

Proceedings

Faculty of Agriculture Undergraduate Research Symposium

FAuRS - 2014



Faculty of Agriculture
University of Peradeniya
Sri Lanka

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*Proceedings of the 1st Faculty of Agriculture
Undergraduate Research Symposium*

FAuRS-2014

held in

*Faculty of Agriculture
University of Peradeniya
Peradeniya
Sri Lanka*

23rd December, 2014

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Editorial Contribution

Academic staff members of the Faculty of Agriculture, University of Peradeniya

Faculty of Agriculture Undergraduate Research Symposium

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MESSAGE FROM THE VICE CHANCELLOR

It is with great pleasure and enthusiasm that I write this message on the occasion of the Faculty of Agriculture Undergraduate Student Research Symposium (FAuRS-2014). I personally believe that the opportunity created by the Faculty of Agriculture to stage the research findings of her graduands is a great step taken as a Faculty, by providing a stepping stone for graduands to reach the height of the future endeavors.

Agriculture is a science of applications which has wide horizons to explore. Research gives the exploring opportunity for young scientists to begin their own paths to travel the world of agriculture widening its customary horizons. Research culture embedded in agriculture is the secret behind facing multifaceted challenges of today, among which meeting the needs of an expanding, especially rapidly urbanizing population of the world under increasingly vulnerable environment. With a futuristic vision, grooming young scientists with research culture and providing an opportunity for them to unveil the findings in front of the able audience, is a great leap that Faculty of Agriculture, University of Peradeniya is taking in its expedition of Agriculture higher education.

I have no doubt that FAuRS is going to be one of the most prestigious and fruitful events organized by the Faculty of Agriculture. The substantial opportunity that will be created by the event to interact with experts, industry and researches could be explored by graduands to capture the insight of the future world opened for them.

I take this opportunity to congratulate the Dean and the staff of the Faculty of Agriculture, the organizing team of FAuRS-2014 for their futuristic vision and untiring effort in staging the event. I also wish all the graduands a successful career.

I wish the deliberations of FAuRS-2014 a great success

Professor Atula Senaratne
Vice Chancellor
University of Peradeniya

15 December 2014

MESSAGE FROM THE DEAN

It is with great pleasure and pride I am issuing this message on the occasion of the 1st Undergraduate Student Research Symposium of the Faculty of Agriculture (FAuRS-2014), University of Peradeniya. The concept of Undergraduate Research Symposia was first introduced to the university system of Sri Lanka by the Faculty of Agriculture, University of Peradeniya with the first Student Research Session organised by the Department of Animal Science of the Faculty in 1993. Since then, the Departmental based Annual Student Research Sessions had been a tradition of the Faculty. This year, the Faculty of Agriculture took another step forward by conducting a common Students Research Symposium for the entire Faculty which will continue as an annual event of the Faculty.

The country needs professionals who can lead the agricultural sector, and the Faculty of Agriculture of University of Peradeniya is the leading higher education institute that shoulders this national responsibility for the last 66 years. In this endeavour the Faculty encourages independent thinking, innovative approach and technological advancement of students especially in their research. Adding new dimension to it the faculty of Agriculture set off a new tradition by holding the Undergraduate Student Research Symposium in providing a platform for graduating students to present their valuable research findings and interact with experts in the sector, peers and prospective employers. I am sure the FAuRS-2014 will be an exciting experience to our graduands.

I know how difficult it was for the organizing committee to stage the FAuRS-2014 in this glamorous way. I wish to extend my sincere gratitude to the symposium coordinator and her team for their hard work. I also take this opportunity to congratulate the graduating students of all three degree programs.

I wish the proceeding of the 1st Undergraduate Student Research Symposium of the Faculty of Agriculture a great success.

Professor K. Samarasinghe
Dean/Faculty of Agriculture
University of Peradeniya

MESSAGE FROM THE OFFICE

It is with great pleasure and pride that we inaugurate the new year of the University of the South. The University of the South is a great institution, and it is our hope that it will continue to grow and prosper. The University of the South is a great institution, and it is our hope that it will continue to grow and prosper. The University of the South is a great institution, and it is our hope that it will continue to grow and prosper.

