased from 8.70 ± 0.12 to $19.01\pm0.40\%$ in *P. millaceum*, 8.11 ± 0.88 to $17.94\pm0.22\%$ in *P. scrobiculatum* and the highest increment was observed in *S. italica* as from 14.18 ± 1.32 to $32.93\pm0.85\%$. During the germination process, the structure of the polysaccharides in the cell wall matrix gets modified to induce a new primary cell wall and this may increase the TDF contents. All selected millet species contained a considerable amount of RS ranged from 2.63 ± 0.14 to 4.70 ± 0.26 . However, during germination, the starch molecules become loose, smooth and susceptible to degradation by amylolytic enzymes. Thus, some proportion of RS could be undergone degradation and that may be the reason for reducing RS content in isolated starch from germinated grains in this study. After germination, the results exhibited a significant increase ($p<0.05$) of WHC in all three species. The increment was ranged as 2.77 to 3.88 (g/g) for *P. millaceum*, 2.08 to 3.50 (g/g) for *P. scrobiculatum* and 3.25 to 5.87 (g/g) for *S. italica*. Dietary fiber content is one of the major factors that affect the WHC of particular flour. Increasing dietary fiber contents in germinated grain flours could be the possible reason for increasing WHC in germinated flours. OHC was significantly ($p<0.05$) increased with germination and it was changed as 1.51 ± 0.24 to 1.96 ± 0.15 (g/g), 1.47 ± 0.12 to 1.77 ± 0.13 (g/g) and 1.38 ± 0.85 to 1.56 ± 0.33 (g/g) in *P. millaceum*, *P. scrobiculatum* and *S. italica*, respectively. Swelling power and water solubility were significantly ($p<0.05$) decreased in all three cereal flours after germination. Peak gelatinization temperature was significantly ($p<0.05$) increased after germination and it was increased from 72.91 to 77.40°C, 75.41 to 75.93°C and 75.02 to 76.40°C in *P. millaceum*, *P. scrobiculatum* and *S. italica*, respectively. During germination, activated various enzymes may cause a significant increase in hydrolytic end products which compete with starch for available water and a consequent reduction in water activity, resulting in an increase in the gelatinization temperature. Studied species of millet; *P. millaceum*, *P. scrobiculatum* and *S. italica* are consisting of functional ingredients such as dietary fiber and RS with acceptable functional properties. Germination has changed all studied parameters and overall, germination can be applied to increase nutritional value of studied cereal flours with altered functional properties in order to prepare functional food products.

Keywords: Functional properties; Germination; *Panicum millaceum*; *Paspalum scrobiculatum*; *Setaria italica*

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Characterization of Physicochemical and Volatile Compounds in the Ethanolic Extract of *Syzygium cumini* (Indian Blackberry) Oleoresin

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Abstract

The natural beverage industry is a rapidly developing sector at a growth rate of 16% per annum. *Syzygium cumini* is a seasonal berry variety cultivated in the Indian subcontinent, and the berries impart a bright purple colour and strong therapeutic effects. However, the seasonality of fruits and the massive post-harvest losses exceeding 40% are significant constraints against the consistent production of beverages. To overcome the issues, the extraction of oleoresins has become a trend in the food industry due to the high stability, enhanced shelf life and convenience in storage, transportation and blending in product formulations. The oleoresin extraction by organic solvents is minimally applied in the industry due to the strict regulations on the residue solvent levels. Ethanol (96%) is recommended by the Food and Drug Administration (FDA) as a solvent in food applications at a maximum residue level of 5000 ppm. Oleoresins possess most of the bioactive compounds that fresh berries consist of within a moisture-free matrix. Therefore, the application of oleoresins is industrially feasible. The extraction mechanism significantly impacts the yield and the quality parameters of oleoresins, whereas both conventional and novel extraction mechanisms are currently applied. The nutritional properties of Indian blackberry have been prominently identified as anti-diabetic, anti-microbial and improving the complexion. The presence of phytochemical compounds enhances the therapeutic effect while a significant antioxidant potential has been reported. However, it is essential to profile the phytochemical contents to highlight the nutritional value and attract the health concerning customer segment. Soxhlet extraction is the most applicable mechanism in the industry based on simplicity, high yield and low operational costs. Initially, ripen flesh berries were collected and Screened by the colour parameters (a^* value $> +6.00$). Then manually separated into flesh and seeds to analyze the

compositions separately. Samples were freeze-dried to prevent the degradation of phytochemicals, and oleoresins were extracted from 10.00 ± 0.05 g (400-micron mesh) of the sample by the soxhlet apparatus with ethanol as the solvent. The residual solvent was removed by rotary evaporation, and the remaining solvent content was quantified by High-Performance Liquid Chromatography (HPLC). The oleoresin yield was calculated as a mass fraction (w/w). The volatile compounds were extracted from the oleoresin by hydro distillation with the Clevenger arm apparatus. The Total Phenolic Content (TPC) was calculated spectrophotometrically using Folin Ciocalteu reagent and expressed as Gallic Acid Equivalent (GAE). The Total Flavonoid Content (TFC) was analyzed by the spectrophotometer and presented as Rutin Equivalent (RUE). The results elucidate that the TPC of flesh (111.40 ± 0.28 mg GAE/g of extract) is significantly higher than seeds (79.01 ± 0.53 mg GAE/g). As per TFC, the flesh exhibited the highest concentration (1.43 ± 0.15 mg RUE/g of extract), followed by the seeds (0.27 ± 0.61 mg RUE/g). The oleoresin content of the flesh ($8.34 \pm 0.28\%$) was significantly higher than that of the seed ($6.58 \pm 0.78\%$). However, the analysis of $L^* a^* b^*$ values by chromameter indicated the drastic variation of a^* of the flesh and seed as 8.34 ± 0.09 and 2.57 ± 0.02 , respectively. The a^* value indicates the redness of the sample, and the presence of anthocyanin in the flesh may have resulted in the dark red colour. The composition of volatile oil varied from $2.78 \pm 0.12\%$ to $3.09 \pm 0.28\%$ in the flesh and seed samples, respectively. According to HPLC analysis, glycerone is the main bioactive compound in the oleoresins of both flesh and seed with the compositions of $26.22 \pm 0.87\%$ and $17.59 \pm 0.98\%$, respectively. Glycerone is a derived compound of glycerin and generates a natural sweetening potential. The results conclude that the oleoresin from the flesh provides strong phytochemical and sensory properties, and therefore, the product formulations from the flesh are more feasible than seeds.

Keywords: Ethanol; Oleoresin; Phytochemicals; Volatile oil

Cost of Jellyfish: Human Well-Being, Impacts and Local Remedies from Sri Lanka

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Abstract

Even though jellyfishes are considered to be a highly potential untapped economic resource, many cultures perceive them as harmful to humans and refer as “pests”. Therefore, evaluating the causes of these negative perceptions is important to evaluate the cost of jellyfishes in contrast to their benefits. These adverse impacts of jellyfishes are depended on the species, bloom size, season, frequency, duration and location of their occurrence in the coastal waters around Sri Lanka (Plate 1), but so far no studies have been conducted on their adverse impacts. Therefore, this study evaluated how the negative impacts of jellyfish affect fisheries and tourism based on the perception of stakeholders at the northern, eastern, southern and western coasts of Sri Lanka.

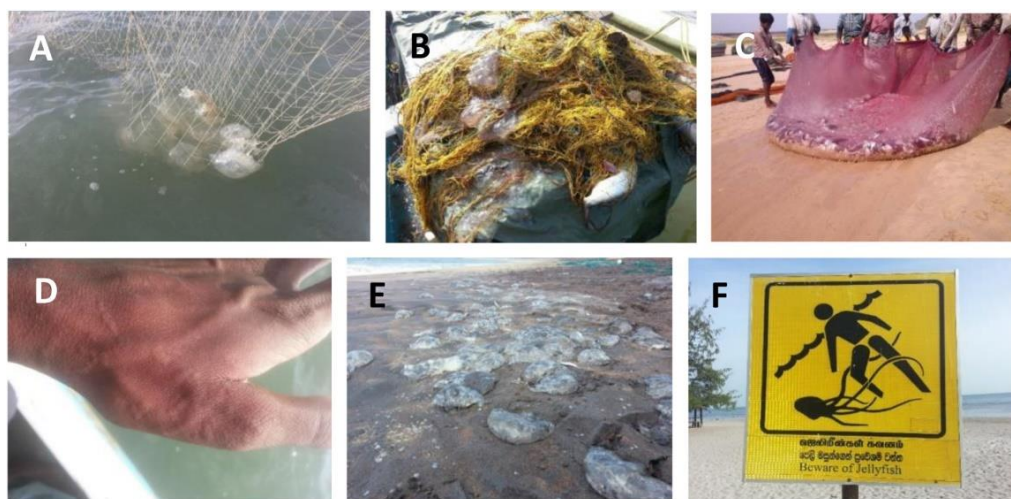


Plate 1. Adverse jellyfish impacts reported from Sri Lanka: a gillnet (A), trammel net (B) and beach seine (C) clogged by jellyfish; the hand of a lagoon fisher stung by jellyfish(D); stranded harmful box jellyfish on a beach (E); a jellyfish warning signpost displayed at a recreational beach in northern Sri Lanka (F).

The major adverse impacts on fishery were evaluated under “health issues on fishers”; “prevention/distant fishing”; “clogging/damaging fishing gear”; “reduction of fish catches or requirement of extra hauls” and “increased sorting time” based on the perceptions of fishers, for four types of fishing operations i.e., netting; hook & lining; trapping; and picking/spearing. While based on the stakeholders who engaged with tourism and related recreational activities the impacts on tourism were evaluated under “health issues”; “limitation/distant recreation”; “damages to the equipment”; “offensive stress in recreation” and “requirement of additional cost for protection”. A semi-structured questionnaire was used when interviewing randomly selected stakeholders ($n = 30$ from each category representing each coastline), from June 2016 to April 2018. Means values of the response scores were compared by using nonparametric Kruskal-Wallis test. Additional information, such as troublesome jellyfish species, traditional remedies for jellyfish stings were also gathered during interviews. Moreover, author observations on impacts during the study period were also tabularized with literature.

At all the study sites, netting was the most affected fishing operation in both the estuarine and marine waters while underwater recreation was reported to be the most affected tourism-related activity. Health issues and prevention of regular activities were the highest adverse impacts at marine/estuarine fisheries and tourism-related activities. The Kruskal-Wallis test resulted that the impacts of jellyfish among four coastlines with respective to each coastal industry are not significantly different at $p = 0.05$ level.

Based on primary and secondary information, the adverse impacts of jellyfishes have been largely reported from the northeast and southwest coasts of Sri Lanka. The estimated degree of impacts of cnidarian jellyfish (medusae and siphonophores) on marine fisheries, estuarine fisheries and coastal tourism were ~50%, 80% and 90% respectively, while the rest of the impacts were caused by ctenophore (comb jellies) and chordate jellyfishes (pelagic tunicates). In general, the most troublesome jellyfishes in marine fisheries, estuarine fisheries and coastal tourism were *Chrysaora caliparea*, *Acromitus flagellatus* and *Physalia physalis* respectively. Applying vinegar, sand, kerosene, tamarind, and a paste of *Ipomoea pes-caprae* leaves; washing with freshwater or seawater; and drinking urine, were amongst the traditional remedies practised for jellyfish stings in Sri Lanka.

Keywords: Bycatch species; Clogging agents; Marine stingers; Opinion survey

Curriculum Analysis and Development of a Validated Tool to Measure Food Literacy Level of Secondary School Children

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Abstract

Food literacy education of secondary school children supports their proper growth and development through healthy dietary behaviors while establishing good relationships with the modern food system as informed consumers. A well-designed school curriculum is a crucial element in food literacy education. Evidence on food literacy levels among secondary school children is limited. Therefore, it is essential to measure the levels and gaps in food literacy of school children. The objectives of the present study were (1) to carry out an in-depth analysis of the junior secondary school (Grade 6-11) food and health curricula and (2) to develop a tool to measure the level of the food literacy level of 13-16 years-old school children in Sri Lanka.

A list of food literacy sub-components (n=34) supposed to be taught in schools was extracted from a literature search. Then, they were categorized under three major components namely; (1) food system from farm to plate, (2) food, nutrition, and health, and (3) broad context of the food system including social, economic, cultural, environmental and political aspects of food. The importance of food literacy sub-components was examined by a purposively selected panel of food and nutrition experts (n=17) using a seven-point Likert-type questionnaire (range: extremely important – extremely unimportant). The data was quantitatively analyzed for the levels of consensus within the expert panel using the Fuzzy Delphi method. Fuzzy scores calculated for subcomponents using a standard formula were above the cut-off value of 0.5 showing all subcomponents had gained expert consensus. Food and nutrition-related content (learning outcomes) in Science, Health and Physical Education, Home Economics, Technical and Practical Skills, and Agriculture and Food

Technology subject curricula were mapped against this list of food literacy sub-components. The results of the curriculum mapping showed that current food literacy curricula contain 31 out of 34 sub-components.

A validated tool was developed to assess the food literacy level of school children. Seven food literacy domains (knowledge, skills and behaviors, food/health choices, culture, emotions, food systems, and eating) were identified through literature review and, 105 items (questions) were generated to be included in the tool. Then, the items were narrowed down to 74 through a brainstorming session conducted with five university academics in the nutrition field. The content validity of the items was evaluated using an expert panel (n=11). The Content Validity Index (CVI) and Content Validity Ratio (CVR) was calculated for each item, and items with a CVI and CVR > 0.78 and > 0.59, were selected to be included in the tool respectively. Face validity was evaluated by conducting two focus group discussions with grade 9 (n=8) and grade 10 (n=6) students. Finally, a validated tool consisting of 47 items representing 7 domains was developed to assess the level of food literacy of Sri Lankan secondary school children.

In conclusion, curriculum mapping revealed that the existing food literacy curricula include most of the sub-components identified by the food and nutrition experts as essential for junior secondary school curricula. However, since we analyzed only the declared curriculum (curriculum that is assumed to be learned by the student), which may differ from the delivered (what is taught) and received (what is learned by the student) curricula, therefore further studies are needed to evaluate the food literacy education in secondary schools. The developed validated tool can be used to assess the food literacy level of junior secondary school children.

Keywords: Curriculum mapping; Food literacy; Junior secondary school; Validated tool

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Development of an Educational Curriculum for Self-Management of Type 2 Diabetes

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Abstract

Glycaemic control is the central focus of diabetes management. Lifestyle modification plays a pivotal role in achieving the proper glycaemic control of type 2 diabetes patients. Self-management of the diabetic condition by the patient is a timely requirement. It ensures the sustainability of lifestyle modification and the accompanied good glycaemic control. However, educating the diabetic patients on self-management of the diabetic condition is scarce in Sri Lanka. Therefore, the current study aimed to develop an educational curriculum which focuses on the lifestyle management of diabetic condition through promoting self-management education.

This qualitative study was conducted as three phases. As the first phase, knowledge and perceptions of type 2 diabetes patients on self-management of diabetic condition were collected using structured individual interviews. Using an online questionnaire, perceptions of the health care professionals of the diabetes management team on self-management of diabetes were collected. Panel consisted of diabetologist ($n=1$), general practitioners ($n=5$), dieticians ($n=5$), diabetes education nurses ($n=5$) and diabetes researchers ($n=2$). In addition to the perceptions of healthcare professionals on self-management, their comments and suggestions on delivering the self-management education and contents to be included in an education curriculum were identified. Using views of health care experts of the diabetes management team and diabetic patients on self-management, education curriculum was developed as the second stage. Validation of the developed curriculum was done with a panel of diabetes management experts ($n=15$) including general practitioners, dieticians and diabetes education nurses as the final phase. Those experts were used in evaluating the contents of the developed curriculum using online individual interviews and online questionnaire. The curriculum was developed as a booklet

with Adobe Page Maker software and graphic designs were done with Adobe Photoshop 2020. Informed consent was obtained from both the diabetes patients and expert panel involved in diabetes management prior to the data collection. Item content validity index and scale content index were derived for the developed curriculum in the validation phase.

According to the comments and suggestions received from experts of the diabetes management team and diabetes patients, eight subchapters were identified for the diabetes curriculum including “What is diabetes”, “How to manage diabetes”, “How to manage your diet”, “Role of physical activities in your blood sugar control”, “How you can manage the stress”, “Effect of alcohol and smoking on your blood sugar control”, “Barriers for your diabetes management plan and how you can overcome them” and “How you can continue the self-management to achieve proper blood sugar level”. First chapter contains the necessary basic information to understand the pathophysiology of diabetes. Second, third, fourth and sixth chapters are focused on management of diabetes through adhering to a healthy lifestyle. All the essential information and guide necessary for shifting and following a healthy lifestyle pattern is provided comprehensively in those chapters. Chapter five has the guide to minimize and manage the stress as it is vital to manage stress to achieve the proper glycaemic control. The last two chapters emphasize the importance of self-management; possible barriers for adapting the self-management and method of overcoming the barriers to ensure the sustainable self-management plan. Further, the final chapter highlights the approaches of continuing the self-management through knowledge gained on healthy diet, active and healthy lifestyle and managing the stress. Validation index values were 0.80 for the item specific validation and 0.94 for scale specific content validation.

The developed curriculum can be used effectively in improving the current diabetes education programmes. However, it is necessary to convert the scientific information presented in this curriculum to simple and easily understandable content in the delivery. Further, patient motivation should be an integral part in promoting the self-management education thus patient empowerment is the cornerstone. Therefore, it is necessary to develop effective educational materials to deliver the contents of the formulated curriculum.

Keywords: Curriculum; Diabetes; Education; Self-management

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Dietary Saturated and Unsaturated Fatty Acids Intake among Sri Lankan Adult Men

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Abstract

Cardiovascular disease (CVD) is the number-one cause of death and disability worldwide. The rapid rise in CVD is especially prominent among South Asians and they have greater evidence of risk of dyslipidemia and hypertension. There is a proven link between increase consumption of saturated fatty acid (SFA) towards elevation of LDL cholesterol which is a significant CVD disease risk parameter. Proportionally higher intake of (6-11% from total energy) polyunsaturated and monounsaturated fatty acids (PUFA & MUFA) than SFA (<10% from total energy) are found to be cardio protective. Hence, it is imperative to assess the dietary fat composition and fat consumption pattern of Sri Lankan adult men. This study aimed to assess the saturated and unsaturated fatty acids intake among Sri Lankan adult men as a part of ongoing research study.

This study was conducted among 176 apparently healthy adult men age between 30 to 60 years, recruited from Wayamba university of Sri Lanka both Makadura and Kuliypitiya premises, nearby villages, government and private institutions surrounding the university. Information on sociodemographic characteristics and CVD risk factors were gathered using an interviewer administered questionnaire. Dietary fat intake was determined using a 3-day diet diary including non-consecutive two week days and one weekend day, food frequency questionnaire and a short in-depth questionnaire on dietary fat consumption pattern. Nutrient intake and dietary fat composition were assessed using FoodBase 2000 nutrient analysis software modified for Sri Lankan foods. All anthropometric and blood pressure measurements were taken using standard equipment and techniques.

Mean age (SD) of the study participants were 42 (± 8) years and 47 % of them were either skilled or semi-skilled workers. Total daily fat intake was 57.6 g and it was 25 % from their total energy intake. Mean intake of SFA, MUFA and PUFA was 38.3 g, 6.8g and 3.1g respectively. Percentage contribution towards total energy intake of respective fatty acid were 16.3%, 2.9% and 1.4% accordingly. These actual intake values were significantly different from the recommended levels established by the WHO which are < 10 % energy from SFA and $> 6-11\%$ from PUFA. The most common SFA source in their usual diet was coconut in which it derived in the form of coconut milk. The most frequent PUFA sources were small fish and green leafy vegetables while MUFA derived from peanuts was most prominent. However, almost all the participants consumed coconut in the form of coconut milk everyday while 57% of them consumed small fish at least three times per week and only 9% individuals eat peanuts at least once a week. Compare to coconut consumption, usage of other SFA sources such as butter, margarine and red meats among the study group was at a very low level. There was a higher proportion of participants (59%) who consumed bakery items either bread, biscuits or buns at least once a day which may contribute apparently towards their SFA intake. The most common added oil source among study participant was coconut oil. There were only 6-8 % of participants' households using either sunflower or olive oil in their cooking purposes along with coconut oil. Mean BMI and waist circumference of the study group were 24.3kg m^{-2} and 89.3 cm respectively. Mean systolic and diastolic blood pressure were 128mmHg and 78 mmHg respectively. As per BMI cut off values for Asians 56% of study individuals were in either overweight or obese category. Similarly, based on waist circumference cut off values for Asians, 59% of study individuals were centrally obese.

These findings reveal habitual intake patterns of saturated and unsaturated fatty acids among the study group do not adhere to the recommended dietary guidelines for a heart healthy diet by WHO. Proper manipulation of both quantity and quality of fatty acids in the diet is warranted to reduce the CVD risk burden among Sri Lankan adult men.

Keywords: Adult men; CVD; SFA; Unsaturated fatty acids

Ethical approval for this study was given by the Ethics Review Committee of Sri Lanka Medical Association (ERC 20-011).

Acknowledgement: *This study was supported by the Wayamba University Research Grant (SRHDC/RP/04/19/05). Refer page 162 of the appendix for further details.*

Effect of Germination on Physicochemical and Functional Properties of Legume Seed Flours of *Canavalia gladiata* and *Mucuna pruriens*

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Abstract

Legumes are an affordable source of protein for the human diet worldwide and recognized as with numerous health benefits. *Canavalia gladiata* and *Mucuna pruriens* are legume varieties, underutilized due to lack of awareness of suitable processing methods to reduce their anti-nutrient effect. Germination has been considered as effective for improving the protein quality and reducing the contents of various anti-nutritional factors in legumes. Moreover, germination significantly affects the seed's biochemical and nutritional composition, sensory and physical characteristics since it utilizes seed reserves by degrading compounds to generate new constituents. The successful performance of legume seed flour as a food ingredient depends on the functional characteristics, such as foaming, emulsification, gelation, water and oil absorption capacities, and gelatinization. The study investigated the effect of germination on physicochemical and functional properties of seed flour of *C. gladiata* and *M. pruriens*.