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Very truly yours,
The University of the South
The University of the South

MESSAGE FROM THE COORDINATOR OF FAuRS-2014

It is with great honour and privilege I write this message as the coordinator of the First Undergraduate Research Symposium of the Faculty of Agriculture. The Faculty of Agriculture has a long history of holding the student research seminars to provide a platform to facilitate the interaction of student community with the stakeholders and prospective employers. Unlike in the past events, the FAuRS-2014 (Faculty of Agriculture Undergraduate Research Sessions) is a conglomerated effort of all eight Departments of Study in bringing in the graduands of the three degree programs of the Faculty on to a common stage of wisdom and sharing. The opportunity created in 2014 is a unique one in the 68-years long history of the Faculty to help broaden the horizons of Agriculture higher education by creating an environment conducive for exchange, share and harmonize ideas, and build, strengthen and pave partnerships. In this context, I personally believe that FAuRS is an opportunity for employers, too, to identify competent and budding graduands that would fit well to the competitive world of challenges and opportunities in their future employment.

Organizing a mega event of this nature for the first time in a premier higher education institute like University of Peradeniya is a challenging task. The seeds were planted several months back with the blessings of the Faculty Board of Agriculture, with a team of dedicated personalities. The time has come to reap a richer harvest of the untiring effort and team work. On behalf of the organizing committee, I wish to record my appreciation and gratitude to the Dean, Heads of Departments, academic staff members, and non-academic staff members of the Faculty of Agriculture for their unsolicited support given throughout organizing FAuRS-2014. The contribution of students, both graduands and their junior colleagues, in staging this event is highly appreciated.

The overwhelming response that the FAuRS-2014 received from sponsors is remarkable. The list of sponsorships hit the maximum that one could expect for an academic event like FAuRS. In addition, staging the FAuRS-2014 is also shouldered by the University of Peradeniya, and funds from World Bank through the Higher Education for the Twenty first Century (HETC) grant and the University Development Grant (UDG). All the sponsors owe a big round of applause for contributing to a fruitful event for the betterment of agriculture higher education of Sri Lanka.

I sincerely hope the FAuRS-2014 will be a memorable academic experience for all the participants,

Professor Pradeepa Silva
Coordinator, FAuRS-2014
Faculty of Agriculture
University of Peradeniya

MESSAGE FROM THE CHAIRMAN OF THE BOARD

It is with great pleasure and pride that I write this message at the conclusion of the 2014-2015 academic year. The University of Georgia has a long history of being a leader in higher education. It is a privilege to lead this institution and to witness the growth and development of our students and faculty. The University of Georgia is a public institution and we are committed to providing a high-quality education to all of our students. We are proud of the achievements of our students and faculty and we look forward to continuing our tradition of excellence in the future.

The University of Georgia has a rich history and a strong tradition of academic excellence. We are proud of the achievements of our students and faculty and we look forward to continuing our tradition of excellence in the future. The University of Georgia is a public institution and we are committed to providing a high-quality education to all of our students. We are proud of the achievements of our students and faculty and we look forward to continuing our tradition of excellence in the future.

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I am proud to be the Chairman of the Board of the University of Georgia and I look forward to continuing our tradition of excellence in the future.

Chairman of the Board
University of Georgia
Athens, Georgia 30602

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Food Production and Product Development

Effect of Ethrel Concentration and Stages of Spray on Growth and Sex Expression of Bitter Gourd (*Momordica charantia* L.)

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The effect of ethrel concentration and stages of spray on growth and sex expression of bitter gourd, variety *Thinnaweli White* was studied using 2 factor Factorial Experiment in a Randomized Complete Block Design (RCBD) with 3 blocks. Eighteen treatment combinations involving 6 concentration of ethrel: 125 ppm, 130 ppm, 135 ppm, 140 ppm, 145 ppm with distilled water as the control and 3 stages of spray: 2-4 leaf stage, flower initiation stage, 2-4 leaf and flower initiation stages were used. Length of vine, number of nodes, internodes length, days to first male and female flower appearance, days to 50% male and female flowering, number of male and female flowers and male: female ratio were measured. Effect of ethrel on vegetative growth parameters was not significantly different among treatments. Spraying of ethrel at flower initiation stage caused significant ($P < 0.05$) delay in male flowering by suppressing male bud initiation and reduced the number of male flowers per vine. On the contrary, ethrel significantly ($P < 0.05$) increased the number of pistillate flowers and also hastened the appearance of the first female flower compared to the control. 140 ppm and 2-4 leaf stage were the best treatment combination from applied concentrations and stage of application, respectively, for increasing female flowers per vine. The application of ethrel caused reduction in male to female ratio up to 21:1. Results revealed that spraying of etherl at different growth stages has a positive effect on femaleness.