Germinated and non-germinated legume seeds were dried and ground into fine powder. The proximate composition, selected mineral content, amino acid profile and functional properties such as water (WHC) and oil holding capacities (OHC), swelling power (SP), emulsifying activity (EA), emulsion stability (ES), foaming capacity (FC), foam stability (FS) and thermal properties were evaluated.

Significantly higher crude protein content (26.09-27.89 %) was detected in both *C. gladiata* and *M. pruriens* germinated seed flours compared to the non-germinated seed flour of the same variety (22.29-24.31 %). Both germinated and non-germinated seed flour of *M. pruriens* had the highest crude fat content (2.59

%). The increase in crude fibre content (5.00 %) after germination of *C. gladiata* was significant. *C. gladiata* had the highest content (2.0 mg/kg) of Selenium and *M. pruriens* seed flour had the highest contents of Iron (57 mg/kg), Copper (10 mg/kg), Zinc (28 mg/kg) and Manganese (17 mg/kg). All minerals analyzed were reported in increased quantities for germinated samples, compared to the non-germinated. When considering the amino acid profile, Glutamic acid had scored the highest in germinated (2.56–2.97 g/100 g) and non-germinated (2.26–3.00 g/100 g) seed flour of both varieties. Aspartic acid was the second-highest amino acid found in increased content in germinated (2.39–2.89 g/100 g) than in non-germinated (1.97–2.69 g/100 g). The highest SP was recorded for non-germinated *C. gladiata* seed flour at 80 °C while its germinated fraction showed a reduction in SP at all temperatures. Also germinated fraction of *C. gladiata* seed flour showed the highest SP at 90 °C indicating an increment in the gelatinization temperature range. However, both non-germinated and germinated *M. pruriens* seed flour had their highest SP at 90 °C, while the germinated fraction showed a reduction in SP compared to the non-germinated fraction. The highest WHC was reported for non-germinated *C. gladiata* seed flour (2.62±0.21 mL/g). Except for the lowest OHC (0.85±0.12 mL/g) recorded for non-germinated *M. pruriens* seed flour, both non-germinated and germinated *C. gladiata* and germinated *M. pruriens* seed flour had similar OHCs. There was a significant difference among FC of all tested samples and the highest FC was recorded for germinated *C. gladiata* seed flour. However, there wasn't any significant difference among the FS of both non-germinated and germinated *C. gladiata* seed flour. The highest EA was found in both non-germinated and germinated *C. gladiata* seed flour. *M. pruriens* seed flour had lower EA which further decreased after germination of seeds. The ES did not change significantly after germination in both *C. gladiata* and *M. pruriens* seed flour. In addition, all experimental samples indicated peak gelatinization temperature within the range of 79.54 - 85.36 °C. However, the peak gelatinization temperature of both *C. gladiata* and *M. pruriens* germinated seed flour was increased when compared to their non-germinated samples. It may be inferred that germination had a significant effect on physicochemical and functional properties of *C. gladiata* and *M. pruriens* legume seed flour. Hence, with improved protein content, mineral content, amino acid profile and functional properties, germinated legume seed flour may be effectively utilized for functional food product development.

Keywords: Amino acids; Functional properties; Germination; Legumes; Mineral

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Effects of Preheating Time on Yield and Quality of Fish Oil Extracted from the Wet Reduction Process

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Abstract

Marine fish oils are good sources of polyunsaturated fatty acids which are extensively used for food, feed and pharmaceutical purposes. Many studies have focused on extracting fish oil using various methods, but the wet reduction process is a popular industrial method as it is environmentally safe. However, the evaluation of the effect of preheating in the wet reduction process for fish or fish by-products is scanty. Further, the use of offcuts from fish processing plants for extracting fish oil has also been rarely discussed. Therefore, this study evaluated the effects of different preheat treatments of the wet reduction process on the yield and quality of oil extracted from yellowfin tuna (*Thunnus albacares*) heads, which is a common offcut in fish processing.

As the preheat treatment, two heating methods; steaming and autoclaving were tested under three heating times (15, 30 and 45 min). A simple wet reduction process was used for fish oil extraction under laboratory conditions by pressing and centrifuging. The effect of each treatment was evaluated by comparing yields. The chemical quality of extracted oils was examined by free fatty acids (FFA), acid value (AV) and peroxide value (PV) using AOCS methods and oil colour was determined by CIE L*a*b* coordinates. Further, the presence of functional groups in the crude oil was determined by the Attenuated total reflectance- Fourier transforms infrared (ATR-FTIR) spectrometry.

The resulted yields for steaming (100 °C) at atmospheric pressure under 15, 30 and 45 min. were 3.20±0.16%, 3.54±0.30% and 3.78±0.14% respectively

($P=0.000$). Whereas, autoclaving ($121\text{ }^{\circ}\text{C}$) at 15 psi under 15, 30 and 45 min. resulted $4.81\pm0.45\%$, $5.37\pm0.22\%$ and $3.49\pm0.30\%$ yields respectively ($P=0.000$). Probably the reduction of yield during autoclaving at 45 min. can be due to the denaturation of proteins at prolonged heating under higher temperatures by creating a firm structure that acts as a barrier in extracting oil.

All peroxide values recorded in this study were well below the maximum allowable limit of 5 mEq/kg oil stated by the World Health Organization (WHO). The PV is a measure of hydroperoxides formation in the primary oxidation of oil thus, the lower the PV higher the stability of the oil. In the steaming method, no significant differences ($P=0.322$, $P=0.325$) were recorded in FFA and AV with increasing pre-heating time. In the autoclaving method, the preheating time has significantly affected the FFA and AV of extracted oils ($P=0.000$) and the lowest FFA and AV were recorded at 15 min and 30 min. In both preheat treatments, AV exceeded the maximum allowable limit of 3.0 mg KOH g^{-1} specified by the WHO. Both FFA and AV are standing as measures of the freely available fatty acids present in the fish oil. As higher amounts of FFA and AV signify the lower quality of the oil, thus, the excessive FFA should be removed during the refining process. The effect of heating time on colour coordinates was not significant in both treatments. All ATR-FTIR spectra confirmed the presence of important functional groups at wavenumbers of 3012 cm^{-1} , 2922 cm^{-1} and 2853 cm^{-1} confirming the existence of PUFA and those at $1,743\text{ cm}^{-1}$ representing the ester carbonyl group of triglycerides. Further, no peaks associated with the secondary products of lipid oxidation in ATR-FTIR spectra, at $3,800\text{--}3,100\text{ cm}^{-1}$, indicating the appropriate quality of extracted oil in terms of oxidation states.

This study revealed that the preheat treatment time is a significant factor in extracting fish oil by the wet reduction process. Autoclaving has produced higher yields of crude oil than steaming. However, steaming for 30 min. can be recommended for extracting fish oils from heads of yellowfin tuna for industrial applications due to the higher quality of fish oil and minimum energy consumption compared to autoclaving.

Keywords: Autoclaving; Oil extraction; Steaming; Wet reduction; Yellowfin tuna head

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Efficacy of Organic Amendments against Root Knot Nematodes (*Meloidogyne* spp.) in Sweet Potato

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Abstract

Root-knot nematodes (*Meloidogyne* spp.) are considered as the most serious nematode pest in the world and have been reported to cause 57-67% crop yield losses in untreated conditions. Chemical control has been the most popular method to manage root-knot nematodes due to its high efficacy. However, chemical nematicides have been toxic to human and environment and researchers are applying other alternatives to control root-knot nematodes. A meta-analysis identified that organic amendments can reduce root-knot nematode numbers and root galling by 63% in general compared to untreated control. Therefore, a pot trial was conducted with the most effective materials identified in the previous systematic review and meta-analysis as well as with other amendments available to growers. The objective of the study was to determine the effectiveness of selected organic amendments on improving yield of sweet potato (*Ipomoea batatas*) by reducing damage by *Meloidogyne* species. The experiment was comprised of two main factors, the organic amendment and the application rates (100 t/ ha and 20 t/ ha). The treatments included cow manure compost (composted with wood chips), fermented compost, sugarcane trash, decomposed poultry manure and a non-amended control. Each treatment contained five replicates and the black polythene pots (10 L) were arranged randomly in the green house. Six litres of ferrosol soil were mixed with the respective amount of amendment and fertilizers in a concrete mixer to fill the pot. Nutrients were adjusted to N 4 g, P 1.6 g and K 4.8 g per plant. The mixture was settled for two weeks in pots before planting. A suspension of 6000 *M. javanica* eggs extracted from 'Tiny Tom' Tomato roots was inoculated to each pot (200 eggs/ 200 mL soil) two days after planting.

The sweet potato vines were harvested ten weeks after planting. The total sweet potato root weight, vine length, shoot fresh and dry weights were collected. Whitehead tray method was used to extract nematodes from soil samples. Root-knot nematodes in roots were extracted using a water mister. Sweet potato roots were assessed for root galling referring to a 10-scale root galling index. The experiment found that sugarcane trash applied at 100 t/ ha as the most effective treatment to suppress soil root-knot nematode numbers, followed by poultry manure applied at 20 t/ ha and cow manure compost applied at both 20 and 100 t/ ha. Sugarcane trash applied at 100 t/ ha increased undamaged sweet potato yield; however, there were no significant yield improvements observed for other treatments. The dominant mechanism of action of the materials would be enhanced natural biological suppression of root-knot nematodes and release of toxic compounds (ammonia from poultry manure). Therefore, sugarcane trash (100 t/ha), cow manure compost (20 and 100 t/ha) and poultry manure (20 t/ha) can be effectively used in root-knot nematode control without affecting the sweet potato yield negatively.

Keywords: *Meloidogyne javanica*; Organic; Root-knot nematode; Sweet potato

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Elephant Movements around Maduruoya National Park; Importance of Elephant Corridors

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Abstract

Elephants are mega herbivores that require large areas to satisfy their ecological requirements, mainly food, water, breeding and shelter. To fulfil their ecological requirements elephants, move among the habitats through their traditional elephant pathways. Maduruoya National Park is home to a total of around 1000 elephants. Elephant movement /migration between habitats and large patches of forests are achieved by means of elephant corridors/link areas, (long, thin strips of forested areas, remnants of once huge habitat expansions that functioned as connectors). Month of May flags the beginning of the dry spell to Maduruoya National park, which continues till the start of October. Elephants mainly feed on grasses. Grasslands fail to produce new flush and majority of the inland tributaries, ponds and small tanks within the Maduruoya National park shrink to mere puddles and dried up riverbeds leaving only the larger reservoirs with low levels of water. As the dry season progresses, remaining water sources gradually contract and vanish away. The dry season thus marks the peak in elephant movements out of the protected area where palatable and quality food is grown by the settlers and farmers. Thence, the study was appraised to better understanding and evaluated the Human Elephant Conflict (HEC) intensity in and around Maduruoya National park by mapping the ranging pattern and area of occupancy in relation to different habitats, land use and electric fences. The elephant movement patterns were studied during the last two years using direct observation (following them and counts and dung pile counts). GPS points were geo-referenced on a 2x2 grid map of Maduruoya National park. Data from the Department of Wildlife Conservation and the observations of elephant movements from wildlife officials and surrounding community were also gathered and transferred into grid maps. Acquired data shows high utilization

and distribution around grassland habitats associated with the reservoirs and shrub land habitats during the wet season where the most palatable grass is found. As the dry season commence the decreasing water levels provide habitat to new grass patches which the elephants favour. As the flourishing river bed associated grassland patches are highly palatable other herbivores and livestock compete for the same resource. Thus as the dry season progresses the data shows more elephant movement out of the national park boundaries towards Wasgamuwa, Galoya, Flood plains and Somawathi national parks in search of nutritious fodder and mates. High visit rates are thus visible in post harvested paddy fields and crop plantations. The data revealed four elephant corridors of varied lengths connecting Maduruoya National park with four surrounding National parks which were intensively used by elephants (Not the entire corridor). Of the four, Ulhitiya, Puwakpale Hungamaloya and Mahawewa corridors that connect Maduruoya National park to Wasgamuwa, Galoya, Flood plains and Somawathi National parks respectively sit within the land owned by Sri Lanka Mahaweli Authority. Human and elephant deaths and property damage data also support the elephant distribution pattern data obtained showing high human elephant interactions. This is indicative of the high usage of the mentioned corridors by elephants in moving between the aforementioned national parks. Ulhitiya with 35.5km and Hungamaloya with 39km constitute the largest corridors in Maduruoya National park based on land area. Puwakpale (Nilgala) proposed corridor, the smallest of the four, with a length of 14.5 km is the only corridor that runs within the land declared as a forest reserve by the Department of Forest connecting Maduruoya National park to Galoya National park. According to the surveys and observations carried out on land use patterns on selected elephant corridors, Puwakpale (Nilgala) proposed corridor constitute 2 579.2 hectares of forested areas, 7.3 hectares of shrub land with only 2.5 hectare of paddy cultivation and no chenna or coconut cultivations. The land use values show the third lowest with regards to paddy cultivation with only 23 families currently residing in the area. In comparison to other corridors barriers to migration are greatly reduced in terms of farmlands. Therein, a program initiated to facilitate relocation of the small human settlement can aid in creating an ideal elephant corridor at Hungamaloya, Kudaoya, Elakotaliya and Sinhapura that reduces human elephant interactions thus reducing HEC in the area. The relocation would aid in the declaration of these corridors as a protected area for safe elephant movement between the protected areas.

Keywords: Elephant; Elephant corridors; Maduruoya National Park; Migration

Is There an Enabling Environment for Nutrition-Sensitive Food Production in Sri Lanka?: Perception of Various Stakeholders

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There is a growing recognition that “nutrition-sensitive” agriculture is necessary to ensure nutrition security and reduce malnutrition. It has been acknowledged that “nutrition-sensitive” approaches that complement “nutrition-specific” interventions are required to achieve nutrition security and reduce undernutrition. The objective of this community based qualitative study was to investigate the perception of the officers in agriculture, livestock and fisheries sectors involved in food production-related intervention programmes, food producers (agriculture, livestock, and fisheries), consumers and food sellers on nutrition-sensitive agriculture as a mean of improving health and nutrition of the population. Key informant interviews (KII) were conducted with purposively selected five Provincial Directors of agriculture, livestock and fisheries sectors, 12 Agriculture Instructors and 40 food sellers (10 from each district: Anuradhapura, Jaffna, Kurunegala, and Nuwara Eliya). Sixteen groups of food producers and 18 groups of rural consumers from four different villages in the above districts participated in focus group discussions (FGD). The participants and the locations were selected purposively to represent the food producers engaged in different types of farming (paddy, vegetable, fruits cultivation and home garden) and ethnic (Sinhala, Tamil and Muslim) and geographical variation (rural, urban and estate) of the consumers and sellers in 2020.

The officers who participated in the study perceived that all the sectors responsible for food production should integrate nutrition into their programs. They perceived that this produces healthier and nutritious foods to address the current nutritional problems. The officers were confident about their capacity of contributing to nutrition-related components in the intervention programs in the future. Crop farmers did not have much understanding in concept of ‘nutrition’ in relation to agriculture. Almost all the crop farmers did not consider the nutritional aspects of crops in their farming. Even in the crop selection, they did not focus on the nutritional importance of the crops. They did not give due

attention in protecting the nutritional values of the harvest during storage and transportation but had concerns about safety aspects of food. Consumers distinguished nutritious foods and unhealthy foods correctly. They thought that yams are healthy as foods grown underground have low amount of chemicals. Fruits, grains and yams are also considered healthy as they help to prevent diseases, growth and body functions. Furthermore, they mentioned that the nutritious foods are rich in certain nutrients and contain energy. However, they had less priority in nutritional value of the foods during food purchasing. Food prices, the quality of the foods and taste preference were the most considered three factors in food purchasing. Less priority was given to the nutritional value of the foods and the health conditions of the family members during food selection. Overall, the food sellers agreed that they should consider the nutritional values of the food during food selling although rarely practiced it. Also some sellers perceived that consideration of nutritional values and nutritional wellbeing of the people is not their responsibility and consumers are responsible for choosing the healthy food. Sellers perceived that the quality and nutritious foods are adequately available and affordable fulfilling consumer demand.

In conclusion, officers perceived that nutrition components are adequately incorporated into the current food production intervention programs. However, food producers do not have adequate nutrition literacy and reliable information sources to be aware on nutrition. Food producers did not consider nutritional aspects in their farming practices and had less motivation to do so in future. However, the consumers had better knowledge of nutrition than food producers. Consumers pay little attention to nutrition in food purchasing, but they followed several good practices to preserve nutrients during food preparation. The attention and motivation of the food sellers and distributors to sell and promote nutritious food were not at a satisfactory level. The findings showed a disparity between perspectives of the officers and other stakeholders. The study suggests that the decision making officers need better training on nutrition enabling them to effectively plan and implement nutrition-sensitive programs. Stakeholders in the food system must be empowered to engage in nutrition sensitive activities in future.

Keywords: Consumers; Farmers; Food sellers; Nutrition-sensitive agriculture, Perceptions

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Occurrence and Distribution of Geometric and Positional Fatty Acid Isomers in Processed Edible Plant Lipids

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Abstract

In the food industry, crude plant lipids are processed using several techniques like refining, bleaching, deodorizing, and partial hydrogenation. In partial hydrogenation, a part of the unsaturated fatty acids (USFA) in lipids changes to saturated fatty acids (SFA) and *Trans* fatty acids (TFAs). Geometric and positional isomers of fatty acids show differential effects on lipid metabolism. Thus, the isomeric profile of fatty acids in edible processed lipids is an important factor for the determination of their health effects. Due to the changes in fatty acid (FA) composition during processing, it is important to determine the total FA composition and isomeric profile of fatty acid in processed plant lipids. This study investigated the total FA composition and occurrence of predominant geometric and positional fatty acid isomers in commercially available edible plant lipids.

Thirty processed edible plant lipids samples, including different edible plant oils, partially hydrogenated lipids and partially hydrogenated oil mixed lipids were used in this study. Oil was extracted from samples using a mixture of normal saline, chloroform, and methanol, then extracted oil samples were methylated using the BF₃-methanol method. Fatty acid methyl esters were analyzed in triplicates using Gas Chromatography fitted with Flame Ionization Detector for the determination of total FA composition and peaks were identified using the Restek 37 component food industry FAME standard. For the determination of the isomeric fatty acid profile of lipids, *cis* and *trans* geometric isomers were pre-separated from total FA methyl esters using Solid-Phase Extraction Chromatography in the silver ion mode followed by GC -MS

analysis. Fatty acid peaks were identified using pure fatty acid standards prepared in a research laboratory.

Results revealed that in the plant oil category, total SFA varied from 12.26% for sunflower oil to 91.80% for virgin coconut oil. The predominant SFA in most edible oil samples was the palmitic acid (16:0). Total monounsaturated fatty acid (MUFA) ranged from 7.03% for virgin coconut oil to 70.31% for olive oil with the prominent presence of oleic acid (*c*-9 18:1). Total polyunsaturated fatty acid (PUFA) ranged from 1.14% for virgin coconut oil to 56.17% for sunflower oil with the key PUFA as linoleic acid (*c*-9,12-18:2). In the semi-hard/hard processed lipid category, SFA content was considerably higher than USFA content in most samples with a few exceptions. Total SFA ranged from 22.57% to 62.34% with the predominant presence of palmitic acid. The USFA/SFA ratio (2.89) was high in Margarine brands with a high MUFA content. Further, TFAs were reported in some margarine brands. Margarine made from sunflower oil contained more total SFA than sunflower oil. It was apparent that the FA composition of a processed lipid sample was different from that of respective crude oil.

According to the results of the isomeric fatty acid profile of lipids, the major *c*-18:1 positional isomer in most plant lipids is *c*9-18:1 followed by *c*6 and *c*7-18:1 isomer. The occurrence of the *c*11, *c*13-18:1 isomer was not detected in the tested plant oils. The contents of *c*-20:1 positional isomer in plant oils varied widely. Peanut oil had the highest levels of total *c*-20:1 (3.85%) and the lowest levels were found in flaxseed oil (0.17%). The predominant *c*-20:1 positional isomer in most of the plant oil was *c*7-20:1. Mustard oil and corn oil contained *c*11-20:1 isomer. Edible plant lipids contained a wide range of *trans* fatty acids, with the predominant presence of *t*11- 18:1 followed by *t*9- 18:1 and *t*12- 18:1.

Results revealed that the occurrence and distribution of geometric and positional fatty acid isomers varied widely in commercially available plant oils. In conclusion, the FA composition and isomeric fatty acid profile of edible plant lipids have changed with further processing.

Keywords: Bleached and deodorized oil; Partial hydrogenation; Positional isomers; Processed plant lipids; Refined, *trans*-fatty acid

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Phenolic Content and Antioxidant Activities of the Ready to Serve Canned Herbal Beverage

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Abstract

Herbal beverages are important in the traditional diet in many Asian countries, among health-conscious consumers. Herbal beverages are prepared from natural ingredients using different morphological plant parts such as leaves, stems, roots, fruits, buds and flowers. The increasing prevalence of diabetes mellitus (DM) has led to high usage of herbal beverages as alternative treatments due to their natural origin, availability and lesser side effects. The leaves of *Artocarpus heterophyllus* belonging to family *Moraceae* have been used traditionally as treatment agents for fever, boils, wounds and skin diseases. Furthermore, the leaves are rich in phenolic compounds such as flavonoids, tannins and triterpenoids. Boiled water of dried flowers, buds and leaves of *Cassia auriculata* L (*Ranawara*) has long been used as a herbal beverage. Previous studies showed that the combination of dried mature leaves of *Artocarpus heterophyllus* and dried buds and flowers of *Cassia auriculata* can improve plasma antioxidant capacity and hypoglycemic effect in healthy subjects. In addition, it was shown that mixing of different ingredient ratios, material weight and infusion time of the tea exerted an impact towards the phenolic content and antioxidant activities of the infusion of the tea bags. However, long infusion time of 16.2 minutes of the herbal tea bag was a drawback for the effective usage. Furthermore, earlier we reported that short term efficacy of the single dose ingestion of the herbal tea on postprandial blood glucose level depended on the carbohydrate load and the glycaemic status of individuals. The objective of the present study was to determine the phenolic contents, antioxidant activities, and α -amylase inhibitory activities of the ready to serve canned herbal beverage and freshly prepared beverage with *Cassia auriculata* buds and flowers and *Artocarpus heterophyllus* leaves along with cinnamon as a flavouring agent. Total phenolic content (TPC), and total flavonoid content

(TFC) of beverages were analyzed. The in vitro antioxidant activities of beverages were evaluated using several spectrophotometric assays such as 2,2-diphenyl-1-picrylhydrazil (DPPH) radical scavenging activity, reducing power, trolox equivalent antioxidant capacity (TEAC) and ferrous ion chelating activity (FICA). All the experiments were conducted in triplicates and the values were reported as mean \pm SD. Subject preference for canned beverage and freshly prepared beverage was determined through a sensory evaluation using 50 untrained panelists. Statistical analysis were performed using SPSS software version 16.0. The TPC of two herbal beverages were 333 ± 10 and 959 ± 26 mmol gallic acid equivalents (GAE) per 300 ml of beverage for canned and freshly prepared beverages, respectively. The antioxidant activity as assessed by TEAC of herbal beverages were 75 ± 5 and 220 ± 10 mmol trolox equivalents for canned and fresh beverages, respectively. The α -amylase inhibitory activity of herbal beverages were 52 and 75% for canned and fresh beverages, respectively. The mean scores for overall acceptance for beverages did not differ significantly. Results showed that freshly prepared herbal beverage comprises of comparatively better TPC and antioxidant activities. This could be due to the destruction of phenolic compounds in the canning with high temperatures reaching in the process. In conclusion, ready to serve canned herbal beverage prepared using dried mature leaves of *Artocarpus heterophyllus* and dried buds and flowers of *Cassia auriculata* are rich sources of phenolic compounds with demonstrated potent antioxidant activities. Further studies are warranted to determine the single and multiple dose efficacy of the ready to serve herbal beverage on the glycemic response.