This work was funded by the Horticultural Crops Research and Development Institute, Gannoruwa.

Keywords: Ethrel, Bitter gourd, *Thinnaweli White*, Female flowers, Sex ratio

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Effects of Crop Management Practices on Populations of Soil Microorganisms

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Population dynamics of soil microbes are heavily influenced by agronomic practices, soil parameters and the influences of the crops grown. The present study was conducted to determine the effects of crop management practices on population density and diversity of soil microbiota. To achieve the above objective, soil samples were collected from two depths of the rhizosphere of mungbean and maize. The crops were maintained under two crop management practices, namely non- integrated pest management package (non IPM) and integrated pest management package with soil conservation practices (IPM). Isolation and identification of bacteria and fungi were based on morphological features and appearance on selective media. Total populations of bacteria, fungi, Gram negative and positive bacteria and beneficial microbes were quantified by dilution plate technique. Total bacterial count including gram positive and negative bacterial counts significantly differed due to crop, crop management practice, depths and their interaction effects at $P=0.05$. Total bacterial population was always significantly higher in all combinations of mungbean rhizosphere. A significantly higher total bacterial population was recorded at 15 cm depth of maize rhizosphere. Gram positive bacterial population was significantly higher in mungbean rhizosphere at both depths and also under IPM conditions. Significantly higher populations of Gram negative bacteria were reported from mungbean rhizosphere at both depths and also from the non-IPM conditions. Mungbean rhizosphere contained significantly higher *Pseudomonas fluorescens* and *Rhizobium* populations in comparison to that of maize. In contrast, populations of *Azotobacter* spp. were significantly higher at 15 cm depth of maize rhizosphere under IPM conditions.

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Keywords: Crop management practices, Identification, *Pseudomonas fluorescens*, Soil microbiota

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Quantification of Phenylalanine Ammonia Lyase Activity in Tomato and Chilli Tissues Grown Under Different Crop Management Practices and Agro-Ecological Regions in Sri Lanka

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High incidences of pests and diseases cause severe economic losses in tomato and chilli cultivations. The present study was focused on determination of the effects of different crop management practices and locations where crops were cultivated on the activity of Phenylalanine ammonia lyase (PAL), a defense enzyme in plants induce against the pathogen infection and herbivore attack as defense mechanisms. Leaf tissues of tomato cv. Thilina and chilli cv. M1 green grown at five different locations and maintained under two crop management systems viz. existing management system (only depending on application of pesticides) and an integrated pest management (IPM) practice with less reliance on pesticides were used for PAL enzyme assay. PAL activity was quantified spectrophotometrically. Mean day temperature during cropping seasons of tomato and chilli was recorded at each location. Findings of present study revealed that there was no significant ($P=0.05$) difference between the two crop management systems on the activity of PAL, indicating the equal efficiency of the IPM practice on induction of host plant resistance as the existing crop management practice. The activity of PAL in both crops significantly varied ($p<0.05$) among locations. Effect of crop management system on the activity of PAL in chilli tissues was significantly influenced ($p=0.009$) by location effect, whereas no significant interaction effect of management system and location of cultivation was noticed on PAL activity in tomato tissues. No significant relationship was observed between mean day temperature of locations and PAL activity in both tomato and chilli tissues under both crop management systems.

Financial assistance by HETC/PGIA/QIG3 is acknowledged.