Keywords: Antioxidant activities; *Artocarpus heterophyllus*; *Cassia auriculata*; DPPH; TEAC

The Coexistence of Dual Burden of Malnutrition in Mother–Child Pairs in Urban, Rural and Estate Sectors in Sri Lanka

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Abstract

The familial coexistence of dual burden of malnutrition is a common phenomenon observed mostly in developing countries, including Sri Lanka due to the marked shift in dietary and lifestyle practices. The aim of this study was to determine the prevalence of the coexistence of the double burden of malnutrition in a single household. A total of 3000 mother-child pairs were selected from urban, rural and estate sectors using multi-stage cluster sampling in 2015-16. The inclusion criteria were non-pregnant women having 3-5 years old youngest child. Anthropometric measurements (height and weight) of mothers and children were taken following standard procedures. Stunting (low height-for-age), wasting (low weight-for-height) and underweight (low weight-for-age) of children were assessed using WHO Anthro survey analyzer and was defined based on the z-scores $<-2SD$ (moderate and severe) of the reference population and the overweight (OW) was defined as the BMI for-age $> +1 SD$. Maternal body mass index (BMI) was classified according to the World Health Organization recommended cutoff points for Asian population. Socio-demographic characteristics of the households were collected using an interviewer administered questionnaire. The mean age of mothers was 32 ± 3 years. The mean age of the children was 40 ± 16 months. The prevalence of underweight was significantly higher in mothers in estate sector (27.4%) compared with mothers in other two sectors (urban 7.9%, rural 14.2%). The prevalence of overweight was 35.1%, 37.2% and 17.9% in urban, rural and estate sectors, respectively. The prevalence of obesity (30.7%) was higher in mothers in urban sector compared with rural (16.9%) and estate (6.7%) sectors. The coexistence phenomenon is shown in Table 1. A household was considered to have a dual form of malnutrition when mother-child pairs consisted of an

underweight child and an overweight/ obese mother or an underweight mother in each sectors. Based on this definition, 120-180 (10-15%) of the mother-child pairs out of the 1200 mother –child pair of urban, 120-200 (10-18%) out of 1100 of the rural and 90-260 (12-38%) out of 700 of the estate mother-child pairs fulfilled the definition of the dual burden of malnutrition (Table 1). The nutritional vulnerability is higher in estate sector compared with other two sectors.

Table 1: Prevalence of the coexistence phenomenon in urban, rural and estate sectors

Mother-child pairs	Prevalence %		
	Urban	Rural	Estate
UWM/SC	20.6	20.3	44.9
UWM/UWC	27.6	23.3	43.6
UWM/WC	20.6	25.6	19.7
UWM/OWC	6.8	1.4	1.8
UWM/ any form of malnutrition in child	41.8	48.6	55.1
NWM/SC	25.5	16.2	46.0
NWM/UWC	19.6	23.4	33.3
NWM/WC	8.8	19.8	8.5
NWM/OWC	2.9	1.5	1.3
OWM/SC	13.8	10.8	32.1
OWM/UWC	12.3	17.6	37.2
OWM/WC	9.6	12.6	12.8
OWM/OWC	8.1	4.3	3.1
OWM/ any form of malnutrition in child	24.2	27.4	51.4

UWM- underweight mother; OWM- overweight/obese mother; NWM-normal weight mother; SC-stunted child; UWC-undeweight child; WC-wasted child; OWC-overweight child

In conclusion, coexistence of two opposite forms of malnutrition (undernutrition and over nutrition) at the same household was observed in 24.2 %, 27.4% and 51.4% households in urban, rural and estate sectors, respectively. The results suggest that the existence of a link between the rise in maternal obesity and an increase in child malnutrition in Sri Lanka and warrants addressing the need of household rather than individual based approach in nutrition intervention. Further analysis needed to determine the factors involved in this phenomenon.

Keywords: Coexistence; Malnutrition; Overweight; Underweight

The Economic Impacts Realized by Giant Freshwater Prawn Exporters in Sri Lanka during the COVID'19 – Pandemic

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Abstract

Since early 2020 with the COVID-19 pandemic, the global business climate of emerging markets and developing economies has become notably more difficult, where the Giant freshwater prawn (GFWP) (*Macrobrachium rosenbergii*) export sector of Sri Lanka (SL) is no exception. GFWP is a new commodity in the Sri Lankan (SL) fisheries exports, which has been continuing since 2015. Entire GFWP production generated from the culture-based fisheries (CBFs) practiced in the reservoirs, which brings a good economic return comparative to the rest of freshwater fish catches. Prior to the COVID-19 epidemic nearly 90% of GFWP purchases were made directly to export markets in Thailand and European Union (EU), gained limited local market potential in the tourist sector in recent years. Objective of the current study is to detail the impact of COVID-19 on the GFWP export companies of SL. The information highlighted in the article were gathered from 13 exporting companies through a phone-call survey and the data on volume, value, and cost of exportation were collected during the sessions. Furthermore, the in-result demand, supply and income elasticities were calculated using the data.

Among the surveyed firms some are exporting large quantities (mean of 737.5 Kg per day) to the Thailand market which act as a retail market hub. Most of the small exporters (mean of 37 Kg per day) aimed at retail stores and chain of restaurants in the EU region. It is obvious that closures and access limitations experienced during pandemic in markets and terminals adversely affected

GFWP exports. According to the findings, exportation to the EU has been totally collapsed while pandemic due to the risk of lower marginal profit and lack of orders with a total loss of 3922 USD per day (1USD = 200LKR), meanwhile, the overall demand has been dropped from 7000 to 5000 Kg per day in Thailand effected in a profit loss of 43,692.5 USD per day (51.84 %).

Previous to the COVID, the larger exporters of SL have used a market penetration strategy with low prices (30 USD) to compete with the other major competitors in Thailand market such as Vietnam, India, Thailand and Cambodia. Meanwhile, the smaller companies targeting the EU market have used the market skimming pricing strategy at a price rate of 35.4 USD. While the epidemic, the larger companies brought the situation at Thailand market under control by increased pricing by 8 USD via creating an artificial scarcity through maintaining the below-mal-supply level at 2000 Kg per day. According to the present study, we believe that economic elasticity methods focus on the symptom rather than the causes. Though negative demand (-1.1619 ± 0.09) and supply (-2.659 ± 0.29) elasticity were realized due to the decrease of demand and supply, the income elasticity was 0.5993 ± 0.0643 reveals that comparative to the minor exporters the larger exporters have ability to sustain in a pandemic crisis due to the size of the firm and also armed various strategies in operations.

Companies have drawn several while-COVID strategies such as; cut-down operational cost via limiting human labour, efficient roster arrangements of labour hours, mutual understanding among exporters to retain the selling price at 38 USD and drop-down of farm-gate prices from 2285 to 2100 LKR, were paid off well in the companies' perspective with a significantly higher average marginal profit over the purchase, which is 190.0% comparatively higher than the prior 119.8%. The main drawback of the above strategies was the farm-gate price down approach which had subsequently an adverse effect on the livelihood of the fishermen at a critical moment, where the need for livelihood security of poor fishermen has to be identified by the government and we recommend a regulatory body in such scenarios.

Though these scenarios are seeming to be temporary, have costly impact on the small enterprises which might be unrecoverable at the end. The present study identified the need for the more market security approaches in small business entities rather than larger once, which eventually create an open competitive and healthy market in a long-run.

Keywords: Economic elasticity; *Macrobrachium rosenbergii*; Pricing

Effect of a Cocktail Enzyme on the Digestibility and Nutritive Value of Conventional Poultry Feed Ingredients

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Abstract

Feed ingredients of plants origin are commonly used in poultry rations. Non-starch polysaccharides (NSPs) are the major component of plant cell walls that reduce nutrient digestibility. Soybean meal, rice polish, coconut-poonac and wheat offal are the conventional feedstuff used in poultry feed formula. Due to high levels of non-starch polysaccharides, these feed ingredients are poorly digested by monogastric animals such as poultry. Improving digestibility of feed resources is a vital breakthrough in monogastric nutrition to optimize the utilization of feed resources. The commercially available exogenous enzyme and feed activators can be used in animal feed to break down the NSPs and improve digestibility. In vitro approaches can be used to determine the effects of exogenous enzymes on digestibility of feed stuff used in poultry feed formula. The objective of this study was to determine the effects of supplementation of an enzyme complex GALZYM-PPB containing xylanase, protease, lipase, amylase, pectinase, phytase and acidification on the nutrient digestibility of soybean meal, rice polish, wheat offal and coconut-poonac.

In the experiment, treatments consisted of the control diet without enzyme and acidifier supplementation, a diet supplemented with GALZYM-PPB at 350g per ton (T1), a diet supplemented with ZACID 6000 acidifier at 3.0kg per ton (T2) and a diet supplemented with both with GALZYM-PPB at 350g per ton and ZACID 6000 acidifier at 3.0kg per ton (T3). The retained gross energy, crude protein, crude fat and crude fiber values of all the treatments were estimated by the AOAC method (Table1). The retained gross energy and soluble crude protein, soluble crude fat and soluble crude fiber were estimated. Data were subjected to ANOVA for a randomized complete block design (RCBD).

Table 1 Retained nutrient content of the feed ingredients

Treatment	Retention%											
	Crude protein				Crude fat				Crude fiber			
	WO	SBM	CP	RP	WO	SBM	CP	RP	WO	SBM	CP	RP
Control	13.62	42.77	16.96	10.46	6.25	6.25	9.47	8.27	14.27	16.85	18.61	8.75
T1	10.80	16.85	14.59	9.99	5.84	5.65	10.40	8.73	11.63	14.28	18.06	8.50
T2	12.60	26.25	14.87	10.22	4.13	4.42	9.51	7.20	11.64	7.95	17.16	8.21
T3	10.16	15.16	14.71	9.11	3.23	3.37	8.86	7.09	7.90	1.47	16.10	8.40
P value	0.001	0.001	0.000	0.000	0.001	0.001	0.001	0.000	0.000	0.024	0.000	0.000

WO-Wheat offal, SBM- Soybean meal, CP- Coconut-poonac, RP- Rice polish

Retained gross energy, digestibility of crude protein, crude fiber and crude fat were significantly different ($P < 0.05$) among the treatment groups. The highest level of soluble crude protein, crude fat and crude fiber content in the feed ingredients were observed in T3 treatment and followed by T1, T2 and control respectively. The carbohydrate and fat are mainly attributed to gross energy content of feed. The incorporation of enzyme and acidifier increased the soluble fat content and carbohydrate content which resulted in lower retained energy in predigested ingredients.

Results show that adding both enzyme and acidifier increased the digestible nutrient content in all ingredients tested. The incorporation of acidifiers without enzymes increased the soluble nutrient content and this may be due to the breakdown of acid-soluble amino acids, protein, fatty acids and carbohydrates. Adding acidifiers in the feed gives a suitable pH level for the enzyme activity. The pre-digestion treatment of feed ingredients with enzyme complex improved the nutrient digestibility and the rate of improvement depends on the type of ingredient. According to the findings of the study, pre-digestion of feed ingredients with both enzyme cocktail and commercial acidifier mixture improves nutrient solubility and also improve the retained gross energy than using either enzyme cocktail or commercial acidifier mixture alone. The pre-digestions of soybean meal, rice polish, wheat offal and coconut-poonac with enzyme complex GALZYM-PPB improves digestibility. The further studies are conducted using feeding trials to test the bioavailability of nutrients from predigested feed ingredients.

Keywords: Acidifier; Digestibility; Enzymes; Pre-digestion; Poultry

Section D
Management

An Investigation of the Relationship between Undergraduates' Participation in Sports and Their Academic Performance

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Abstract

It is a well-known fact that engaging in sports activities improves both the physical and mental fitness of people. However, recent data show that the number of Sri Lankan undergraduates' participating in sports-related activities is less than 10 per cent of the total student population. This is significantly low when it is compared internationally. There are a number of factors that contribute to this unfavourable situation. Generally, students believe that participating in sports activities with a strict academic timetable will adversely affect their academic performance. This study aims to investigate the relationship between undergraduates' participation in sports activities and their academic performance. For this purpose, Wayamba University of Sri Lanka was selected, and 127 students representing four faculties of the university were randomly selected as the sample. Academic performance was measured in terms of accumulated final Grade Point Average (GPA), while the degree of involvement in sports-related activities was measured by devising a "*Sports Achievement Index*" (SAI); there, the marks were allocated for every sport-related activity they were involved with.

Table 1: Sports Achievement Index (SAI)

	Performances	Points Allocated
01	Representation of University team	01 pts per team
02	Won the University Colours	02 pts per sport
03	First place at Inter-university Championships	03 pts
04	Second place at Inter-university Championships	02 pts
05	Third place at Inter-university Championships	01 pts
06	Won the Sri Lanka University Colours	05 pts per sport
07	Member of the National University Team	07 pts per sport

First, the students who passed out of the university were randomly selected from four faculties, and their SAI was determined using the above procedure. Then, the students who had no points were taken as the students who did not take part in sports at the university. After that, the GPA of all the selected students were obtained from the faculty offices.

Accordingly, 45 out of the 127 students selected for the study had done sports during their stay at the university. Moreover, 14 students out of the 45 students who had done sports during their stay at the university obtained a GPA of 3 to 3.5, 23 obtained a GPA of 2.5 to 3 and 13 obtained a GPA of 2 to 2.5. Therefore, approximately 82.22% have obtained a GPA of 2.5 or above, which is considered a better academic performance. Therefore, it is evident that the students who do sports perform better in their academic work too.

Table 2: Relationship between the participation in sports activities and academic performance

Faculty	Total Students	Sportsmen /women	GPA 2-2.5	%	GPA 2.5-3	%	GPA 3-3.5	%
FAS	31	06	03	50	02	33.33	01	16.66
FAPM	30	12	01	8.33	05	41.66	06	50
FBSF	32	19	05	26.32	09	47.36	05	26.31
FLFN	34	08	04	50	02	25	02	25
Total	127	45	13	28.88	23	51.11	14	31.11

University students are the future leaders and will inherit their nations' leadership to develop their countries with their own cultural values and identity. Therefore, it is hoped that the involvement in sports will not be a hurdle for these university students to have higher academic achievements on par or even better than non-athletes. Of course, we cannot deny the fact that there are other factors that could influence the academic achievement of university athletes. However, since the present study focused only on one particular university and a small sample, future research can expand it to other universities and a large student population to generalize the findings of this study.

Keywords: Academic performance; Sports; Sports Achievement Index; Undergraduates

Anxiety During Strategic Impromptu Speaking among Adult Second Language Learners

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Abstract

Anxiety that evolves during impromptu style public speaking can seriously impair the performance. Interference Retrieval Model of Anxiety explains how cognitively demanding tasks inhibit recall of previous knowledge while Skills Deficit Model of Anxiety suggests how poor language proficiency affects the output. Although strategic impromptu speaking, which draws insights from the two models, allows quick preparation through brainstorming and outlining to facilitate the process, anxiety may still operate at a considerable level. This research devoted to identify the impact of anxiety confronting strategic impromptu speaking in Sri Lankan adult second language learning context.

104 second year undergraduates of the Faculty of Technology, Wayamba University of Sri Lanka received opportunities to deliver impromptu speeches in 3-4 minutes before an audience. However, unlike the traditional impromptu speeches, the speakers received a brief time to brainstorm a broader theme both collaboratively and individually and to prepare a quick outline to help them speak under comparatively less cognitive interference. It was assumed that such provisions would be vital to promote continuous speech in a second language, and the findings over the experience was thus significant. After two impromptu speaking sessions, an adapted form of Hurwitz's (1986) questionnaire was administered, and nine questions out of it were analyzed quantitatively through one sample t test. Further, the feedback over an open-ended question that elicited the participants' feelings over experience was coded and analyzed qualitatively.

The statements (Table 1) addressed common issues like the fear/nervousness before impromptu speaking (1-3), fear/nervousness while impromptu speaking (4-6) and worry over one's performance during impromptu speaking (7-9). The open feedback from the participants belonged to five basic themes. While

responses for specific statements measured the gravity of the problem, the open feedback threw light on the details connected to each emotional trauma.

Table 01: Learner perceptions on issues faced during strategic impromptu speaking in a second language

Statement	Mean Value	Std. Deviation	Sig. (2-tailed)
1. I never feel quite sure of myself when I am speaking in English in speaking sessions.	3.26	.836	.000
2. I tremble when I know that I'm going to be called on to speak in English.	3.33	.999	.000
3. Even if I am well prepared for the topic, I may feel nervous about it.	3.45	.811	.000
4. I get nervous and confused when I am speaking in speaking sessions.	3.25	.973	.000
5. In speaking sessions, I can get so nervous I forget things I know.	3.53	1.061	.000
6. I get nervous when I do not get enough time to read the note that I made before the impromptu speech.	3.61	.875	.000
7. I worry about making mistakes in speaking sessions.	3.52	.870	.000
8 I worry about the consequences of failing in my speaking sessions.	3.45	.894	.000
9. I keep thinking that the other students are better at English than I am.	3.71	.910	.002

As per the mean values, irrespective of the use of strategies, the effects of anxiety during impromptu speaking were significant at 5% level of significance. The open feedback revealed that the participants were ashamed of 'poor language proficiency, grammatical and lexical errors occurred and for lacking patterns and vocabulary' particularly when they compared themselves with more competent peers. Moreover, fear occurred due to natural phobia for public speaking, unsupportive audience and lack of prior experience. Talking 4 minutes in a second language, English, without a script was cognitively demanding for the speakers and made them forget the content. The limited language proficiency also affected the performance both at the word and the sentence level. In conclusion, anxiety affects public speaking of adult second language learners significantly even under modified strategic instruction, and accordingly, further research is required to minimize the negative consequences.

Keywords: Anxiety; Impromptu speaking; Open feedback

Best Practice Reference Model to Evaluate Logistics Service Providers in Terms of Adopting Lean Management and Sustainability Practices

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Abstract

The uncontrolled industrial waste generation and inefficient industrial waste management have caused devastating environmental issues all around the world. Meanwhile, the extreme business focus leads to insensitivity towards the community and environment, which has challenged the successful long run of the business organizations. The logistics industry is highly affected by this challenge as it is one of the leading industrial waste generators due to the nature of the business operations performed. Different philosophies, concepts, theories, technologies, management techniques and best practices have emerged to promote the change of the context of business in an environmental friendly manner while enhancing community engagement during the last few decades as an effort to address this challenge. Sustainability is a new paradigm that is becoming popular as it guides the industrial professionals to balance the industrial focus on three aspects popularly known as triple bottom line; economic, social and environmental in such a way to implement business operations successfully in the long run. Lean management is another widely adopted management tool used for minimizing different types of wastes generated and helpful in efficient waste management. Although applicability of lean management techniques integrated with sustainability concepts have been researched widely in many different industrial settings, through this study, a theoretical gap has been identified and addressed with regard to the logistics industry. This study aims to examine the best practices to be followed when applying lean management techniques and sustainability concepts in the logistics industry. Moreover, this study defines different levels of best practices to evaluate the logistics service providers' implementation of lean management and sustainability practices to improve their business operations. The research gap was addressed through an extensive literature review followed by a survey questionnaire distributed among professionals employed in major logistics

service providers along with an expert review conducted with the contribution of logistics experts leading the major logistics service providing organizations in Sri Lanka. Three major logistics service providers in Sri Lanka were visited to study the business operations, warehousing and transportation, through observations, studying different reports and comprehensive discussions with industry experts. Then the questionnaire was developed focusing on identified best practices related to lean management techniques and sustainability practices, based on the knowledge and experiences gathered through literature review, observations and discussions. The identified best practices were categorized by the authors into five levels as “Initial”, “Managed”, “Defined”, “Measured”, and “Optimized”, to develop the “Best Practice Reference Model” which is the result of this study (Figure 1). This developed model allows the logistics service providers to evaluate the best practices implemented by them in adopting lean management techniques and sustainability practices as an integrated approach to improve their transportation and warehousing functions. Moreover, this model layout a comprehensive roadmap for logistic service providers to realize their current level in implementing relevant best practices and how they can improve to the next level. It can be concluded that the waste generated in the transportation and warehousing functions can be minimized and effectively managed by adequately following the identified best practices related to lean management techniques. At the same time, the logistics service providers will be able to successfully implement their business operations in the long run if they appropriately adopt the suggested best practices relevant to the sustainability concept by properly managing the 3Ps in the triple bottom line; “People”, “Profit” and “Planet”.

The developed Best Practice Reference Model is shown in Figure 1. Five levels have been defined regarding the implementation of both lean and sustainability concepts as an integrated approach.