Keywords: Chilli, Integrated pest management, Mean day temperature, Tomato, Phenylalanine ammonia lyase

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Diversity, Abundance and Nesting Habits of Non-*Apis* Bees (Hymenoptera: Apoidea) in Vegetable Agro-Ecosystems of Mid- Country Sri Lanka

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Wild bees are considered as important pollinators in ecosystems. Their abundance is determined by the availability of suitable nesting sites. The knowledge on the nesting sites of wild bees is limited under local conditions; therefore, the present study was conducted with the objectives of investigating the availability of nesting resources for non-*Apis* bees in vegetable ecosystems and assessing the acceptability of the introduced reed nests for their *in-situ* conservation. Nesting resources such as bare ground percentage, availability of dead wood, pithy stems, snail shells, pre-existing burrows and cavities were surveyed in four vegetable agro-ecosystems, in Dodangolla, Gampola, Gannoruwa and Meewathura areas in mid country region. Three types of reed nests: bamboo, gliricidia and drinking straws were installed in each location as five nests in each. The diversity and abundance of pollinators in each location were measured. The available nesting resources for wild bees in the tested locations were not significantly different among locations except, cavities in the land. The latter was significantly high ($P < 0.05$) in Gannoruwa and the lowest in Meewathura. Among the introduced reed nests, bamboo and gliricidia nests were accepted by bees in Gannoruwa and Dodangolla. Gliricidia nests were preferred by *Anthidiellum* sp. and *Braunsapis cupulifera*, while the bamboo nests were accepted by *Heriades binghami*. A total of 31 non-*Apis* wild bees were collected during the study and they belong to three families and nine genera. Abundance of *Heriades* sp. was significantly ($P < 0.05$) high in the ecosystems and it was followed by genera *Anthidiellum* and *Trigona*. The abundance of wild bees was not significantly different ($P > 0.05$) among the locations. The highest pollinator diversity ($H' = 0.364$) was recorded from Gannoruwa followed by Dodangolla and Meewathura. These results revealed that there is a rich non-*Apis* bee diversity in vegetable ecosystem and their availability can be facilitated by introducing artificial nesting sites.

This work was funded by the Pollinator Conservation Advisory Group, Ministry of Environment & Renewable Energy Sri Lanka

Keywords: Agro-ecosystem; artificial nest; pollinator; Non-*Apis* bees; Sri Lanka

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Identification of Causal Organism/s of Nutmeg Leaf Fall Disease

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Leaf fall disease is a rapidly-spreading disease of nutmeg in Sri Lanka and pathogenicity of the disease has not been confirmed yet. Therefore, the objectives of the present study were to confirm the pathogenicity and identification of causal organism/s to species level by molecular methods. Sensitivity of the pathogens to currently-using fungicides was determined *in vitro*. Soil, root, stem and leaf samples were collected from typical symptom-showing nutmeg plants from five different locations. Confirmation of pathogenicity was done by following the steps of Koch's postulates. Microorganisms consistently-associated with the isolated samples were purified and five fungal isolates were inoculated to roots and leaves of symptomless nutmeg seedlings. Symptom development and no. of days taken to initiate the symptoms were recorded to determine the variation of pathogenicity of each fungal isolate. The identity of the re-isolated fungi was confirmed through morphological features. Based on morphology, four cultures were identified as *Colletotrichum* spp. and the other as a *Pestalotia* spp. Only the *Colletotrichum* isolates produced the typical leaf blight symptoms on inoculated seedlings and there was a significant variation among these isolates on the rate of symptom development. None of the *Colletotrichum* isolates identified by morphological features were completely controlled by the fungicides used. The four *Colletotrichum* cultures were subjected to molecular characterization by PCR amplification of the ITS regions using ITS1 and ITS4 primers. A PCR product (~600 bp) was produced by one culture. DNA sequencing of the PCR product and subsequent homology search identified the fungus as *Neofusicoccum mediterraneum* with a 77% identity. *Neofusicoccum* spp. have been reported to cause leaf dieback, fruit rot and wood decay of forest and orchard trees and have similar colony and spore morphology to *Colletotrichum* spp. Hence, *Neofusicoccum* spp. could be confirmed as a causal organism of nutmeg leaf fall disease.