Category of Practices		Levels in the adopted Best Practice Reference Model				
		Initial	Managed	Defined	Measured	Optimized
Lean Management Practices		Identifying wastes in the processes	Implementing basic Lean concepts to eliminate the wastes identified in the processes	Streamlining all the processes within organization while providing Lean training to employees	Measuring the operational performance improvement while building a strong lean culture in the organization	Developing the lean culture through out the value chain to optimize operations
Sustainability Practices	Profit (Economic)	Basic financial management practices	Practices focused on improving organizational profit	Practices which share profit benefits with employees	Practices focused on “Win-Win” strategy with stakeholders	Practices focused on service offering to clients
	People (Social)	Basic HR related practices	Employee empowering practices	Employees’ career development practices	Stakeholder relationship development practices	Community development practices
	Planet (Environment)	Disposing industrial wastes	Minimizing industrial wastes and disposing properly	Recycling and reusing industrial wastes	Wastes are minimized, recycled and reused throughout the supply chain	Implementing sustainable environmental development practices

Figure 1: Best Practice Reference Model developed by authors

Keywords: Best practices; Lean management; Logistics service providers; Reference model; Sustainability practices

Does Ownership Diversity Affect Firm Performance? Evidence from Non-Financial Firms Listed in Colombo Stock Exchange

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Abstract

Ownership diversity can be defined as the spread of ownership and control within many different types of shareholders. In recent years, many Sri Lankan companies' ownership structure has been increasingly diverse in terms of ethnicity, nationality, gender, and socioeconomic status. These diversified ownership structures have created some performance problems in the Sri Lankan companies during the last few years. Therefore, finding the effect of ownership diversity on firm performance is significant for all stakeholders participating in the capital market. Many research studies have been carried out to determine the impact of ownership structure on firms' performance. However, only very few studies investigate the impact of ownership diversity on the firm's performances, measured using an acceptable diversity index. In the Sri Lanka context, it is rare to find studies that investigated the ownership diversity impact on the firms' performances. Considering this research gap, the researcher used different theories, including the agency theory, stewardship theory, and entrenchment theory, to investigate how to affect ownership diversities on the firm's performance of listed non-financial companies in the Colombo Stock Exchange (CSE).

This research study investigated ownership diversity's effect on firms' performances by taking a sample of 186 non-financial firms listed on the CSE from 2012 to 2019. The researcher used Tobin's Q (TQ), Return on Assets (ROA), and Return on Equity (ROE) to measure the firms' performances. As a generally accepted indicator of measuring diversity, this study used Herfindahl-Hirschman Index to measure the ownership diversity of listed non-financial companies in CSE. To calculate the diversity index, the researcher incorporates

block holdings of domestic individual ownership percentage, domestic institutional ownership percentage, foreign individual and institutional ownership percentage, and government ownership percentage of the listed non-financial companies in CSE. The researcher incorporated firm size, net profit margin, payout ratio, leverage, and sales growth as control variables of this study. The study used descriptive statistics to provide summary statistics on the variables of the research study. Correlation analysis was used to establish the association between variables and to investigate the impact of ownership diversity on firms' performances, three-panel regression models were used. Marginal probability analysis was also carried out to identify the likelihood of change in probability associated with the variables of the study.

The summary statistical results revealed that most of the non-financial companies have a non-diversified ownership structure. The correlation analysis indicates that ownership diversity is negatively and significantly ($P < 0.05$) associated with the firms' performances. The results of the research study's three random effect panel regression analysis revealed that the ownership diversity coefficient is negatively and statistically ($P < 0.05$) impacts the firms' performances (TQ, ROA, and ROE) of the listed non-financial companies of the CSE. The study's regression models further revealed that the net profit margin, payout ratio, and firm size are positively and statistically ($P < 0.05$) impact the firms' performances. In contrast, the financial leverage negatively and statistically ($P < 0.05$) affects the firms' performances. The marginal probability analysis of the research study indicated that there is a small percentage of probability of occurrence among the effect of ownership diversity with the firms' performances.

Based on the above findings, it can conclude that there is a negative impact of ownership diversity on the firms' performances. The main reason behind this negative impact could be the increase of the cost due the incurring the monitoring cost to monitor the diversified shareholders without creating information asymmetric to obtain the personal benefits and not ignoring the minor shareholders' interest. The increase in the cost will decrease the film's performances. Based on the above findings, it can conclude that when ownership gets diversified, it will reduce the firms' performance of the listed non-financial companies in the CSE.

Keywords: Agency cost; Colombo Stock Exchange; Firm performance; Herfindahl-Hirschman index; Ownership diversity

Feedback Gamification and Generation Z IT Professionals' Job Satisfaction in Post-COVID-19 Environment

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Abstract

Due to the Covid-19 pandemic, the Work-From-Home (WFH) concept became the primary way of being employed at software development firms. Prior to pandemic, software developers have utilized WFH parallelly with conventional workplace. Since having exposure on WFH settings; software development firms have been able to sustain their profits and operations with minimal interruptions compared to other business sectors during the pandemic. Moreover, employees and employers have preferred to continue the WFH method even in post-COVID-19 environment. However, employees have worried that they could not have an adequate level of feedback and analysis over their performance since they have not much direct connectivity with their superiors.

Meantime, in the present workplace, since baby boomers (born from 1946 to 1964) have reached retirement age, Generation Z (born from 1995 to 2010) are gradually entering into the workforce. However, previous researchers have identified that since Generation Z cohort employees have grown up in a dynamic digitized world, their expectations from the workplace are completely different from the existing workforce in the workplace. Notably, recent findings have shown that if Gen-Z employees are unable to access detailed information about how much their work has contributed for the organization development, they are likely to leave the organization. Therefore, more literature has suggested that as an organization, it needs to have a mechanism that gives the opportunity for the employees to understand how much their work has contributed towards the organizational growth.

Since Generation Z cohort employees are comparatively new to the workplace than the Generation Y (millennials). Even the WFH initiative is also a novel concept to the contemporary workplace. Therefore, quite limited previous

literature that have been conducted to understand the behaviours about the Generation Z over the gamified real-time feedback systems workplace that are predominantly operating via the WFH mechanism. Hence that it has been taken as the research gap to operationalize this study. Therefore, the central objective of this study would be; to identify the gamification features as a visualization aid for enhancing feedback systems to increase the job satisfaction of Generation Z software development employees who employed through the WFH concept in a pandemic situation or beyond COVID-19. Therefore, from this study, identify the research model as follows; which can be utilized to improve job satisfaction among the software professionals by having the immersion, achievement, and social-related gamification features into the real-time feedback system in a software development organization.

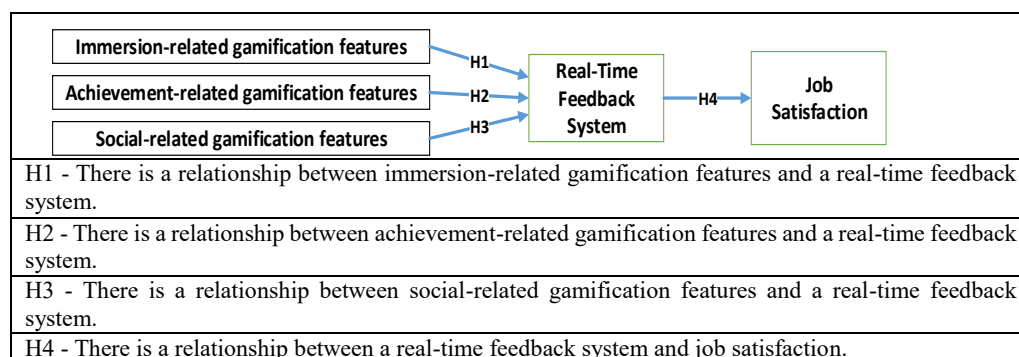


Figure 1: Research model

Based on the exploratory factor analysis and Cronbach's Alpha on a pilot sample of 50 responses that identified the questionnaire with 31 items. Therefore, it can be utilized to main data collection from the respondents who selected through disproportionate stratified random sampling technique. Therefore, the study is suggesting to consider “the existing Generation Z software engineers from software development companies that are operating within Colombo district” as the unit of analysis. Gamified features are suggested as the data visualization techniques from this paper by proposing a conceptual framework with the questionnaire constructed based on the previous literature. Based on the framework, it explains the impact of gamified visualization on the feedback system may enhance the job satisfaction of Generation-Z cohort employees who work from home in a post-COVID-19 environment.

Keywords: Data visualization; Feedback; Gamification; Generation Z; Job satisfaction; Software professionals; Work-From-Home.

Impacts of Foreign Equity Markets on the Sri Lankan Equity Market: A Time Series Analysis

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Abstract

An equity market plays a vital role in the capital generation and uplifting of an economy. Recently, global connectivity has offered both risks and rewards to financial markets where significant domestic, regional and global events leading to distress in the equity markets. These significant events having regional and global impact had caused a contagious effect often referred to as a Domino effect on financial markets. Previous studies identified that immunity toward these events' distress and calamity could be formed through early identification and buffer policy implementation. Thus, identification of the causal relations among markets provides the opportunity of reducing vulnerability towards calamitous events.

The study aimed to empirically analyse the long term and short term causal effects of two prominent foreign equity markets has with the Sri Lankan equity market in identifying vulnerability of the Sri Lankan equity market to contagions from global and domestic events. The study analysed daily index closing prices of the All Share Price Index (ASPI) of Sri Lanka, Dow Jones Industrial Average (DJIA) of the United States and the Footsie Index (FTSE100) of the United Kingdom from February, 1992 to December 2020. The log of daily closing price data for the indices were used in the analysis in their local currencies. The co-integration between the ASPI and the two indices analysed established the long run equilibrium relations. Johansen co-integration test was performed and the Vector Error Correction Model (VECM) was used in modelling the relations. Both models have Johansen normalization restriction imposed on the ASPI and error correction (ECT) term predicting the long run influence of each index on the ASPI.

The results obtained confirms the long run and short run relations equilibriums present for ASPI. In the long run, at *ceteris paribus*, log closing values of both DJIA and FTSE100 are significantly correlated with ASPI suggesting weakly exogenous influence on ASPI. Thus at a 95 percent confidence interval, the effects caused by a shock in the DJIA and FTSE100 would be adjusted at a speed of 78.52 percent and 84.66 percent to restore the long run equilibrium between the ASPI and DJIA and FTSE100 respectively following the shock in the system (Refer Table 01). The p-values of short run dynamics form the VECM analysis in both indices indicated significant causality at 95 percent confidence from both DJIA and FTSE100 towards ASPI.

The eigenvalue stability was checked for the estimates and the both models were stable with modulus eigenvalues less than 1. The robustness of the model through Jarque – Bera test suggested the non-normality of the disturbances and former studies relate to the model misspecification with equity market data through time periods and market dynamics. It is suggested that non-normal stable models are not inappropriate in estimating with the data considered. The post estimations identified autocorrelations in the lag order where the previous studies have identified non-synchronous trading, weekend and holiday effects, and market opening and closing time differences as causes that could lead to the misspecification.

In conclusion, there is a linear relation among the ASPI and foreign index prices that brings an equilibrium among the indices in the long run. It has the tendency to deviate from equilibrium in short term, but return to the long-run equilibrium to move in tandem. Both foreign indices are receptors of external shock that in turn would be passed down to ASPI. Thus, the foreign equity markets considered has the ability of propagating ripples form a regional or global event into the Sri Lankan equity market. The investors and policy makers require to consider both the long run and short run effects in forecasting and buffering contagious effects passing through the foreign indices to the local equity market.

Table 01: Long run relations for ASPI

	Coefficient	p-value
ECT (log_ASPI – log_DJIA)	-0.7852	0.000*
ECT (log_ASPI – log_FTSE100)	-0.8466	0.000*

**p-value significant at 95% confidence*

Keywords: ASPI; DJIA; FTSE100; Long-run relations; Short-run relations; VECM

Key Themes in Corporate Sustainability Reporting: An Exploratory Study Based on Sri Lankan Listed Firms

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Abstract

Private sector firms have a major role in participating in the global agenda for sustainable development by reporting their commitment on sustainable performance to their stakeholders. While several sustainability reporting (SR) frameworks have been introduced for corporate reporting in the global context, the most dominant framework for SR is the framework guided by the Global Reporting Initiative (GRI) integrating Sustainable Development Goals (SDGs). Integrating SDGs into SR is important for business firms since it showcases their contribution to sustainable development and achievement of SDGs to the relevant stakeholders. Nevertheless, firms' adaptation of global reporting frameworks and guidelines may show variations owing to the relevance of the formulated guidelines to individual business processes and choice & knowledge of firm employees. Prior literature reveals that the sustainability information published by firms in Sri Lanka varies significantly despite using a particular reporting framework. The objective of this study is to explore the major motifs reported on the corporate sustainability reports of Sri Lanka. Secondary data from annual reports in the year 2019 were collected and coded. The top 25 firms with the highest market capitalization listed in the Colombo Stock Exchange were selected for the study. Thematic content analysis technique was employed to identify the major reported motifs in the sustainability disclosures. Initially, information in the sustainability disclosures were freely coded based on the concepts of the 17 SDGs formulated by the United Nations Member states in 2015. Widely accredited SDGs were used to identify the reporting content and the major themes of the sustainability disclosures.

The results revealed that 48 reporting categories could be identified in the SR content of Sri Lankan firms. These categories were classified according to each SDG, which resulted in detecting 17 focused nodes and finally to 3 themes as

social, economic and environmental aspect reporting. It was revealed that most of the firms report on investing in community-based education programs (5.8%) and on improve the firms' talent pipeline (4.89%). Content and phrases associated with providing food supplies to low-income families and groups (0.54%), supporting farmers to adapt sustainable practices (0.54%), and content related to firms' involvement on sustainable practices in managing the water resources and beaches (0.72%) were shown to be less proclaimed in SR of Sri Lanka. Seventeen nodes or sub themes were generated with clustering the reporting categories in accordance with the 17 SDGs. Most firms have reported their sustainability performance on achieving the SDG 8, 4 and 3 related to improving the economic value within company and community (15.4%), satisfying the timely educational needs to improve productivity (10.69%) and improving the health of employees and community (9.78%). Content pertaining to SDG 14, 17 and 2 were least reported in the sustainability reports of Sri Lankan firms considering the areas of firm's involvement on managing the natural water resources or beaches (0.72%), international partnerships on sustainable development (1.99%) and sustainable food production & distribution processes (2.90%). The nodes and categories were finally classified to the major themes and the results suggest that firms focus more towards the social aspect reporting (40.22%), than the environmental aspect reporting (25%). The results are in accordance with the prior literature, where developing countries are stated to have much focus on social issues such as poverty, unemployment and education than developed countries.

On the fact that the most eminent global reporting standards and frameworks are formulated by the organizations in developed economies, more comprehensive reporting framework compatible with the developing economical settings could lead to better engagement of the firms in SR practices. The results through the study could support in the formulation of minimum reporting standards for SR in Sri Lanka and it could be suggested for industry regulating authorities and institutional bodies to improve the regulations related to environmental performance reporting, as the environmental performance reporting in the country appears to be at a lower level. Further, the results could be used by authorities on formulating a more comprehensible set of guidelines for SR, where the medium scaled businesses also would have the opportunity to progress towards a sustainable future.

Keywords: Corporate sustainability reporting; SDGs; Stakeholders; Thematic analysis

Perceived Barriers of Employee Transition to Entrepreneurship: A Scale Development

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Abstract

Entrepreneurship is a worldwide phenomenon with economic growth across the globe that is rendered by the emergence of new and innovative business start-ups. An emerging recognition is that employees who transitioned from organisational employment to entrepreneurship may have identified valuable entrepreneurial opportunities and may subsequently have better entrepreneurial performance than other individuals. However, employees are usually reluctant to transit to entrepreneurship for many reasons that were tested in the developed context. In contrast, in the context of developing countries, it is still unclear why transition is triggered.

Most of previous studies have focused on individual impact of either demographic, environmental, human capital, motivational or social cognitive variable on employee transition to entrepreneurship, and majority covered different factors (such as parental influence, impact of role models, learning and education, social impact, financial ability and so on) affecting on entrepreneurship intention. Limited literature was found on employee intention to transit for the entrepreneurship. Employee readiness to entrepreneurship and their perceived barriers for such transformation is the main research gap identified. Based on a rigorous systematic literature review, the authors identified the five factors: demographic factors, motivational factors, human capital factors, environmental factors, and behavioural factors as the perceived barriers in employee transition to entrepreneurship in the shed of prevailing theoretical and empirical inventories. Age, gender, educational level, marital status, occupation and family are the decisive demographic factors that might be the perceived barriers for the employee transition to entrepreneurship. In addition, financial motive, intrinsic motive, passion and fear of failure may

hamper opportunity evaluation and exploitation motives by lowering perceptions of the desirability and feasibility of entrepreneurial opportunities. Entrepreneurs equipped with appropriate education, previous business experience, and prior knowledge will have a greater chance to survive weak institutions and successfully run their business ventures. Moreover, environment refers to the government's access to finance, availability of resources/services, community consideration, business network that influence people's willingness and ability to undertake entrepreneurial activities and the availability of assistance and support services that facilitate the start-up process. The Social Learning Theory helps identify the fundamental behavioural factors that sharpen the epistemological belief, self-efficacy, education and experience and role model. These comprehensive findings of the systematic literature review provide a platform to develop a portfolio of items to measure the perceived barriers towards the employee transition to entrepreneurship. Thereby, this paper aims to propose a scale on perceived barriers of employee transition to entrepreneurship to measure the construct in the developing countries context. A pilot study was conducted with the participation of employees of both the private and public sector (n=67). An exploratory factor analysis identified the dimensions based on the values of factor loading. Initially, 122 items were tested out of which 58 items were identified significantly explaining the variance of the construct (78%). Accordingly, the items were patterned among five major dimensions namely Demographic Factors(03), Motivational Factors(09), Human Capital Factors(09), Environmental Factors(20), Behavioural Factors(17). The proposed scale will add value to the existing body of knowledge in the area of employee transition to entrepreneurship in terms of making available a valid measure with sound measurement properties to quantify the constructs which is scant in literature. The future researchers are welcome in validating the proposed scale by testing in different contexts such as manufacturing & services, micro, small, medium & large and national & multinational.

Keywords: Employee transition; Entrepreneurship; Perceived barriers; Scale development

The Impact of Role Conflict and Role Ambiguity on Job Performance through Self Efficacy: A Study on the Interns of State Universities in Sri Lanka during the Covid-19 Pandemic

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Abstract

The majority of bachelor's degrees of Sri Lankan universities require undergraduates to complete a compulsory internship as a partial requirement of the programs. Though the internship programs were conducted smoothly in past, the present turbulent environment resulted by the Covid-19 has interrupted it. The new situation may weaken the effectiveness of internships thereby, the achievement of expected outcomes of such programs. Particularly, the work from home mode adopted during the Covid-19 affects the performance through intensified work-related stress. Thus, it is essential to investigate the effects of the stressors in the new work environment and their effect on the undergraduates' performance. Therefore, the objective of this study is to examine the impact of role conflict and role ambiguity on job performance and their impact through self-efficacy among the interns of state universities in Sri Lanka during the Covid-19 Pandemic.

The research-based evidence indicates that the role conflict and role ambiguity result in work-related stress intern, it affects the job performance. Also, the individuals who possess higher self-efficacy well-adjust the changing environment. Based on this literature support, the present study postulates the research framework depicted in Figure 1.

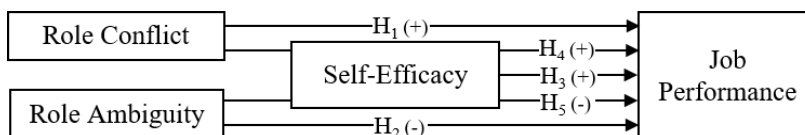


Figure 1: Research Framework

The population of this study was the undergraduate interns of state universities in Sri Lanka and 304 respondents were selected by purposive sampling technique. The data were collected through a structured online questionnaire.

This study used reflective, previously validated measures to operationalize the constructs. The respondents rated their level of agreement for each item over a 5-point Likert Scale, ranging 1 (strongly disagree) to 5 (strongly agree). Above 89 percent Cronbach's alpha statistic for each item indicates the constructs' reliability. Also, several sociodemographic characters such as gender and employment sector were collected. The study employed regression analysis to test the hypothesis along with basic descriptive statistics and correlation.

The sample consisted of 66.8 percent female respondents while 79.3 percent were working in the private sector and 20.7 percent were working in the government sector. Analysis showed that the role conflict ($M=3.1$, $SD=0.74$), self-efficacy ($M=3.7$, $SD=0.83$), and job performance ($M=3.6$, $SD=0.81$) among the intern were above average, whereas the role ambiguity ($M=2.3$, $SD=0.83$) was at the below average. The correlations analysis indicated significant positive association between all variables except the significant negative associations between role ambiguity and both self-efficacy and job performance. The regression analysis showed that role conflict positively ($F=72.46$, $R\text{-square}=.19$, $p < .01$; $B=0.48$, $p < .01$), role ambiguity negatively ($F=274.41$, $R\text{-square}=.48$, $p < .01$; $B=-0.67$, $p < .01$), and self-efficacy positively ($F=340.74$, $R\text{-square}=.53$, $p < .01$; $B=0.71$, $p < .01$) influence the job performance. This finding supports the hypothesised relationship between variables. The results of mediating effect analysis showed that the self-efficacy partially and positively mediated between role conflict and job performance ($F=182.17$, $R\text{-square}=.55$, $\Delta R\text{-square}=.36$, $p < .01$). Also, the self-efficacy partially and positively mediated between role ambiguity and job performance ($F=217.89$, $R\text{-square}=.59$, $\Delta R\text{-square}=.11$, $p < .01$). Accordingly, the two hypothesis related to the mediating effect were accepted.

Empirical studies show a significant positive relationship between role conflict and job performance. Also, several studies confirm the significant relationship between self-efficacy and job performance while its mediating effect between both role conflict and role ambiguity and job performance. The findings of the present study are in line with that of previous studies. The insight gained out of the finding of the study helps authorities to find strategies to enhance the performance of interns of state universities thereby, build a positive image of state universities and improve the employability of undergraduates. Also, the study contributes to the theory by investigating and establishing the relationships among focal variables in the present Covid-19 pandemic.

Keywords: Intern students; Job performance; Role ambiguity; Role conflict; Self-efficacy; State universities

Section E
Medicine

A Descriptive Cross-Sectional Study to Assess the Changes in Urine Output, Urine Osmolality and Proteinuria in Critical Phase of Dengue; Interim Analysis

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Abstract

Annually, approximately 50-100 million individuals are infected with dengue and two to three billion people are at risk of developing Dengue Fever (DF). Dengue causes a spectrum of disease, ranging from a mild febrile illness to a life-threatening dengue hemorrhagic fever and dengue shock syndrome. The classical features of dengue infection are high-grade fever, headache, retro-orbital pain, arthralgia and myalgia, vomiting, sore throat, and maculopapular rash. The initial stage of DF is febrile phase followed by critical or leaking phase and finally the convalescent phase. The main clinical features which are detected at the time of plasma leakage is haemoconcentration detected by packed cell volume, a sudden drop of platelet count and the reduction of urine output. As the haemoconcentration can be controversial where the patient is having concealed bleeding, the practical clinical sign of detecting leakage is the sudden reduction of platelet count and the urine output. Renal involvement in dengue is one of the complications identified. It can range from mild proteinuria to acute renal failure in severe dengue haemorrhagic fever. This study is planned to detect the time at which the renal functions are deranged in DF, by detecting the changes that occur in urine and serum.

A descriptive cross-sectional study is being conducted at the medical wards of Provincial General Hospital-Kurunegala. All the patients diagnosed with DF were recruited for the cohort. Demographic data, duration of illness on admission and presenting clinical manifestations, were obtained using an interviewer administered questionnaire before discharging the patient from the ward. The recorded data in BHT and the data of the attachments of BHT on selected investigations were extracted into a data extraction sheet. On admission, all patients with DF investigated for baseline tests of serum creatinine, urine osmolality, urine protein, and urine glucose. Further, the diagnosis was confirmed with serological testing. Once the patient enters into leaking phase, 6 hourly urine samples was taken for urine osmolality and urine

protein and a serum sample was obtained for serum creatinine. On discharge a urine sample and a serum sample was obtained for above mentioned tests. From the recruited 51 patients, 9 patients were excluded due to incomplete data. The sample consists of 36 non-leaking and 8 leaking patients up to now. Majority of the patients were in 20-29 years' age group (31%) and females (76.2%). According to current literature, DF is more common among males and young age group in Sri Lanka. Majority of the patients were Sinhalese (92.9%) and educated up to GCE O/L (38.1%). In accordance with the literature, patients from families with low income levels were predominant (57.1%) and that may be due to poor environmental conditions of the houses. From the onset of the disease, 42.9% of the patients had fever whilst 2.4% of the patients had no fever. Major signs and symptoms of the disease were generalized body ache (61.9%), myalgia (54.8%), anorexia (50%), headache (45.2%), arthralgia (35.7%), sore throat (19%), nausea (16.7%), vomiting (7.1%), and retro orbital pain (2.4%). Diabetes mellitus and hypertension were reported as comorbid conditions for 11.9% and 7.1% of patients respectively. Contact history was not reported in majority of patients (61.9%).

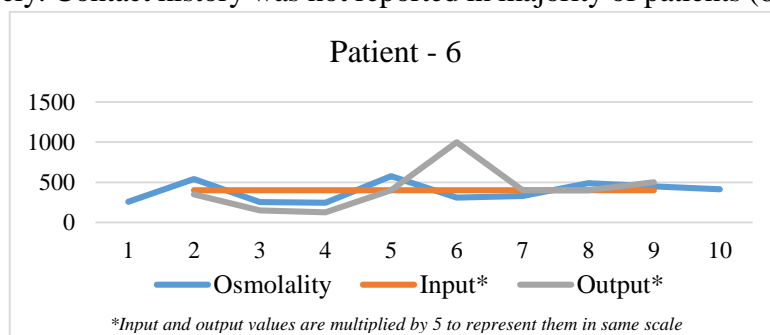


Figure 1

As per the hypothesis postulated at the inception of the study, it reveals that there is a discrepancy in the renal water conservation at the time of reduced urine output (Figure 1). Four out of five patients showed a reduction in the urine osmolality with the reduction in urine output without a change in the fluid input. At the same time, there was a transient proteinuria during the leaking period of dengue. Although the number of cases tested is not adequate to postulate a theory, it is quite obvious that the renal tubular and glomerular functions are affected in the early stages of the dengue infection and it can lead to long-term effects unidentified. With the available data up to now, it can be proven that, the renal involvement in dengue fever comes early in the disease process and it may need to adopt reno-protective management strategies in managing even mild cases of dengue fever without overburdening the renal parenchyma.

Keywords: Dengue fever; Leaking phase; Renal involvement

Acknowledgement: We would like to acknowledge for Wayamba University for providing support for this study.

Evaluation of the Relationship Between Attendance and Academic Performance of Medical Undergraduates in Wayamba University of Sri Lanka

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Abstract

Currently universities employ diverse teaching methods. Lectures tutorials and practical classes together form a major part of undergraduate teaching. Student participation in these academic activities is crucial in fulfilling the intended learning outcomes. Some higher education institutes have compulsory attendance policies, while others refrain from making it compulsory. Despite varying policies, there seems to be a consensus among the intellectuals about the positive effect of attendance in academic performance. Not attending classes is seen as one of the main reasons for academic failure. The recent advances in information and technology require a re-evaluation of the traditional teaching methods and the belief that undergraduate students benefit from class attendance.

Exploring the relationship between class attendance and academic performance in terms of examination results is helpful to students, teachers and policy makers. It is an institutional requirement to have a clear understanding on student participation in academic activities and its impact on their performance. The main objective of this research was to evaluate the relationship between attendance in academic activities and examination performance of students of Faculty of medicine Faculty of Medicine Wayamba University of Sri Lanka (WUSL). It expands the prevailing literature on class attendance and academic performance with more focus on the local setting at WUSL.

This study was conducted as a cross sectional study at the Faculty of Medicine, WUSL. The relationship between attendances of each subject with the relevant examination performance in that subject in 74 students was studied. Overall attendance of students was favourable with mean practical session attendance

of 94 % and mean tutorial attendance of 96%. Students who accessed online lecture materials through the Learning Management System were marked as present. Therefore, all students had 100% attendance for all the lectures. There was a significant positive correlation between tutorial and practical class attendance and written examination performances which included Multiple Choice Questions (MCQ) marks and Structured Essay Questions (SEQ) marks ($r=0.30$; $P<0.01$) while having stronger relationship with the Objective Structured Practical Examination (OSPE) performance ($r=0.34$; $P<0.01$). These results signify the importance of the active engagement in academic activities to score more in the components assessing the practical implication of the new knowledge acquired by the students. Though there is a limitation with the sample size, it can be concluded that the active engagement significantly influences the academic performance of the students. Further, this can be repeated with larger sample to confirm the impact and can be used to motivate students to increase participation in academic activities.

Keywords: Academic performance; Class attendance; Medical undergraduates

Morphometric Analysis of Dry Mandibles of Sri Lankans for Sex Determination

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Abstract

Mandibular morphometric values play a crucial role in the objective assessment of the craniofacial appearance of individuals. These values have a direct relationship with sex. Sex determination of human bones is vital in many fields such as forensic medicine, archaeology and plastic and Oro faciomaxillary surgeries. Many morphometric criteria have been laid down for sex determination in previous studies. However, this has not been previously investigated for the Sri Lankan population. Therefore, this study aimed to investigate the mandibular parameters to be used as indicators of sex determination in the Sri Lankan population. A total of seventy-five dry mandibles of Sri Lankans were selected for the study. The sex and age of each mandible were determined by assessing the morphological characteristics reference to standard literature. Forty male and 35 female mandibles were identified. The age of the mandibles ranged from 60 – 80 years, and the mean age of the studied samples was 67.545 ± 4.36765 . A single investigator obtained thirteen mandibular measurements to minimise the inter observer bias. Measurement mandibulometer and digital Vernier calliper with no zero error was used to obtain the measurements. The mean value of three times measured each parameter was taken to minimise the intraobserver bias. The mean, standard deviation, mean difference and P-value for each measurement were separately analysed for males and females.

A parameter of which the P-value was less than ($<$) 0.05 and t – value was more than ($>$) 1 for both males and females were identified as suitable values for sex determination. The mean mandibular measurements of each mandibular morphometric parameter in males were higher than that in the females except for the height and breadth of the mandibular body and mandibular angle. The

maximum mandibular length, bigonial width, maximum ramus height, bicondylar breadth, bicoronoid breadth, bimental breadth and mandibular notch depth of males were significantly higher (<0.05) than the females. The present study findings of Sri Lankan population, provide information for forensic pathologists for establishing the identity of mutilated bodies, archaeologists and anthropologists to support their ancestry evaluation studies and for the maxillo-facial and plastic surgeons for designing surgical interventions.

Keywords: Mandible; Morphometric analysis; Sex determination; Sri Lankans

Patterns of Hump-nosed Viper (*Hypnale hypnale*) Bites in Anuradhapura; A Descriptive Study

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Abstract

Snakebite is an occupation-related health hazard in Sri Lanka, with more than 80,000 annual snakebites. Hump nosed viper (HNV), a snake of highest medical importance, accounts for more than 35% of hospitalised cases of snakebite in Sri Lanka. They frequently cause severe local effects and are capable of causing severe systemic envenoming in a smaller fraction of patients. Detailed identification of the recent HNV bite exposure patterns is essential for effective prevention. This study analysed the recent snakebite pattern of HNV presented to Teaching Hospital Anuradhapura (THA), aiming to provide information for developing practical preventive guidelines.

A descriptive study was conducted using the primary data from the Anuradhapura snakebite cohort; an electronic database. Details of 544 confirmed HNV bite victims admitted to THA between 2013 and 2020 were analysed to identify vulnerable groups, high-risk activities, and other HNV bite associated factors.

Most of the victims are males (325, 59.7%), and the mean age of a victim is 44.1 years (SD= 16). The majority are involved in farming (314, 61.2%). Most of the bites occurred from 6 pm to 9 pm (146, 27.2%), and there was no diurnal variability (6am to 12 noon: 131, 24.4%, 12 noon 6pm: 129, 24.1%, 6pm to 6am: 276, 51.5%) in the bite pattern. Outdoor bites (456, 84.1%) were common, with the highest percentage of bites occurring at the home garden (300, 56%). The majority of the bites occurred while walking (205, 38.7%), engaging in agriculture-related activity (71, 13.4%) and cleaning outdoor (70, 13.2%). Foot (331, 61.3%) and hand (176, 32.6%) were the common sites of the HNV bites. Only 18.4% (100) of bites were resulted due to provoked bites. 69.1% (376) of

victims had seen the snakebite, and 66% (359) correctly identified the snake as HNV. HNV bite incidence varied during the calendar year. The majority of the bites (300, 55.1%) occurred from August to November (early stage of Maha season) and during the months of February (61, 11.2%).

This study concludes that the middle-aged males involved in farming are at higher risk of facing HNV bites, especially while engaging in outdoor activities before and during the rainy seasons in the study area.

The findings of this study can be considered when preparing preventive strategies and educating the community on snakebite. Further research is needed to identify the perception of the stakeholders of the snakebite regarding the applicability of these findings to the existing preventive strategies of snakebite.

Keywords: Anuradhapura; Hump-nosed viper bite; Snakebite

Preferences and Determinantal Effects of Using Electronic and Printed Learning Materials among Medical Students in Wayamba University of Sri Lanka

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Abstract

Electronic learning materials have been getting popular globally during the past two decades among the students in the higher education system. Electronic learning materials give a clear advantage since they are up to date, cost-effective, portable, easy to store, and easy to handle. However, there are also some drawbacks. Identifying the preferred type of learning materials and their determinants is essential, particularly in the development of library facilities. Therefore, this study was aimed to identify the students' preference of electronic and printed learning materials, reasons behind their preferences and limiting factors of using each learning material among medical students in the Wayamba University of Sri Lanka.

A cross-sectional descriptive study was carried out. The study population was all the medical students at the Wayamba University of Sri Lanka. All the individuals in the population were invited to participate in the study by filling a self-administered internet-based Google form, and 188 students participated by giving informed consent. 132 (70.2%) participants were females, and 56 (29.8%) were males. Participants were in the 20-25 years age range. The majority of the participants (176, 93.6%) used printed learning materials before entering the university, while 10 (5.3%) used electronic and printed materials.

Among the participants, 100 (53%) were using electronic learning materials more frequently for their undergraduate studies, and 88 (47%) were using printed learning materials frequently. There is no significant difference between the two categories (P value=0.342). 52.7% (48.5%-59.8%) of students preferred printed learning materials only, while 37.1% (30.1%-44%) preferred electronic

and printed learning materials. 10.2% (5.9%-14.6%) preferred electronic learning materials only.

The main reason for preferring printed learning materials was mentioned as being easy to read. Easy handling, high reliability and easy access were also identified as reasons behind preferring printed learning materials. Freely availability for downloading was the main reason for preferring electronic learning materials. Easy sharing, accessing, cost-effectiveness and easy finding of information were other main reasons for preferring electronic learning materials.

Participants identified that the difficulty in deviating from printed materials (60.5%, n=92) as the main reason for limiting electronic learning materials. Eye strain with the use of electronic devices and difficulty accessing technology were identified as other reasons limiting electronic learning materials by (57.3%, n=75) and (31.3%, n=41) respectively. Difficulty in carrying was the main limiting factor for the benefit of printed materials (73.3%, n=96). Participants also found that the difficulty in scoring (28.2%, n=37) and expensiveness (57.3%, n=75) has limited their use of printed materials.

This study concluded that students are transitional in adapting to electronic learning materials for their higher studies. Therefore, these findings can be used in preparing Teaching-Learning materials and in library development. Further research among different specialities of undergraduates is necessary to evaluate the preferences and determinantal effects of using these learning materials to get an overall clear picture in higher education.

Keywords: Electronic learning material; Learning material preference; Medical Students; Printed learning material

Resilience Level among Grade 10 Adolescents in the Gampaha District

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Abstract

Introduction: Resilience is the process of adapting well in the face of adversity, trauma, tragedy, threats, or significant sources of stress such as family and relationship problems, serious health problems, or workplace and financial stressors. Facing changes and challenges, adolescents are considered as one of the most vulnerable segments of the population. Those who are having lack of resilience are more susceptible to drug addiction, sexual abuse and eating disorders which can lead to immediate health problems and chronic disorders later in life. In addition, they may be subjected to peer pressure, violent crimes and other illegal and human rights violation activities, exposing them further to high stress levels leading to mental health conditions like depression and anxiety. Thus, concept of resilience is considered as a primary preventive measure to ward off negative psychological and behavioural outcomes.

There are five core characteristics of resilience. They are equanimity (composure/evenness of mind especially under stress), meaningfulness (purposeful), perseverance (determination), self-reliance (belief on one's own abilities), and existential aloneness (awareness that every person is unique and sense of independence).

The level of resilience among Sri Lankan adolescents is important to assess the magnitude of the problem in order to ensure availability of resources to tackle the problem.

Objectives: To determine the level of resilience among grade 10 Sinhala conversant school going adolescents in government schools of Gampaha district.

Methods: This study is a part of a component of a more extensive research project which is based on a preliminary assessment to determine the level of resilience that prevailed among the grade 10 adolescents. A descriptive cross sectional study was conducted to achieve above.

Cluster sampling was used as the sampling method where a class was considered as a cluster. Thus, the computed sample size was 1380 after applying the design

effect. Using stratified cluster sampling, 92 clusters were selected from the grade 10 students in Type I AB, I C and Type II government schools in the Gampaha district. Students with physical and mental disabilities were excluded using a screening questionnaire. Study instrument used was 14-Item Resilience Scale-Sinhala version which was subjected to exploratory (EFA) and confirmatory (CFA) factor analysis, which generated a two factor model. The latter was also subjected to judgmental validity via Delphi technique, and construct validity was confirmed using CFA. Internal consistency and test-retest reliability were assessed by computing Cronbach's alpha and Kappa coefficient, which were 0.869 and 0.842 respectively. Composite reliability was confirmed using CFA. In the original 14 Item Resilience Scale, the resilience score ranged from 14 to 98 with higher scores, indicating a higher resilience. Based on the resilience score, six levels of resilience were identified namely: High (91-98), Moderately high (82-90), Moderate (74-81), On the lower end (65-73), Low (57-64) and Very low (14-56). Levels of resilience were described as percentages and 95% confidence intervals (CI).

Results: Response rate was 97.0%. Mean age of the study participants was 15.8 years (SD = 0.89). Majority of adolescents (53.3%; n = 735) were females. Ninety-eight percent (n = 1347) were Sinhalese and 1203 (87.2%) were Buddhists.

The resilience score was observed to have a skewed distribution. The overall resilience score of the study participants ranged from 15 to 98. The median resilience score among grade 10 adolescents was 79.00 (IQR: 70.00 - 86.00) and mean was 76.9 (SD: 13.2). Highest median score of 80.0 (IQR: 73.0 - 87.0) was observed in adolescents from Type I C schools and the lowest of 77.0 (IQR: 69.0 - 85.0) in Type II schools. The prevalence of resilience levels in grade 10 adolescents in Gampaha district are as follows: High 11.6% (n = 159; 95% CI = 9.9 - 13.3), Moderately high 29.3% (n = 405; 95% CI = 27.0 - 31.8), Moderate 25.5% (n = 352; 95% CI = 23.2 - 27.9), On the lower end 20.2% (n = 279; 95% CI = 18.2 - 22.5), Low 7.8% (n = 108; 95% CI = 6.4 - 9.3) and Very low 5.6% (n = 77; 95% CI = 4.4 - 6.9).

Conclusions and recommendations: A total of 916 grade 10 adolescents had moderate or high levels of resilience for which the prevalence was 66.4%. The balance of 33.6% (one third of the adolescents) had acquired only a low level of resilience.

Recommend adoption of relevant measures such as cognitive behavioral therapy (CBT) to boost their level of resilience, which should be conducted regularly at the school level.

Keywords: Adolescents; Resilience; Cognitive behavioural therapy

The Effectiveness of Online Learning Over In-Person Learning of Medical Undergraduates in Wayamba University of Sri Lanka

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Abstract

The history of online learning runs for more than 50 years. Since the whole world became a global village with technology, digital literacy is playing a pivotal role in sharing the knowledge. Online learning has the advantage of crossing the time and geographical boundaries, and at the same time it provides opportunity for the student centered learning rather than the teacher centered learning that we practiced for centuries. Although the world has picked the pace with E-learning, Sri Lanka stands far behind with respect to the rest of the world. Though it has lot to do with the lack of infrastructure facilities to provide equal learning opportunities throughout the country, lack of interest to try new methods within the education system also played a role. Despite all this, due to the COVID 19 pandemic new steps had to be taken to adhere to the new norms abruptly with little or no training on distant learning techniques. Online teaching is one of the new concepts that was introduced in Sri Lanka to overcome the travel restrictions following the pandemic. As with all the other teaching institutions, medical faculties also had to adjust their methods of delivering lectures, practical, tutorials and conducting assessments using the online platform. This study is planned to assess the effectiveness of online learning over the in-person learning on academic performance of medical undergraduates.

A cross sectional analytical study was conducted in the Faculty of Medicine, Wayamba University of Sri Lanka. All the students from 2017/2018 advance level batch who have completed the 2nd MBBS examination were recruited to the study. Data regarding the performance of each student in 2nd MBBS examination, 3rd year semester one examination which were compared was obtained from the relevant authorities. Total of 71 students from the inaugural batch were selected, as they were the only batch of students who had both in-

person and online learning experience including assessments. They had their lectures, practical sessions, tutorials, end semester examinations of first three semesters and the 2nd MBBS comprehensive examination in physical presence. Whereas the 3rd Year 1st semester lectures, tutorials and the examination were done in an online platform.

Their final marks obtained at 2nd MBBS examination and 3rd year first semester online examination results were assessed. As per the hypothesis postulated at the beginning of the study, it revealed that there is a statistically significant reduction of marks between 2nd MBBS comprehensive examination (mean- 60.0499, SD- 7.380) which was done in person and 3rd year first semester examination (mean- 52.2458, SD- 11.1401) which was done in an online platform ($p < 0.001$).

	Mean	Number	Standard deviation	Std. Error Mean	t value	P value
2 nd MBBS marks	60.0499	71	7.38027	0.87588	8.560	>0.001
3 rd year semester one continuous assessment marks	52.2458	71	11.14017	1.32209		

Although the number of the sample tested is not adequate to postulate a theory, it is quite obvious that there is a significant reduction of marks in students with online learning. Further, there can be a considerable influence on the examination performance from the type of electronic device they used to attend lectures, access E-learning materials, and examinations. We would like to suggest further studies on the area to have better understanding on the influence of distance learning platform on the undergraduate students, in view of supporting better learning.

Keywords: Academic performance; Medical undergraduates; Online learning

Acknowledgement: We would like to acknowledge Faculty of Medicine Wayamba University of Sri Lanka for providing the necessary support to this study.

Voluntary E-Learning Engagement among Medical Undergraduates in Wayamba University of Sri Lanka

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Abstract

E-Learning refers to learning experience conducted electronically. The rapid advancement of technology has been increasing the availability of knowledge and information for the learners. The improvement of storage capacities and processing powers of electronic devices are substituting the traditional methods of learning. Accessibility and portability of E-Learning provide feasible learner engagement and motivation. Apart from this, confining to the traditional learning practices does not accord with the emerging educational demands of the modern world. Medicine is a field where new knowledge is continuously generated and disseminated. Medical undergraduates are required to have a sustainable intention to pursue new knowledge. E-learning being one of the most feasible ways of acquiring knowledge, it is vital to assess the medical undergraduates' voluntary engagement and motivation towards E-learning.

This study aimed to investigate the extent of voluntary engagement in E-learning and the ways of accessing the E-learning materials among medical undergraduates of the Faculty of Medicine, Wayamba University of Sri Lanka; an emerging medical faculty.

All the medical undergraduates following the basic science stream of the Faculty of Medicine, Wayamba University of Sri Lanka, were invited to participate for the study. A self-administered questionnaire was given, and the data was analysed to assess the voluntary E-Learning engagement.