Keywords: Koch's postulates, PCR, ITS regions, Pathogenicity

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Isolation and Characterization of *Azotobacter* spp. from Sugarcane Rhizosphere

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The sugarcane rhizosphere is in a mutualistic relationship with free-living nitrogen fixing bacteria. Some sugarcane varieties obtain 70% of their nitrogen requirement via nitrogen fixing organisms, mainly from genus *Azotobacter* and *Azospirillum*. With the purpose of isolating and characterizing of free-living nitrogen fixing bacteria of the genus *Azotobacter*, 16 soil samples were collected from Pelwatte belonging to the agro-ecological zone DL₁. Using a soil paste plate method 18 bacterial colonies were cultured. Selected soil seeds were transferred to a nitrogen-free mannitol agar medium and subsequently selected colonies were transferred to a liquid glucose agar medium with bromothymol blue pH indicator. Single colony isolation was performed from liquid glucose agar medium. Out of 15 bacterial samples acid production was observed in all but in one sample. The colonies were morphologically characterized based on their acid production, colony morphology, pigment production, cysts production and aged culture morphology. All the isolated bacterial colonies were gram negative. A total of 10 possible *Azotobacter* species including *A. chroococcum*, *A. vinelandii*, and *A. paspali* were identified. For the molecular characterization of the *Azotobacter* spp. an amplified ribosomal DNA restriction analysis (ARDRA) was carried out. Crude DNA was extracted from *Azotobacter* spp. cultured in a bacterial broth with a modified TSB medium. The modified TSB medium consisted of peptone (3 g/L) and provided optimal conditions for the growth of the *Azotobacter* spp. resulting a higher crude DNA yield. For the identification of *Azotobacter* spp. eubacterial universal primers 1495r and 27f were used to amplify ribosomal DNA. An approximately 1500 bp size ribosomal DNA fragment was amplified from 10 samples. The fragment was digested using *EcoRI* and based on the polymorphism the colonies were characterized up to species level.

Keywords: ARDRA; *Azotobacter*; Nitrogen fixation; Sugarcane

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Analysis of Morphological and Molecular Variation in Department of Agriculture Certified Seed Lots of Tomato Variety “Thilina”

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Morphological and molecular studies of 7 seed lots (V/1/12/Ban/Br/014, V/1/13/Kun/St/006, V/1/13/Rik/St/639, V/1/13/Kun/Ba/011, V/1/13/Kun/Ba/021 & conserved seed lot at PGRC) of *Lycopersicon esculentum* Mill variety *Thilina* were carried out in order to find out variation of seed lots as complained by farmers. The quantitative and qualitative characters studied included 20 characters according to the set standards for morphological characters by IPGRI (International Plant Genetic Resources Institute) and Plant Genetic Resources Center (PGRC). The extracted DNA samples from leaf tissues using modified CTAB method at PGRC were amplified by Polymerase Chain Reaction using 8 simple sequence repeat (SSR) primers. Resulted products were separated by 8% Polyacrylamide Gel Electrophoresis (PAGE). Using SAS 9.1 software, cluster analysis was performed while resulted banding pattern was analyzed using POPGENE 32 software. In morphological study, all seed lots were clustered into one major cluster. Immature fruit shape and style position were showed variation among population. It contained 48% round shape, 1% flattened and ellipsoid shape while 50% plants showed heart-shape. In molecular analysis, 3 clusters were resulted. V/1/13/BAN/BR/002, V/1/13/KUN/BA/021, V/1/12/BAN/BR/014 seed lots were clustered with conserved *Thilina* variety and plants in seed lot no V/1/13/RIK/ST/639 which have shown large leaf as off character show the highest genetic distance (0.4212) from conserved variety.

This work was funded by the Horticultural Crop Research and Development Institute and Plant Genetic Resources Center at Gannoruwa.

Keywords: Cluster analysis, Immature fruit shape, Polyacrylamide Gel Electrophoresis (PAGE), SSR primer

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Proving of Pathogenicity and Detection of *Acidovorax avenae* sub sp. *citrulli* Causing Fruit Blotch in Watermelon through Molecular and Serological Methods

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In the recent past, a new disease showing necrotic lesion on leaves and blotches on fruits has been reported on watermelon (*Citrullus lanatus*) cultivations. This was suspected to be watermelon fruit blotch disease caused by bacterial pathogen *Acidovorax avenae* sub sp. *citrulli*. The experiment was planned to isolate the pathogen associated with symptomatic plants, proving pathogenicity and detection of pathogen through serological and molecular means. The bacterial pathogen was isolated from infected fruits collected from Kalpitiya and Puttlam areas. Bacterial pathogen isolated on Sucrose-Peptide Agar (SPA) medium showed smooth, round, off-white colored colonies within 24 hours. Pathogenicity was proved through fruit pathogenicity assay in which mature watermelon fruits were inoculated by injecting 1 ml of bacterial suspension at 10^6 CFU/ml with a sterile syringe up to 0.5 cm depth. Rotting initiated within 24 hours of inoculation and complete within 3 days. PCR assay using species-specific primer WFB 1 (5'-GAC CAG CCA CAC TGG GAC-3') and WFB 2 (5'-CTG CCG TAC TCC AGC GAT-3'), based on 16S rDNA consistently gave amplified product of 360 bp with DNA extracted from bacterial pure cultures and infected fruit tissues. Optimum annealing temperature, 57°C was determined through gradient PCR technique. Thus, PCR technique confirmed the newly emerged pathogen in watermelon to be *Acidovorax avenae*. Commercially available Immuno Strips assay confirmed the pathogen as *Acidovorax avenae* subsp. *citrulli*.

This work was funded by the Horticultural Crops Research and Development Institute, Department of Agriculture, Gannoruwa, peradeniya 20400, Sri Lanka.

Keywords: Watermelon, Bacterial fruit blotch, *Acidovorax avenae* sub sp. *Citrulli*, PCR detection, Immuno strip assay

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Relationships of Yield and Yield Related Characteristics with Maturity Duration in Near Isogenic Rice Lines

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Development of rice (*Oryza sativa*) varieties with short maturity duration is important in rice improvement programs. The objective of the present study was to ascertain the genetic variability of yield and yield related characteristics and their relationships with maturity duration using near isogenic lines in comparison to cultivated varieties in rice. The ideal study to highlight the influence of maturity duration on grain yield would be to compare grain yield of near isogenic lines with different maturity durations in the same genetic background. Near isogenic lines (30) and cultivated varieties (18) were used in the experiment in a randomized complete block design with two replications. Differences of maturity duration, grain yield, yield components and other yield related characteristics among near isogenic lines as well as among cultivated varieties were found to be significant at 1% probability level. In near isogenic lines grain yield increased with increasing maturity duration from 80 to about 100 days and then almost stabilized up to 135 days. Number of panicles per hill and 1000 grain weight were independent of maturity duration whereas filled grain percentage and number of spikelets per panicle correlated with maturity duration. Harvest index was negatively related while above ground vegetative biomass, culm height and all the root characteristics were positively related with maturity duration. The relationships established using cultivated varieties were different from those established with near isogenic lines that appeared logical, realistic and useful in utilization in plant breeding programs. Rice varieties that mature within 100 days with maximum expected grain yield may be developed. Attention must be paid to increase above ground biomass and root clump length as much as possible in such varieties. However, there is a possibility of developing 90 day varieties without sacrificing much grain yield if efforts are made.

This work was funded by the Rice Research and Development Unit, CIC Agri Businesses, Pelwehera.

Keywords: Grain yield, Maturity duration, Near isogenic lines, Rice

¹ CIC Agribusinesses, Pelwehera, Dambulla

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The Species Diversity of Bee Pollinators (Hymenoptera: Apoidea) in Vegetable Agro-ecosystems in Batticaloa District, Sri Lanka