Ninety-two out of a total of 146 medical undergraduates in whom ages ranging from 22 years to 25 years, consented to participate to the study. Among them 30.4% (n=28) were males and 69.6% (n=64) were females. The majority; 92.3%

(n=84) of them, were using mobile devices like phones, tablets or iPad, and 8.6% (n=8) were using personnel computers as a device to access E-learning materials. Almost all the students 98.9% (n=91) were using the learning management system which is an E-learning source that has been incorporated in to the formal university teaching. The voluntary engagement of E-learning as an additional aid to the formal teaching and learning was 69.56% (n=64). Among medical undergraduates 67.7% (N=62) were using E-learning to clarify the theory taught in the university curriculum, and 54.3% (n=50) of them were using E-learning to gain additional knowledge. The students' enrolment into online courses related to medicine was 39.1% (n=36). The activities mostly done in E-learning was watching animated videos and viewing descriptive illustrations related to the taught content.

These findings conclude that voluntary E-learning is popular among medical undergraduates of Wayamba University of Sri Lanka. The advancing technology is altering mode of knowledge dissemination and student engagement rapidly in modern higher educational context. Therefore, the findings of this research provide valuable information for the academics to determine the suitable ways of promoting the learning with the use of newly advancing technology to achieve better outcomes in medical education.

Keywords: E-Learning; Medical education; Medical undergraduates

Section F

Technology

Anomaly Detection of SVM under Poisoning Attack

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Abstract

Machine Learning (ML) applications have been adopted heavily due to the use of artificial intelligence systems, cloud computing, social media and smart computing. Vendors integrate ML into products across various industries. ML systems train models periodically to enhance the ad hoc functionality. However, data poisoning has been identified as a challenge in ML, and this can be occurred by an injection attack or a label flipping. A hacker needs to know the existing system, and they have to craft and transplant compromised data points avoiding outlier regions for an injection attack. In label flipping, the hackers should access training data systems and make alterations or periodically insert data into the systems through a proper channel trending towards wrong decision making. Support Vector Machine (SVM) is an algorithm which is commonly used in ML, but the algorithm has become a target for data poisoning. The objective of this study was to develop early identification parameters in order to check whether a SVM model is attacked by data poisoning or not.

Danmini Doorbell (DDb) data in University of California, Irvine (UCI) machine learning repository was used in this experiment. Each record contained N=115 features which were generated by the publishers of the dataset using the raw attributes of network traffic. The top 20 (n) was picked from the total N features using the Gini index obtained by the Random Forest algorithm in order to test them according to a reduced feature set architecture. Accuracy and kappa were calculated using One Class SVM model to identify a poisoning attack on the training data set.

Table 1: The change of accuracy and kappa values in data poisoning

	Sample	A	B	C	D	E	F
All features 115	kappa	0.8876	0.8894	0.8697	0.2349	0.2112	-0.0423
	Accuracy	0.9951	0.9951	0.9941	0.8909	0.8800	0.8657
Top 20 features	kappa	0.8851	0.4254	0.2261	0.1135	0.0997	-0.0446
	Accuracy	0.9950	0.9502	0.8847	0.7900	0.7783	0.8243
	% poisoning	0	0.0099	0.0199	0.2	0.2999	1

According to the results, in the all-features set architecture, the accuracy and the kappa values were decreased with the increase in data poisoning (Table 1). Similar results were also obtained in the reduced-features set architecture as well.

The results revealed that the SVM anomalous behavior due to data poisoning can be identified by checking accuracy and kappa on training data sets. However, in order to make firm applications it should be further investigated with different data sets and algorithms.

Keywords: Accuracy; Data poisoning; Kappa; Machine learning

Application of an Improved GIS based MCA Approach for the Integration of Flood Losses in Flood Risk Analysis

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Abstract

Floods have caused massive destruction to people and society. Although floods occur occasionally, they are responsible for massive death tolls and other damages once they occur. Flood risk is estimated by the probability of a flood event and the potential economic, social and environmental losses and damages. Flood losses can be categorised into tangible and intangible based on the ability to assess them in monetary terms. As implied by its name, tangible losses can be evaluated in monetary values and, therefore, frequently incorporated in flood risk analysis. Generally, intangible losses are recorded by non-monetary measures such as the number of fatalities or injuries. Currently, intangible losses are barely incorporated in flood risk analysis due to the lack of appropriate methods for their evaluation and integration in flood risk. This paper presents a novel Geographic Information System (GIS) based Multi-criteria Analysis (MCA) approach, which is proposed and applied for the integration of intangible losses in flood risk analysis.

Tangible losses (also called monetary or economic losses) and four categories of intangible losses (i.e. loss of life, physical injuries, mental health impacts and cultural losses) were first evaluated using several available and novel approaches for a selected pilot site and selected flooding scenarios. The spatial distribution of losses was presented in raster GIS maps. Then a GIS-based MCA approach, a combined MAUT-AHP (Multi-Attribute Utility Theory - Analytical Hierarchy Process) approach, was developed to integrate flood losses. Even though several MCA approaches are available, the focus is put on the approaches, which can be performed in the GIS environment. Among the diverse methods available, the MAUT value functions approach is selected and applied for this study due to its capability of aggregating the different losses

with properly standardised criterion values and calculated criterion weights. Here, value functions are developed for each criterion for the standardisation of the criterion values. The pairwise comparison method of AHP was selected to estimate criterion weights since this approach ranks the different criteria and determines the relative importance of each criterion. For the multi-criteria analysis, direct economic losses and the four categories of social losses mentioned above are selected as the evaluation criteria.

Once the criterion weights for all losses are determined, and the standardised criterion maps are produced, the total loss of each raster cell of the GIS map is calculated according to the multi-attribute value function – weighted sum method and the aggregated loss map is generated. Then the flood risk level of each grid cell is determined by combining the aggregated flood loss in each cell with its flooding probability.

The results show that estimated tangible losses slightly affect the integrated total loss compared to integrated intangible losses for the case study. This is mainly due to the (calculated) high criterion weights for social losses, especially human-health losses compared to economic losses. Therefore, for this study, the dominant categories of flood losses are related to human losses as reflected by their criterion weights, which emphasises the importance of consideration of intangible losses in flood risk. In addition, the proposed MAUT value function approach is compared with the widely used simple additive weighting (SAW) - linear scale transformation approach. The value function approach provides better results for identifying areas with the most critical flood losses (especially loss of life) than the SAW approach.

Large uncertainties might result due to the assumptions and author's judgements required for the development of value functions and the elicitation of criterion weights. Due to resource constraints, experts' involvement in reducing these uncertainties is not carried out in this study and should be a task for future research.

Keywords: Analytical hierarchy process, Flood risk, Geographic Information System, Intangible flood losses, Multi-attribute utility theory

Approach for Synthesis of Molybdenum Disulphide using Solution Reaction and Heat Degradation Method

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Abstract

In the present era, Au, Pt, Ge, Cd, In, Se, Te, Ga, Cr and W are the critically identified expensive metals other than Cu, and Al, which are used in electronics, solar cells, optoelectronics and photonics-based industries. Such metals are needed on a large scale for commercial productions, so there are many difficulties based on these materials due to high cost, supply risks, toxicity and other environmental concerns. Pt, W and In are expensive and need high temperatures for processing. Therefore, new eco-friendly, inexpensive, low toxic and good environmental stable materials such as MoS₂ have a great demand for electronic manufacturing. As MoS₂ has a wide bandgap, stable dimensional crystal structure, relatively large absorption capacity for wavelengths from 400 nm to 500 nm, it can be used in various electronic and optoelectronic based applications. To date, many methods have been employed in the synthesis of MoS₂, such as chemical vapour deposition, hydrothermal synthesis, etc. In conventional processing methods of MoS₂, it is usually synthesized by reacting ammonium molybdate with a hazardous sulphur source such as H₂S. As a solution, the current invention relates to the preparation of MoS₂ without using H₂S. The high purity ammonium tetrathiomolybdate can be produced at room temperature using an alkaline medium named ammonium sulphide and the basic medium of ammonium hydroxide using solution reaction method and heat degradation method within a short period (30 min - 3 hrs). The approaches for fabricating MoS₂ are by preparing (NH₄)₂MoS₄ through the reaction of Ammonium heptamolybdate/MoO₃ and ammonium sulphide solution. The preparation method of ammonium tetrathiomolybdate was comprised of the following steps: the first step, weighing a certain amount of (NH₄)₆Mo₇O_{24.4}H₂O or MoO₃, then adding 3 - 6 amounts of distilled water. Next, during heating (40 – 60 °C) and stirring, add concentrated ammonia to the

solution to dissolve. The amount of concentrated ammonium hydroxide is 1-2/1 (ml/g). By controlling the temperature of the solution between room temperature and 90 °C add ammonium sulphide into the ammonium solution while stirring, to maintain S/Mo molar ratio (4-6/1) in the reactant liquid. Then the mixture should keep 0.5 - 3 hours while stirring to obtain a deep red colour liquid. After the reaction completing the solution must cool to room temperature and stand for 8-4 hours. Then filter and wash with cold distilled water for 3 times and finally should wash with ethyl alcohol about 3 times. Then wait again for 24 hours letting the crystals dry at room temperature to obtain the final reactant. Then decompose the high purity $(\text{NH}_4)_2\text{MoS}_4$ at 120 °C to MoS_3 using the heat degradation method. These MoS_3 will be heated in a tube furnace under 800 °C. Finally, the MoS_2 can be obtained. Therefore, the materials have less amount of waste exhaust and a high product yield, reaction time is greatly shortened and the malodorous and poisonous hydrogen sulphide gas doesn't need to be treated. The obtained black crystalline products are characterized by X-ray diffraction (XRD), Fourier transforms infrared spectrometer (FTIR), UV visible spectroscopy and particle size analysis on their structure, composition, absorbance and size distribution of particles. The XRD pattern was recorded using an X-ray diffractometer (ultima IV, Japan) using $\text{Cu } \alpha$ radiation operating at 40 kV. The pattern of the sample can be readily indexed as hexagonal 2H- MoS_2 (according to the JCPDS 37-1492), and the FTIR spectrum of the MoS_2 shows the band at 480 cm^{-1} corresponds to the $\gamma_{\text{as}}(\text{Mo-S})$. Attractive electronic optoelectronic and mechanical properties of MoS_2 metal opens up the possibility of many applications such as solar cells, bio-sensors, gas sensors, electronic, and catalytic based applications.

Keywords: Ammonium Molybdate, Heating degradation, MoS_2 , Synthesis

Development of Portable Rubber Tree (*Hevea brasiliensis*) Girth Measuring Instrument using Infrared Proximity Sensors

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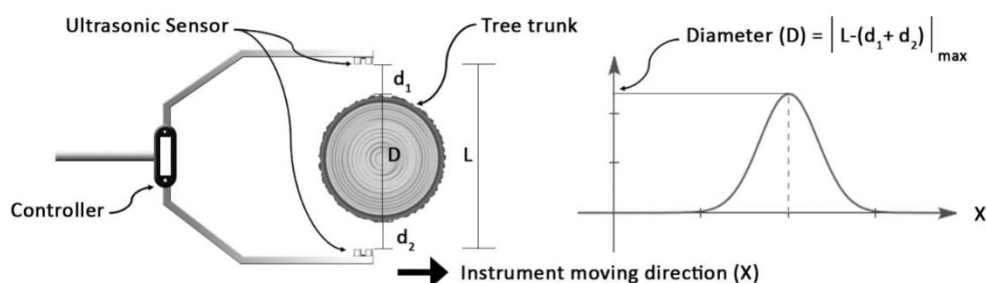
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Abstract

Rubber (*Hevea brasiliensis*) plays a vital role in the Sri Lankan economy as a primary foreign exchange earner, a commodity for domestic consumption, and an employment source. Precise measurement of girth increment is critical in obtaining a higher number of latex vessels to attain an economic yield in rubber cultivation. The traditional approach, measuring the tree girth with a measuring tape, is extremely time-consuming due to many trees in a regular plantation and inefficient from the production point of view since it requires more labor and human errors occurring with the measurements. Therefore, this study was focused on overcoming the practical issues of obtaining precise tree girth measurements and increasing the efficiency of the process by developing a portable electronic device.

As shown in the figure below, the device was made with two ultrasonic proximity sensor modules (HC-SR04), a commonly available module having a 4 MHz base operating frequency in the initial stage, considering the simplicity and ease of operation. The proximity sensor is the critical element in the device responsible for making a precise measurement. The ultrasonic proximity sensor used in this study could measure 50 mm – 4000 mm range with 2 mm resolution, which was ideal for the device. The readings obtained by the proximity sensors were sent to the Atmega328 microcontroller-based controller. It is capable of performing the necessary calculations to obtain the tree girth. With the capabilities of the microcontroller, the device was equipped with several functionalities to store the measurements, display them in a Liquid Crystal Display (LCD) and uniquely identify trees with radio identification tags, making the measuring process more accurate, easy, and efficient.

Further, the system was developed to be lightweight (< 250 g), portable, and driven by a rechargeable 9V battery. It was tested with 1000 plants in a rubber plantation located in Padukka, Sri Lanka. It was found that the uncertainty of measurement was ± 0.001 m with a standard deviation of 2.5 against the standard tape measure. The results were within the acceptable range for a measurement of a tree girth. However, it was evident that the ultrasonic proximity sensor could not take accurate measurements due to the speed, angle of wheeling the device, and the typical environmental conditions of a rubber tree plantation. Therefore, the ultrasonic proximity sensor was replaced with Pololu 38 kHz Infrared (IR) Proximity Sensor to overcome the ultrasonic proximity sensor's low data acquisition rate (40 Hz) and other disadvantages. The IR Proximity Sensor could perform the same operation with a 1 mm resolution having a reading range of 1 mm to 600 mm, ideal for the device's design conditions. With the new proximity sensor, the device's uncertainty was improved to ± 0.0001 m having the standard deviation of 0.5 against the standard tape measurement, which is a notable enhancement. The device was performed well to natural rubber plantation environment conditions showing remarkable resistance to most conditions such as reflectivity of the tree surface and ambient lighting conditions, humidity, and environmental temperature. The sampling rate of 1 kHz was satisfactory for obtaining accurate distance measurements. The device with ultrasonic proximity sensors was only allowed to measure circular-shaped tree trunks, and it was assumed that the rubber trees were almost cylindrical. With the high data acquisition rate with the IR proximity sensor, the device could measure and calculate the girth of tree trunks with any shape. Therefore, with the results obtained, the study was concluded that the instrument is capable of measuring the girth of the rubber trees and recording them effectively and efficiently. Further, the device can accurately measure tree girths in any shaped tree with less than 500 mm diameter, which could be helpful in forestry.



Keywords: IR proximity sensors; Tree girth measurement; Ultrasonic proximity sensors

Effect on the Use of Natural Esters on the Area of the Creeping Discharge Propagation

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Abstract

The use of environmentally friendly natural ester oil is gaining popularity as a replacement for petroleum-based oil in high-voltage assets. Creeping discharges on the solid/liquid interfaces of high voltage assets may occur when the electric field stress inside the dielectric liquid exceeds threshold values. As a result, alternative dielectric liquids must be investigated to minimize creeping discharge development. Previous researches have shown that the discharge length of creeping discharge patterns propagating on material samples immersed in soybean and sunflower oil has no significant difference. The streamer channel thickness decreases as it propagates along the streamer, and the discharge length concept considers only the length of streamers, ignoring the thickness. As a result, it can't be used to predict how much discharge it will form. So, information on the area of the propagating pattern is required to classify soybean and sunflower oil to reduce creeping discharge propagation. The goal of this study is to use a point-plane electrode system to investigate the area of creeping discharges propagating on material samples immersed in soybean and sunflower oils.

In a laboratory setting, creeping discharges are generated using a test setup based on a point plane electrode system. The test setup is similar to what the authors have used in their previous works. However, some of the main features are recalled. A hollow PMMA cylindrical core with an inner diameter of 140 mm, a vertical tungsten point electrode with a hemispherical tip, a brass flat electrode, a camera, and a movable bearing system make up the test setup. Square-shaped glass material samples with a side length of 9 cm and a thickness

of 5 mm are inserted between electrodes. As the alternating dielectric liquid on the solid interface, commercially available readymade soybean oil and sunflower oil samples are used as received. The point electrode is connected to a high-voltage power supply, while the flat electrode is grounded.

A software is used to extract the traces of all the streamers of creeping discharges recorded by the camera, and the area of the patterns is calculated in pixels² using binary images. Figure 1 shows the area of the patterns propagating over glass/soybean oil and glass/sunflower oil interfaces as a function of voltage. In contrast to the quasilinear variation of the discharge length with applied voltage, the area of the pattern increases at an increasing rate with applied voltage for both liquid types. Furthermore, the area of the pattern propagating on samples immersed in soybean oil is higher than that of samples immersed in sunflower oil. Natural esters are triglycerides containing a variety of fatty acids. Unsaturated fatty acids make up nearly all of the fatty acids in the chain in the soybean and sunflower oil. Unstructured nature forms at least one $\pi(\pi)$ bond in its acid chain and each of these bonds can easily break and release more electrons as the creeping discharge propagates. As in Table 1, soybean oil has a higher concentration of fatty acid composition with more π bonds than sunflower oil, which can cause the discharge to propagate.

Table 1. Acid Composition in alternative oils

Fatty Acid Scientific name	Fatty Acid Common Name	Soybean Oil	Sunflower Oil
Caproic	C6:0	ND	ND
Caprylic	C8:0	ND	ND
Capric	C10:0	ND	ND
Lauric	C12:0	ND-0.1	ND
Myristic	C14:0	ND-0.2	ND-1
Palmitic	C16:0	8.0-13.5	2.0-6.0
Palmitoleic	C16:1	ND-0.2	ND-0.05
Margaric	C17:0	ND-0.1	ND-0.05
Heptadecenoic (cis-10)	C17:1	ND-0.1	ND-0.06
Stearic	C18:0	2.0-5.4	2.9-6.2
Oleic	C18:1	17-30	75-90
Linoleic	C18:2	48.0-59.0	2-17
Linolenic	C18:3	4.5-11.0	ND-0.3
Arachidic	C20:0	0.1-0.6	0.2-0.4

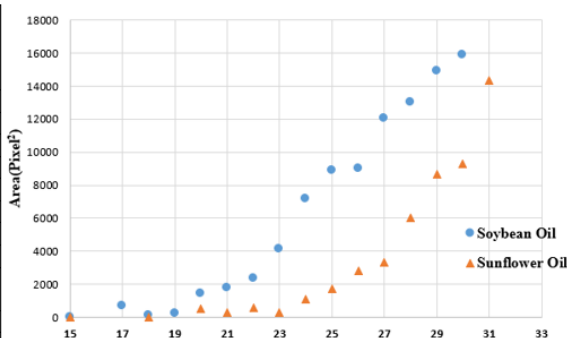


Figure 1. Area of creeping discharge on glass/liquid interfaces

This research shows that the fatty acid composition of a natural ester oil has a significant impact on discharge propagation, and sunflower oil inside high-voltage assets can significantly reduce creeping discharge propagation compared to soybean oil.

Keywords: Alternative oil; Creeping discharges; Discharge length; High voltage; Propagation

Environmental Factors Influencing Labour Productivity in Sri Lankan Building Construction Projects

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Abstract

The construction sector is one of the significant contributors to the development of infrastructure facilities towards the economic growth in a country. The productivity of labour operations is the key to the construction firms for achieving their organizational goals. Past studies pointed up a wide range of labour-related issues that result in the low productivity of construction operations in many developing countries, including Sri Lanka. Sources revealed that environment-related factors are one of the significant contributors to the productivity loss in the Sri Lankan construction sector. The labour operations are handled in different directions by different work categories. Hence, the perspectives of different work categories play a very important component in the decision-making process and upgrading construction management practices. This study intends to investigate the environmental factors that affect labour productivity in construction projects based on the different perspectives between two working categories, namely construction managers/engineers and construction supervisors/ technical officers.

Many studies highlight the extreme weather conditions and negative social attitude on some occupations as the significant environmental factors affecting the productivity of labour operations in construction, where a few pointed out changing nature of the construction market, social activities and entertainment, growth of self-employment, perception of the industry and ethnic characterization. Only a few studies were found that investigated construction labour productivity in the Sri Lankan context. Hence, a series of interviews were also conducted among industry experts to understand the current industry

practices in Sri Lanka. The majority of the interviewees highlighted the climatic factors, negative social attitude on some occupations and growth of self-employment as significant, where a few of them revealed that productivity of labour is affected due to various social / entertainment activities. The qualitative approaches were used to filter the factors identified from the literature review and interviews. The quantitative study methodology was then adopted through a questionnaire survey among 154 building contractors from the Sri Lankan construction industry, where construction managers and engineers represented 90 contractors, and construction supervisors and technical officers represented the remaining 64 contractors. The Relative Importance Index (RII) method was used to measure the severities of the environmental factors on labour productivity.

Figure 1 displays the severity levels of the environmental factors on labour productivity with the differences in perspectives of different working categories. Overall, the environmental factors had a moderate level impact on labour productivity, where ‘negative social attitude on some occupations’ was the only factor that had a high-level impact on labour productivity. Notably, there was a significant gap between the perspective levels of different working categories on this factor. The study findings can be useful for the Sri Lankan construction firms in their decision-making processes related to labour operations.

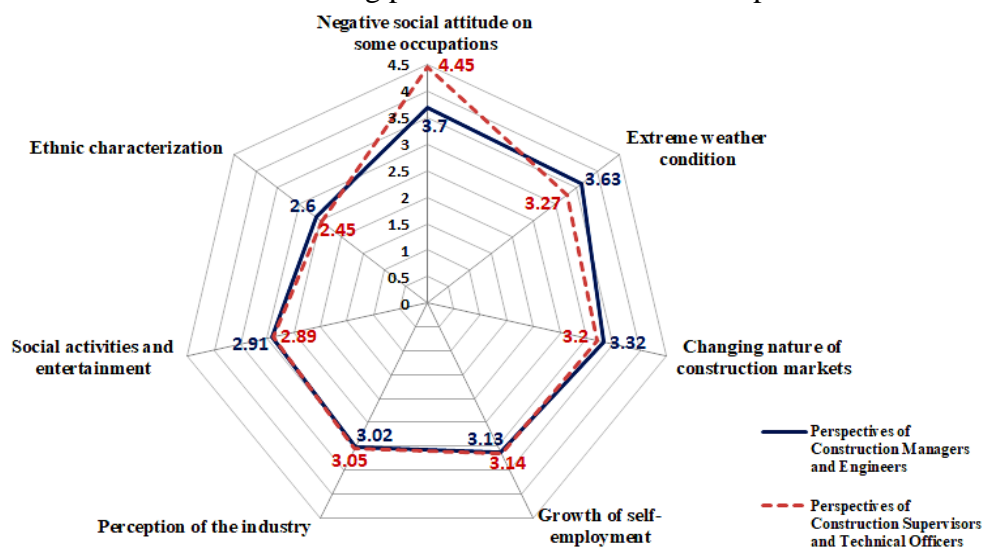


Figure 1: Severity Levels of Environmental Factors on Labour Productivity in Sri Lankan Building Construction Projects

Keywords: Building projects; Construction industry; Environmental factors; Labour productivity; Sri Lanka

Millimetre Level Accurate Landing of Drone Using Active and Passive Position Correction

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Abstract

Due to the increasing popularity of drones currently, the need for drone automation has increased. One of the most critical factors that drones face is their battery life. This is why implementing a millimetre level accuracy automated drone landing on the docking station to support battery recharging or battery swapping system to improve the efficiency and effectiveness of their missions.

If the drone only relies on the Global Positioning System (GPS) in the horizontal plane, it results in a landing position that typically deviates from the intended one by 1 to 3 m. In vision position control, when the ArUco marker is detected, the drone changes its flight behaviour in order to land on the target position where the marker is located. The results show an average offset of only 15 cm from the target.

For this study, a landing guider was developed to land on the precise position without any internal control within 15 cm, which supports by vision position control.

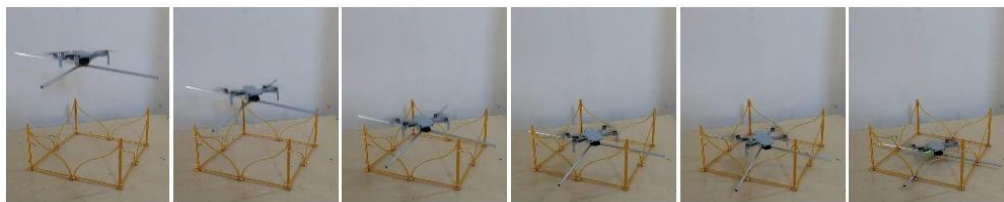


Figure 1: Drone Landing on Landing Pad

During the last 15 cm, the position correction is done by the guider without using any sensors or actuators. This process is suggested to be called “Passive Position Correction” by this research study.

Sensors such as GPS, cameras and LIDARs are used for identifying the position in GPS and Vision Base Position Controlling and controlled by a propulsion system (Actuator). These methods are called “Active Position Correction”.

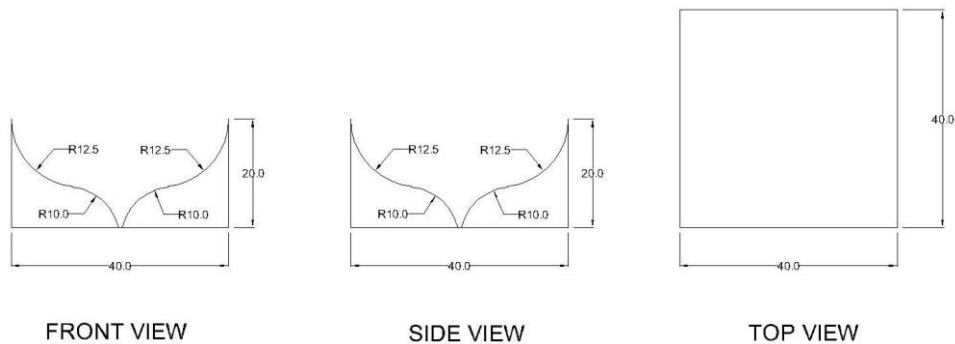


Figure 2: Technical Diagram of Guider

Seven out of ten experiments in the indoor environment showed successful results and failed due to a deficiency in vision control.

Further research into the geometry of the relevant shape is needed for a smoother and more accurate landing at the exact position. The ability to land in such a precise location makes the robot service to the drone more convenient and less complicated.

Keywords: Drone; Drone landing; Position correction

Suppression of Noise in Image Differencing by a Post Filtering Technique

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Abstract

The image differencing is used to identify the visible differences between two comparable images. It is one of the important image processing techniques, and there are several image differencing related applications reported in the previous studies, such as real-time traffic analysis, medical image classification, extract of defects in product quality monitoring systems, etc. Moreover, it can be used to identify the differences in the edges of two graphics. For example, consider two images of an ideal object and another one with defective edges or edges of foreign materials. The image differencing of the defective image and the ideal image shows the deviated edge regions of the defective object. To enable the proper operation of image differencing the targeted graphics should be in the same orientations but two comparable images may not perfectly match. Hence, the resultant images may contain unwanted pixels called noise due to incomplete cancellation of unchanged pixels and random noises. To suppress these unwanted pixels, we propose a post noise filtering mechanism for the resultant image of image differencing.

The presented method can be applied for the resultant image from the image differencing by recoloring each image pixel using the average value of local pixel submatrices beyond a certain threshold value. The size of the submatrices of pixel neighborhoods could be chosen to be 3×3 , 5×5 , or more depending on the size of expected unwanted points and camera settings. If the average of the pixel values of the submatrix is less than the threshold, the corresponding pixel recolors as the background. The threshold value depends on the average of the pixel values in the submatrix and the nature of the image. Here we test the proposed post-filtering

techniques using the edge filtered binary image resultant form image differencing as shown in Figure 1. In the test, two experiments were conducted using a series of images of transparent containers, which were generated from the custom experimental setup. It consists of a low-cost general-purpose camera with 2-megapixel CCD and a LED light source with a light-diffusing plate to provide uniform light to the target. For image differencing, two photographs of the same target object were used in the first experiment, and two photographs of defective and non-defective samples of the same objects were used in the second experiment. The edges of the captured images were filtered by using the standard Canny edge filter. To identify the effectiveness of the test results of the proposed method, the black-to-white pixel ratios of the resultant image from image differencing and the percentage of suppression of the unwanted pixel points of filtered images were calculated. The test results are given in Table 1. The black-to-white pixel ratio clearly shows that the unwanted pixels were suppressed by both filters and the 5×5 filter suppresses more compared with the 3×3 filter. Finally, image differencing is an important technique and with these results, we conclude that the presented method has great potential to suppress the noises in the resultant image of image differencing.

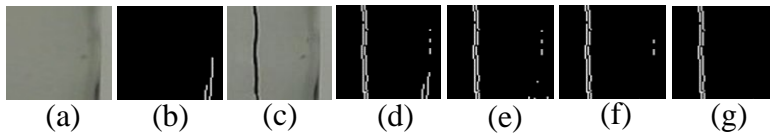


Figure 1: Image segment of an ideal object, (b) Edge-filtered image of (a), (c) Comparable image segment which has a foreign object inside the target object, (d) Edge-filtered image of (c), (e) Resultant image from simple subtraction of (b) from (d), (f) 3×3 filter applied, and (g) 5×5 filter applied

Table 1: Test results before and after applying the proposed noise filtering

Image Sample	Black-to-white pixel ratios of experiment 1 (%)		
	Image differencing	Suppression of unwanted pixels	
		3×3	5×5
1	1.1	24.2	45.5
2	2.6	21.4	47.9
3	3.1	33.6	45.4
4	3.2	18.8	40.6
5	2.4	12.5	41.7

Image Sample	Black-to-white pixel ratios of experiment 2 (%)		
	Image differencing	Suppression of unwanted pixels	
		3×3	5×5
1	2.5	11.9	34.8
2	2.8	25.4	49.5
3	3	16.4	31.8
4	3.9	8.7	14.4
5	6	9.2	17.7

Keywords: Defective edges; Edge filtering; Image differencing; Noise filtering

**Details of Research Grants Awarded by the
Wayamba University of Sri Lanka**

Grant Number & Year Received: SRHDC/RP/04/18-02, 2018

Title of the Grant: Farmer Perceptions and Economics of Technology Adoption in the Smallholder Rubber Sector in Sri Lanka

Total Grant Received: Rs. 650,000.00

Principle Investigator: Prof. Jagath C. Edirisinghe

Co-Investigators: B.M.D.C. Balasooriya

Output of the Project:

Publications

- Balasooriya, B. M. D. C., Edirisinghe, J. C. and Seneviratne, P. (2021). Factors affecting technology adoption in smallholder rubber sector: A case study in Kurunegala district. Proceedings of the International Symposium on Agriculture and Environment. University of Ruhuna, Sri Lanka. 10.
- Balasooriya, B. M. D. C., Edirisinghe, J. C. and Seneviratne, P. (2020). The Role of Farmer Perception in Fertilizer Application by Smallholder Rubber Farmers in Kegalle District: A Preliminary Investigation with Bayesian Analysis. Proceedings of the Wayamba University Research Congress. Senate Research and Higher Degrees Committee, Wayamba University of Sri Lanka. 11 -12.
- Balasooriya, B. M. D. C., Edirisinghe, J. C. and Seneviratne, P. (2019). Nexus between Awareness of Recommendations and Income from Rubber Cultivation: A Structural Equation Model. Sri Lanka Journal of Economic Research, 6(2), pp.29–38.
- Balasooriya, B. M. D. C., Edirisinghe, J. C., Seneviratne, P. and Piyasena, N. M. (2019). Status of Farmer Awareness and Adoption of Recommended Technologies in the Smallholder Rubber Sector in Kegalle District. Proceedings of the Wayamba University Research Congress. Senate Research and Higher Degrees Committee, Wayamba University of Sri Lanka. 95 -96.

- Balasooriya, B. M. D. C., Edirisinghe, J. C. and Seneviratne, P. (2018). Impact of perception, awareness and adoption of technologies in reducing production variability in smallholder rubber cultivations in Kurunegala district. Proceedings of the Wayamba University Research Congress. Senate Research and Higher Degrees Committee, Wayamba University of Sri Lanka. 56 -57.
- Hettiarachchi, H. A. I. U., Balasooriya, B. M. D. C. and Edirisinghe J. C. (2018) Scale Efficiency in Smallholder Rubber Sector in Kegalle District: A Data Envelopment Analysis. Proceedings of the 17th Agricultural Research Symposium. Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka.

Grant Number & Year Received: University Research Grant 2019
SRHDC/RP/04/19-12

Title of the Grant: Title Screening Antibacterial Activity of Fresh Leaves of
Selected Fruit Trees Grown in Dry Zone in Sri Lanka

Total Grant Received: Rs. 347,000.00

Principle Investigator: Dr. W.M. Wishwajith W. Kandegama

Co-Investigators: Dr. K.W.M.D. Kamathewatta

Output of the Project:

Publications

- Abstract was published in Wayamba University Congress and manuscript was prepared to submit to SCI journal

Other achievements

- Research is continuing for further analysis to identify potential herbal product development

Grant Number & Year Received: SRHDC/RP/04/18-14 (01/09/2018)

Title of the Grant: Expression analysis of flavonoid biosynthesis genes in Sri Lankan light red and dark red grained rice in relation to the antioxidant activity

Total Grant Received: Rs. 280,000.00

Principle Investigator: Dr. (Mrs.) D.R. Gimhani, Senior Lecturer, Department of Biotechnology, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka.

Co-Investigators:

Prof. N.S. Kotterarachchi, Professor, Department of Biotechnology, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka.

Dr. (Mrs) J.A.A.C Wijesinghe, Department of Bio-Systems Engineering, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka

Output of the Project:

Publications

- D.A.U.H. Perera, H.R.M.G.C. Thilakarathna, D.R. Gimhani, J.A.A.C. Wijesinghe and N.S. Kotterarachchi. (2021). Evaluation of Anti-oxidant Properties of Four Sri Lankan Traditional Red Rice Varieties. Proceedings of the **5th International Research Conference of Uva Wellassa University, (IRCUWU2021)**, 1st- 2nd July 2021. Uva Wellassa University, Badulla, Sri Lanka. 10.
- Welagedara J.W., Gimhani D.R., Kotterarachchi N.S. and Wijesinghe J.A.A.C. (2020). Assessment of Genetic Basis of Grain Pigmentation in Sri Lankan Rice Germplasm. Proceedings of the **5th Wayamba University Research Congress (WURC)**, 12th February 2021. Wayamba University of Sri Lanka. 3-4.
- D.A.U.H. Perera, H.R.M.G.C. Thilakarathna, D.R. Gimhani, J.A.A.C. Wijesinghe and N.S. Kotterarachchi. (2020). Determination of Anthocyanin, Proanthocyanidin Content and Anti-oxidant Properties of Sri Lankan Traditional Red Rice Varieties. In Proceedings of the **19th Agricultural Research symposium (AGRES)**, 22nd January 2021.

Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka.248-252.

- J.W. Welagedara, D.R. Gimhani, N.S. Kottarachchi and J.A.A.C. Wijesinghe. (2019). Allelic Diversity of Rc Gene Regulating Pigmentation in Sri Lankan Rice Germplasm. In Proceedings of the **18th Agricultural Research symposium (AGRES)**, 7th January 2020. **Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka.**
- J.W. Welagedara, D.R. Gimhani and N.S. Kottarachchi. (2020). In silico analysis of allelic variation in Rc gene involve in rice pigmentation in Sri Lankan rice germplasm. Sri Lanka Association for the Advancement of Science. Proceedings of the 76th Annual Sessions 2020,13-18 December 2020. **Sri Lanka Association for the Advancement of Science (SLAAS).21.**

Other achievements

Two students completed their final year undergraduate research.

- J.W. Welagedara, Department of Biotechnology, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka.
- D.A.U.H. Perera, Department of Biotechnology, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka.

Grant Number & Year Received: SRHDC/RP/04/19-02 2019

Title of the Grant: Urban Residential Gardens: Contribution to the Biodiversity Conservation

Total Grant Received: Rs. 538,000.00

Principle Investigator: Prof. K. Yakandawala

Co-Investigators: Prof. Emily Minor, Ms. J.K.W.N Subashini

Output of the Project:

Publications:

- Subashini, J.K.W.N., Yakandawala, K and Minor, E.S. (2021), Perceptions of urban residents on the cultural and ecological roles of residential gardens in Gampaha divisional secretariat. In proceedings of the International Conference on Applied and Pure Sciences 2021, University of Kelaniya Pp. 29

Accepted, yet Unpublished

- Subashini, J.K.W.N., Yakandawala, K and Minor, E.S. (2021)

Abstract Title: The Impact of Socioeconomic factors on Urban Residential Garden Management: A Case Study in the Gampaha Divisional Secretariat Area. The 77th Annual Sessions of Sri Lanka Association for the Advancement of Science 2021.

Under Review

- Subashini, J.K.W.N., Yakandawala, K and Minor, E.S.

Abstract Title - Perceptions and Social Divers of Urban Residents on Wildlife Gardening: A Case Study of Residential Landscapes in Gampaha District. 26th International Forestry and Environment Symposium, University of Sri Jayawardhanapura, Sri Lanka.

Grant Number & Year Received: SRHDC/RP/04/19-16

Title of the Grant: Impact of nutrition education on lifestyle management and glycaemic control of type 2 diabetes patients

Total Grant Received: Rs. 486,700.00

Principle Investigator: Dr HP Gunawardena

Co-Investigators: Dr Ananda Chandrasekara, Ms Selani Dharshika

Output of the Project:

Publications: 04 Conference Proceedings (01 international and 03 national)

- HP Gunawardena, Pramodi Jayawickrama, Ananda Chandrasekara and Selani Dharshika (2021) Development of a dietary education booklet for individuals with type 2 diabetes, World Diabetes Congress 2021, International Diabetes Federation (Accepted for a poster)
- HP Gunawardena, Bavantha Bandara, Selani Dharshika and Ananda Chandrasekara (2021) Development of an educational curriculum for self-management of type 2 diabetes, Wayamba University Research Congress (accepted)
- PP Jayawickrama, NVS Dharshika, A Chandrasekara and HP Gunawardena (2021) Development and validation of an educational booklet on dietary management of type 2 diabetes mellitus, Proceedings of Undergraduate Research Symposium, Faculty of Livestock, Fisheries and Nutrition, pg 21
- BM Samaraweera, NVS Dharshika, A Chandrasekara and HP Gunawardena (2021) Development of education materials for self-management of type 2 diabetes mellitus, Proceedings of Undergraduate Research Symposium, Faculty of Livestock, Fisheries and Nutrition, pg 46

Other achievements:

Three (03) final year undergraduates of Department of Applied Nutrition, Faculty of Livestock, Fisheries and Nutrition, Wayamba University of Sri Lanka have completed their final year research projects and the B Sc [Hons] in Food Science and Nutrition Degree last year using this particular grant. Details of their publications are given above.

Grant Number & Year Received: SRHDC/RP/04/19/05, 2019

Title of the Grant: The chronic and acute effect of different saturated or unsaturated fatty acids on vascular function, blood pressure and other cardio metabolic risk markers in healthy adult men

Total Grant Received: Rs: 455,750.00

Principle Investigator: Dr (Mrs.) RLD Kumari Malkanthi

Co-Investigators: Dr. Ananda Chanrasekara, Ms. ULDS Perera

Output of the Project:

Publications

- Perera ULDS, Chandrasekara A, Rathnayake KM (2021) **Coconut fat consumption and prevalence of cardiovascular disease risk factors among selected group of adult men in Sri Lanka**, young Scientists' conference for multidisciplinary research, Virtual International conference organized in conjunction with 40th Anniversary of National Institute of Fundamental studies, Kandy, Sri Lanka
- MARMP Jayathilake, Perera ULDS, MGN Sewwandi, KBM Madushani, Chandrasekara A, Rathnayake KM (2021), **Dietary fat and fatty acid intake of Sri Lankan adult men**, 30th Anniversary academic sessions, Faculty of medicine, University of Kelaniya, Sri Lanka
- Another 2 abstract has been submitted for presented at Wayamba university research congress and Annual sessions of Nutrition society of Sri Lanka. Title of those abstract are as follows
- ULDS Perera, MARMP Jayathilake, GNM Gunathilaka, Ananda Chandrasekara and Kumari M. Rathnayake, **Diet quality of adult men in Sri Lanka based on the Diet Quality Index-International (DQI-I) and other diet quality indices**
- U.L.D.S Perera, M.A.R.M.P Jayathilake, M.G.N Sewwandi, A. Chandrasekara and K.M Rathnayake, **Dietary saturated and unsaturated fatty acids intake among Sri Lankan adult men.**

Other achievements: Not relevant

Grant Number & Year Received: SRHDC/RP/04/19-13 – Year 2019

Title of the Grant: “Incentives for Sustainable Utilization of Coastal Resources in Sri Lanka: Implications for Development-Conservation Initiatives”.

Total Grant Received: Rs. 350,000.00

Principle Investigator: Dr. J M M Udugama

Co-Investigators: Dr. T P S R Guruge

Output of the Project:

Publications

- N.P.M Wijayanayake, **J.M.M. Udugama** and T.P.S.R. Guruge (2020) ‘An Assessment of Recreation Value of Rumassala Coastal Region in Sri Lanka’ *Applied Economics and Business*, 4(2) 89-97.

Other achievements

- Four undergraduate students have completed their undergraduate research study under this project.

Grant Number & year received: SRHDC/RP/04/18-13, 2018

Title of the grant: Identification of potential microalgae for wastewater treatment from domestic, agricultural and industrial waste water stabilization ponds

Total grant received: Rs. 310,000.00

Principle investigator: B.L.W.K. Balasooriya

Co investigators: -

Output of the Project:

Publications

Conference proceedings (local / international) as an abstract

- Balasooriya, B.L.W.K.2021. Isolation, Identification and Compiling of Micro Algae species from Aquatic Environments in Sri Lanka. World Microbe Forum, 20 -24 June, 2021, Online worldwide, American Society for Microbiology and Federation of European Microbiological Societies
- Dilshan, U.H.B.Y, Balasooriya, B.L.W.K., Bandara, N.G.C.A, Amirthalingam S. 2020. Isolation and Identification of Microalgae for Wastewater Treatment from Agricultural, Domestic and Industrial Wastewater Ponds. Proceedings of the 18th Agricultural Research Symposium, Wayamba University of Sri Lanka.
- Dilshan, U.H.B.Y, Balasooriya, B.L.W.K., Bandara, N.G.C.A, Amirthalingam S. Wastewater Treatment through isolation of microalgae from Agricultural, Domestic and Industrial Wastewater stabilization Ponds. Nature Conferences: Waste Management and Valorisation for a Sustainable Future. 26–28 October 2021, Seoul, South Korea

Other achievements

- Undergraduate Thesis: U.H.B.Y. Dilshan, B.Sc. Hons. (Agriculture) from Wayamba University of Sri Lanka in 2020
- Balasooriya, B.L.W.K., - Speaker on “How Microalgae can Save the Planet” in 24hr live stream programme to celebrate the International Microorganisms Day by Federation of European Microbiological Societies (FEMS) 16th September 2021

Grant Number & Year Received: SRHDC/RP/04/19-8 - 2019

Title of the Grant: The effect of pre-digested feed rations using cocktail enzyme on broiler performance

Total Grant Received: Rs. 299,000.00

Principle Investigator: Prof. B.P.A. Jayaweera

Co-Investigators: Dr. J.M.K.J.K. Premarathne

Output of the Project:

Publications

- A.G.U.R. Amarasinghe, S. Manopriya, J.M.K.J.K. Premarathne, B.P.A. Jayaweera (2021). Effect of cocktail enzyme on the nutritive value of coconut poonac and rice polish, Proceeding of the 7th Undergraduate symposium (URes), Faculty of Livestock Fisheries and Nutrition, Wayamba University of Sri Lanka. 60 pp.
- M.N.M. Nisthaj, S. Manopriya, J.M.K.J.K. Premarathne, B.P.A. Jayaweera (2021). Effect of cocktail enzyme on the nutritive value of soya bean meal and wheat offal, Proceeding of the 7th Undergraduate symposium (URes), Faculty of Livestock Fisheries and Nutrition, Wayamba University of Sri Lanka. 71 pp.

Other achievements

- Undergraduate research project completed by 2 research students specialised in Department of Livestock and Avian Sciences, Faculty of Livestock, Fisheries and Nutrition, Wayamba University of Sri Lanka.
Student detail
 1. A.G.U.R. Amarasinghe – Reg no: 168527
 2. M.N.M. Nisthaj - Reg no: 158515

Grant Number & Year Received: SRHDC/RP/04/19-06, 02/12/2019

Title of the Grant: Novel architecture for passive RFID tags embedded with sensors

Total Grant Received: Rs. 109,000.00

Principle Investigator: Dr. P.M. Senadeera

Co-Investigators: Prof. (Mrs.) J.M.J.W. Jayasinghe

Output of the Project:

Publications

- “Low Power ASK Demodulator for Passive UHF RFID Tags”, Shyama Wickramasinghe, Melaka Senadeera, Jeevani Jayasinghe, Women in Engineering Symposium (WIESymp2020).
- “Design of a Radio Frequency Energy Harvesting Circuit for Passive RFID Tag and Sensor Device”, Wickramasinghe W.M.S.M., Senadeera P.M., Jayasinghe J.M.J.W, Wayamba University Research Congress (WURC 2020)
- “Design of a low power and high efficient rectifier circuit for microcontroller based RFID application”, P.M. Senadeera, J.M.J.W. Jayasinghe, and W.A.S. Wijesinghe, Wayamba University Research Congress (WURC 2021) (Accepted for publication)

Grant Number & Year Received: AHEAD R2 DOR HEMS Number 04, 2019

Title of the Grant: Accelerating Higher Education Expansion and Development (AHEAD)- Development Oriented Research (DOR) grant, Faculty of Applied Sciences, Wayamba University of Sri Lanka.

Total Grant Received: Rs. 10,000,000.00

Principle Investigator: Dr. Asankha Pallegedara

Co-Investigators: Mr. D.M. Jayasena, Dr. A.S. Kumara, Dr. K.M. Dissanayake, Mr. Mohan Samaranayake

Output of the Project:

Publications

Publications published in peer reviewed internationally indexed journals

- Kumara, A.S., & Pallegedara, A. (2020). Household waste disposal mechanisms in Sri Lanka: Nation-wide survey evidence for their trends and determinants. *Waste Management*, 114, 62-71.

Communications/Abstracts

- Pallegedara, A. (2021). Knowledge, Practices and Issues of Solid Waste Management; A Qualitative study in Kuliyaipitiya Pradeshiya Sabha Area. *Proceedings on Open University Research Sessions*, (p. 116).
- Soysa, R.N.K., Pallegedara, A., & Jayasena, D.M. (2020). Corporate Sustainability Reporting. A Review of Literature. *Proceedings of the 2nd International Conference on Environmental Monitoring & Management*, (p. 13).
- Soysa, R.N.K., Pallegedara, A., & Jayasena, D.M. (2020). Firm Specific determinants of Corporate Sustainability reporting; Systematic Review and Meta-Analysis. *Proceedings of 7th International Conference on Multidisciplinary Approaches 2020*, (p. 25).
- Soysa, R.N.K., Pallegedara, A., Kumara, A.S., Jayasena, D.M., Dissanayake, K.M., & Samaranayake, M.K.S.M. (2021). Corporate environmental performance disclosures in publicly listed companies of Sri Lanka. *Proceedings of International Symposium on Agriculture and Environment*, (p. 71).

- Soysa, R.N.K., Pallegedara, A., Kumara, A.S., & Jayasena, D. (2021). Extent of Incorporating Sustainability Development Goals(SDGs) in Corporate Sustainability Reporting(CSR) of Firms in Sri Lanka. *Proceedings of 3rd International Research Symposium on Social Sciences and Humanities*, (p. 69).

Other achievements: NA

Grant Number & Year Received: SRHDC/RP/04/19-01, 2019

Title of the Grant: Development of a High Speed and Low-Cost Product Quality Monitoring System

Total Grant Received: Rs. 248,000.00

Principle Investigator: Dr. W.A.S. Wijesinghe

Co-Investigators: Dr. I.P.M. Wickramasinghe, Mr. M.R.H.E. Bandara

Output of the Project:

Publications

- **Hasitha Eranda Bandara,** Susantha Wijesinghe, Manjula Wickramasinghe, “Suppression of Noise in Image Differencing by a Post Filtering Techniques”, *Wayamba University Research Congress (WURC 2021)*, Wayamba University of Sri Lanka. (Accepted - Yet to present)
- **Hasitha Eranda Bandara,** Susantha Wijesinghe, Manjula Wickramasinghe, “Identification of Degree of Defects for the Product Quality Monitoring System Using Image Edge Filtering”, *10th IEEE International Conference on Information & Automation for Sustainability (ICIAFS)*, Sri Lanka 2021
- **Hasitha Eranda Bandara,** Susantha Wijesinghe, Manjula Wickramasinghe, “Detection of Foreign Materials in Transparent Containers for Low-Cost Product Quality Monitoring Systems”, *Proceedings of the Wayamba University Research Congress (WURC 2020)*, 12th February 2021 at Wayamba University of Sri Lanka.

Grant Number & Year Received: SRHDC/RP/04/19-17, 2019

Title of the Grant: Optimization of an *in vitro* clonal propagation technique for mass cultivation of *Stevia rebaudiana*

Total Grant Received: Rs. 700,000.00

Principle Investigator: Dr. P.S. Warakagoda

Co-Investigators: Dr Menuka Arawwawala

Output of the Project:

Publications

- Millavithanachchi, S.S and Warakagoda, P.S. (2020). Effect of plant growth regulators on *in vitro* shoot proliferation and rooting of *Stevia rebaudiana* Bertoni. Proceedings of the 18th Agricultural Research Symposium, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila, Sri Lanka. pp. 285-289.
- Jayasundara, R.G.G.R.M.D and Warakagoda, P.S. (2020). Effect of the explant type, adenine sulphate, salicylic acid and carbendazim on *in vitro* shoot proliferation of *Stevia rebaudiana*. Proceedings of the 18th Agricultural Research Symposium, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila, Sri Lanka. pp. 260-264.

Other achievements

- Two undergraduate students were completed their final year research under this grant.
 1. Ms. S.S. Millavithanachchi
 2. Ms. R.G.G.M.D. Jayasundara

Grant Number & Year Received: SRHDC / RP / 04 / 19-04

Title of the Grant: Perceived Barriers of Employee Transition to Entrepreneurship in the context of Sri Lanka

Total Grant Received: Rs. 532,000.00

Principle Investigator: Ms. WMNM Wijethunge

Co-Investigators: Ms. WDNSM Tennakoon, Ms. AKDN Dilshani, Ms. PABH Dilshani, Ms. SMN Praveeni, Ms. WJAJM Lasanthika

Output of the Project:

Publications

- “Perceived Barriers of Employee Transition to Entrepreneurship in Sri Lankan Small and Medium Enterprises: A Concept Paper”, International Conference on Business and Information (ICBI – 2020) organized by Faculty of Commerce and Management Studies, University of Kelaniya held on 19th November 2020, WDNSM Tennakoon, AKDN Dilshani, WMNM Wijethunge, PABH Amarathunga, WJAJM Lasanthika & SMN Praveeni
- “Perceived Barriers of Employee Transition to Entrepreneurship: A Literature Review”, 10th International Conference on Management and Economics (ICME – 2021), Ruhuna University of Sri Lanka, held on 2nd September 2021. WDNSM Tennakoon, AKDN Dilshani, WMNM Wijethunge, PABH Amarathunga, WJAJM Lasanthika & SMN Praveeni.
- “Perceived Barriers of Employee Transition to Entrepreneurship: A Literature Review and Research Agenda”, Vavuniya University International Research Conference (VUIRC – 2021), held on 15th October 2021, WDNSM Tennakoon, AKDN Dilshani, WMNM Wijethunge, PABH Amarathunga, WJAJM Lasanthika & SMN Praveeni.

Grant Number & Year Received: NSF grant: RG/2016/OMR/01 - in 2016

Title of the Grant: Taxonomic identification and present status of jellyfish resource in the coastal waters of Sri Lanka

Total Grant Received: Rs. 3,053,168.00

Principle Investigator: Dr MDST de Croos

Co-Investigators: None

Output of the Project:

Fourteen abstracts were presented in different symposia; six articles were published in peer-reviewed journals; contributed to a field guide for identification of jellyfish; seven articles were published in non-refereed journals/magazines/newspapers; three seminars were conducted on jellyfish; and two foreign workshops were attended with travel grants.

Abstract Presentations

- Karunarathne, K.D., Kumari Y.H.H.W. and De Croos, M.D.S.T., 2017.
First Record of three Jellyfish Species from West Coast of Sri Lanka Based on Taxonomic Identification, Proceedings of Wayamba University Research Congress 2017, Senate Research and Higher Degree Committee, p. 71.
- Karunarathne, K.D., and De Croos, M.D.S.T., 2017.
First record of three jellyfish species from Western and Northwestern coastal waters of Sri Lanka based on taxonomic identification. Proceedings of Third National symposium on Marine Environment (MEPA), at BMICH, Colombo, Sri Lanka, pp. 6-7.
- Amirthalingam, A., Karunarathne, K.D. and De Croos, M.D.S.T., 2017.
Association between juvenile Carangid fish with the jellyfish *Phyllorhiza punctata*. Undergraduate research symposium 2017, Faculty of Livestock, Fisheries & Nutrition, Wayamba University of Sri Lanka, p. 45.
- Karunarathne, K.D., and De Croos, M.D.S.T., 2018.
First record of three jellyfish species from Northeast coast of Sri Lanka. Proceedings of Wayamba University Research Congress 2018, Senate Research and Higher Degree Committee, pp. 37-38.

- Amirthalingam, A., Karunarathne, K.D. and De Croos, M.D.S.T., 2018.
Association between juvenile carangid fish with the jellyfish *Phyllorhiza punctata*. Proceedings of the Wayamba University International Conference, Sri Lanka, 24-25 August 2018, p. 362.
- Karunarathne, K.D., and De Croos, M.D.S.T., 2018.
Undescribed box jellyfish: *Carybdea* sp. (Cnidaria: Cubozoa) from Sri Lanka. Proceedings of the Forth National Symposium on Marine Environment (MEPA), 20th October 2018 at BMICH Colombo, Sri Lanka, p. 26.
- Karunarathne, K.D., and De Croos, M.D.S.T., 2019.
The first record of three imperative jellyfish species from the coastal waters of Sri Lanka. Proceedings of 6th Ruhuna International Science & Technology Conference (RISTCON), University of Ruhuna, Matara, Sri Lanka, p. 31.
- Karunarathne, K.D., Gershwin, L., and De Croos, M.D.S.T., 2019.
Taxonomical Contemplation on Floating Jellyfishes Found in Sri Lanka., Proceedings of Wayamba University Research Congress 2019, Senate Research and Higher Degree Committee, pp. 56-57.
- Karunarathne, K.D., Fernando, M., and De Croos, M.D.S.T., 2019.
Identification of some jellyfishes collected off the coast of Colombo, Sri Lanka. Proceedings of the 25th Anniversary Scientific Sessions of the Sri Lanka Association for Fisheries and Aquatic Resources (SLAFAR), 19th August 2019. Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Sri Lanka, p. 38.
- Karunarathne, K.D., Gershwin, L., and De Croos, M.D.S.T., 2019.
First record of three species of pelagic gelatinous fauna from Sri Lanka. Proceedings of the Fifth National Symposium on Marine Environment (MEPA), 24th October 2019 at BMICH Colombo, Sri Lanka, p. 17.
- Karunarathne, K.D. and De Croos, M.D.S.T., 2019.
Ctenophores (Comb jellies) found in Sri Lankan Waters. Proceedings of the 4th International Research Symposium on Pure and Applied Sciences (IRSPAS), 25th October 2019-Faculty of Science, University of Kelaniya, Sri Lanka, p. 18.

- Rimza, M.R.F., Karunarathne, K.D., Gonapinuwala, S.T. and De Croos, M.D.S.T., 2019.
Extraction of acid soluble collagen from fish discards and processed jellyfish. Undergraduate Research Abstracts – 2019, Faculty of Livestock, Fisheries & Nutrition, Wayamba University of Sri Lanka, p. 75.
- Karunarathne, K.D. and De Croos, M.D.S.T., 2020.
Some mild-stinging jellyfishes reported off Sri Lankan coastal waters. Proceedings of 7th Ruhuna International Science & Technology Conference (RISTCON), University of Ruhuna, Matara, Sri Lanka, p. 120.
- Karunarathne, K.D. and De Croos, M.D.S.T., 2021.
Two Species of Undescribed Lion's Mane Jellyfish (*Cyanea* spp.) Found from Sri Lankan Waters. Proceedings of Wayamba University Research Congress 2020, Senate Research and Higher Degree Committee, pp. 58-59.

Peer-reviewed articles

- Karunarathne, K.D., and De Croos, M.D.S.T., 2020.
A new species of box jellyfish, *Carybdea wayamba* sp. nov. (Cnidaria: Scyphozoa: Cubomedusae: Carybdeidae) from Sri Lanka. Plankton and Benthos Research 15(4): 317-326.
- Karunarathne, K.D. and De Croos, M.D.S.T., 2020.
First records of three cepheid jellyfish species from Sri Lanka with redescription of the genus *Marivagia* Galil and Gershwin, 2010 (Cnidaria: Scyphozoa: Rhizostomeae: Cepheidae). Sri Lanka Journal of Aquatic Sciences 25(2): 45-55.
- Karunarathne, K.D., Liyanaarachchi, S.M. and De Croos, M.D.S.T., 2020.
First record of upside-down jellyfish *Cassiopea andromeda* (Forskål, 1775) (Cnidaria: Scyphozoa: Rhizostomeae: Cassiopeidae) from Sri Lankan waters. Sri Lanka Journal of Aquatic Sciences 25(2): 57-65.
- Karunarathne, K.D. and De Croos, M.D.S.T., 2021.
Pelagic tunicates (Appendicularia and Thaliacea) of Sri Lanka: two first records with an annotated checklist. Zootaxa 5067(3): 352-376.
- Karunarathne, K.D. and De Croos, M.D.S.T., 2021.
Jellyfish Species Used as Live Baits in Traditional Trap Fishery of Sri Lanka: *Acromitus flagellatus* and *Lychnorhiza malayensis* (Cnidaria: Scyphozoa). Journal of the Indian Society of Coastal Agricultural Research 39(2): (in press).

- Karunarathne, K. D., de Alwis, G. W. A. and de Croos, M. D. S. T. 2021. Live Jellyfish-baited Small-scale Traditional Trap Fishery Operated off the Eastern Coast of Sri Lanka. *Journal of the Indian Society of Coastal Agricultural Research* 39(2): (in press)
- Karunarathne, K.D. and De Croos, M.D.S.T. Occurrence of pleustonic colonies of cnidarians (*Physalia physalis*, *Porpita porpita*, and *Velella velella*) along the coastal belt of Sri Lanka. *Indian Journal of Geo-Marine Sciences* (accepted).
- Karunarathne, K.D. and De Croos, M.D.S.T. Rediscover of *Crambione mastigophora* Maas, 1903 and first record of *Rhopilema hispidum* (Vanhöffen, 1888), two edible jellyfish (Cnidaria: Scyphozoa), to Sri Lanka. *Indian Journal of Geo-Marine Sciences* (under review).
- Karunarathne, K.D. and De Croos, M.D.S.T. First record of *Mastigias sidereus* Chun, 1896 and *Phyllorhiza punctata* von Lendenfeld, 1884, two species of spotted jellyfish (Cnidaria: Scyphozoa), to Sri Lanka. *Thalassas: An International Journal of Marine Sciences* (under review).

Books

- Maran B.A.V., Aungtonya C., Hoe C.C., Metillo E.B., Miyake H., Iesa I., Arsiranant I., Karunarathne K.D., Densing L.A.F., De Croos M.D.S.T., Rizman-Idid M., Yap N.W.L., Nilamani N., Sianturi O.R., Rungraung P., Kwang S.Y., Sharifuzzaman S.M., Karim W. and Das Y., 2021. Field Guide to the Jellyfish of Western Pacific. Centre for Marine and Coastal Studies, Universiti Sains Malaysia, Penang, Malaysia, 145 p.

Articles in non-refereed journals/magazines/newspapers

- Karunarathne, K.D., and De Croos, M.D.S.T., 2017. *Sri Lankawe methek handuna nogath thawath sampathak: Jellyfish*, (in Sinhalese) “Sath Samudura”, Marine Environment Protection Authority Publication, pp. 1-8.
- Karunarathne, K.D., and De Croos, M.D.S.T., 2018. *Sri Lankawe hamuwana wisha sahitha jelly mathsayan*, (in Sinhalese) “Sath Samudura”, Marine Environment Protection Authority Publication, pp. 43-49.
- Karunarathne, K.D., De Alwis, G. W. A., and De Croos, M.D.S.T., 2019. The Traditional Small-Scale Trap Fishery Operates in Eastern Sri Lanka by Using Live Jellyfish-Baits, “Sath Samudura”, Marine Environment Protection Authority Publication, pp. 32-38.

- Karunarathne, K.D., and De Croos, M.D.S.T., 2020.
A newspaper article: “Jellyfish: an untapped marine resource” for Ceylon Today newspaper, Echo, C12, January 20.
- Karunarathne, K.D., and De Croos, M.D.S.T., 2020.
A paper article: “*Methek nisi agaya kireemak nowu sri lankawe jeli mathsaya sampatha*” (in Sinhalese) for *Vidusara* newspaper, November 11.
- Karunarathne, K.D., and De Croos, M.D.S.T., 2020.
Discovering unexplored jellyfish resource of coastal waters of Sri Lanka. *Vidya*, The Quarterly Newsletter of the National Science Foundation, 22 (2), pp. 9.
- Karunarathne, K.D., and De Croos, M.D.S.T., 2020.
Carybdea wayamba: A new species of box jellyfish, named to honour Wayamba University of Sri Lanka. The Newsletter of Wayamba University of Sri Lanka.

Seminars conducted

- An awareness seminar on risky jellyfish (A lecture on the risk associated with Jellyfish was done for 20 police officers who represented police lifesaving unit and 45 training officers from the Bronze medal course in Police Marine Division of Sri Lanka in 2018).
- Public lecture on jellyfish diversity of Sri Lanka (A lecture organized by Sri Lanka Natural History Society on the diversity of jellyfish species in Sri Lankan waters was conducted for public community in 2019).
- A lecture on ‘the jellyfishes of Sri Lanka’ (A lecture organized by the Aquatic club, University of Kelaniya on the current status of jellyfishes in Sri Lankan waters was carried out for the undergraduates of the Faculty of Science, University of Kelaniya in 2019).

Workshops invited with travel grants

- Japan-Asia Youth Exchange Program in Science (SAKURA Exchange Program in Science was conducted by Shibaura Institute of Technology, Japan in 2018).
- The 2nd WESTPAC Workshop on Harmful Jellyfish Sampling Protocol and Data Analysis in Western Pacific Region (The workshop conducted by UNESCO was attended in Penang, Malaysia in 2019).

Grant Number & Year Received: SRHDC/RP/04/18/12 received on 2018

Title of the Grant: Hydraulic & Economical Analysis of Sub-Surface Drip irrigation in Coconut cultivations

Total Grant Received: Rs. 6,500,000.00

Principle Investigator: Dr. H.A.W.S. Gunathilaka

Co-Investigators: Dr. C.S. Ranasinghe, Mr. I.J. Amadoru

Output of the Project:

Publications

- Hettiarachchi S.D. and **Gunathilaka, H.A.W.S.** (2018). Evaluation of Manufacturing Variability of Drippers Commonly Used in Sri Lanka. Proceedings of 17th Agricultural Research Symposium, November 2018, Sri Lanka, vol 1. 36-40.
- **Gunathilaka, H.A.W.S.** and Wickramasinghe W.D.M.M. (2021). Optimization of Lateral Length of sub-Irrigation System for Coconut (*Cocos nucifera* L.). Proceedings of 02nd National Symposium on Sustainable Plantation Management (NSSPM), February, 2021. 07-12.
- **Gunathilaka, H.A.W.S.** and Silva K.P.S.A. (2021) Performance Evaluation of a Sub Surface Drip Irrigation System in a Coconut Cultivation. Proceedings of the Wayamba University Research Proceedings, December, 2021

Other achievements

Completed Undergraduate Students

1. S.D. Hettiarachchi. Dept. of Plantation Management (2019)
2. K.P.S.A. Silva, Dept. of Plantation Management (2019)
3. W.D.M.M. Wickramasinghe (2020)

Grant number and year received: SRHDC/RP/04/18-04 - 2018

Title of the grant: Plasma antioxidant capacity, glycaemic response and insulin resistance of herbal teas in healthy and hyperglycemic individuals

Total grants received: Rs. 650,000.00

Principal Investigator: Prof. (Mrs.) GAP Chandrasekara, Professor/Department of Applied Nutrition, Faculty of Livestock Fisheries and Nutrition

Co- Investigator: Dr. A Chandrasekara, Senior Lecturer/Department of Applied Nutrition, Faculty of Livestock Fisheries and Nutrition

Output of the Project:

Publications

- GAP Chandrasekara, KKN Maduwanthi, MZF Zafarina, A Chandrasekara (2019) Phenolic content and antioxidant activities of herbal tea infusions as affected by levels of ingredients, ratio and infusion time. Presented at the Wayamba University Research Congress (WURC 2019) Wayamba University of Sri Lanka, Sri Lanka, July 11
- GAP Chandrasekara, KKN Maduwanthi, MZF Zafarina, A Chandrasekara (2020) Single dose efficacy of herbal tea on glycemic response in healthy and hyperglycemic individuals. Presented at the Wayamba University Research Congress (WURC 2020) Wayamba University of Sri Lanka, Sri Lanka, February 12

Other achievements

- Two undergraduate research projects were completed
- One postgraduate directed study project is in progress

Grant Number & Year Received: SRHDC/RP/04/20-21 Year: 2021

Title of the Grant: An Early Warning System on Contagion Effect Detection for Equity Market of Sri Lanka

Total Grant Received: Rs. 250,000.00

Principle Investigator: Dr. Asankha Pallegedara

Co-Investigators: Mr. D.M. Jayasena, Ms. IDW Samarawickrama

Output of the Project:

Publications

- Samarawickrama, I., & Pallegedara, A. (2021). Financial Contagion Effects on Stock Market: A Literature Review. Proceedings of Peradeniya University International Research Sessions 2021. 23, p. 583. Kandy: University of Peradeniya. Retrieved from <https://www.pdn.ac.lk/ipurse/2021/docs/iPURSE2021-Proceedings.pdf>

Other achievements: No

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