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Pollinators provide a valuable free service to increase both the size and quality of harvests. As the intensive agriculture continues, it threatens the wild pollinators. Maintaining these pollination services requires the conservation of pollinators and management of sufficient resources for wild pollinators within agricultural landscapes. There is paucity of data on pollinator diversity in agro-ecosystems locally. Therefore, this study was conducted with the objective of investigating the diversity of bee pollinators and their abundance in vegetable cropping systems of Batticaloa district of Sri Lanka. Pollinators were surveyed in vegetable agro-ecosystems, in Koddaikallar, Onthachimadam, Kaluwanchikudy, Kalluthavallai and Periyakallar in Batticaloa during September to November, 2014. A total of 91 bee specimens were collected and identified. They were belonging to three families: Apidae, Halictidae, and Megachilidae and to 13 genera. Family Apidae included the largest number of collected bees (51). Most of them were belonging to the genera *Apis* and *Amegilla* followed by genus *Ceylalictus*, and *Megachile*. The highest bee species diversity ($H' = 2.017$, $P > 0.05$) and Evenness ($E = 0.712$) were recorded from Koddaikallar agro-ecosystem and it was followed by Kalluthavallai ($H' = 1.937$, $E = 0.647$). The abundance of bee species was not significantly varied among the locations. *Apis florea* was the leading bee pollinator (35%) in all locations; however, there was a considerable proportion of bee fauna represented by wild bee species. The findings of this study are useful in correct use of cultural practices to promote, enhance and protect the existing pollinators within the vegetable based agro-ecosystems.

This work was funded by the Pollinator Conservation Advisory Group, Ministry of Environment & Renewable Energy Sri Lanka

Keywords: Agro-ecosystem; Batticaloa; Bee pollinators; Species diversity; Sri Lanka

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Molecular Detection of Viruses Associated with Tomato Curly Top Disease in Sri Lanka

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Viral diseases are one of the main constraints in tomato production in Sri Lanka. Among the four viruses believe to present in Sri Lanka, only the Curly top virus have not been systematically studied. Therefore, a survey was conducted in Matale and Kandy districts to determine the disease incidences caused by the tomato curly top viruses under farmer field conditions. Infected plants showed stunted growth, yellowing, mosaic, mottling, upward curling of leaves and purple coloration of veins. The occurrence of virus infected plants showing characteristic symptom of the curly top disease was found in the all the tested locations. The virus symptoms were initially appeared in fields within 12-21 days after planting. The infected plants showing characteristic symptoms of the disease ranged from 5-10%. Furthermore, mixture of curly top virus and tomato yellow leaf curl virus diseases were also observed under field conditions. DNA was extracted from leaf tissues obtained from healthy plant and plants showing characteristic symptoms of yellow leaf curl disease, curly top virus disease and plants showing mix infection. Polymerase chain reaction assays with specific primer for begamo viruses gave 506 bp amplified product from all samples showing characteristic symptoms of Tomato yellow leaf curl disease and mix infection. The group specific primers for Curly top viruses amplified 1200 bp fragment from plants showing characteristic symptoms of curly top disease and mixed infections suggesting the presence of the Curly top virus in curly top affected tomato plants and mixed infected plants. PCR assays with species specific primers for beet mild curly top viruses and beet severe curly top viruses revealed the presence of beet mild curly top viruses but not beet severe curly top viruses in curly top infected tomato plants collected from Kandy and Matale.

Financial assistance given by Horticultural Crop Research and Development Institute, Gannoruwa is Acknowledged.

Keywords: Tomato curly top virus; Tomato yellow leaf curl virus; Molecular detection

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The Effectiveness of Organic Additives (Potato, Watermelon, and Avocado) in *Gerbera* Tissue Culture

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To study the effect of common organic additives (potato extract, watermelon extract, and avocado extract) in *Gerbera* tissue culture, two varieties (*Gerbera jamesonii* 'Kilimanjaro' and *Gerbera jamesonii* 'Ruby red') were selected and cultured on the media containing three organic additives separately with and without hormone. Capitulum explants from plant house grown plants were used. The media containing watermelon and potato extract with hormone showed a significant effect at $I \leq 0.05$ levels on callus induction and shoot initiation. Media containing 100 g/L watermelon extract with 3 mg/L BAP (average rank was 578.3) and media containing 100mg/L watermelon extract with 3 mg/L BAP (average rank was 566.9) gave best results on callus induction and shoot initiation of capitulum explant of *Gerbera jamesonii* 'Kilimanjaro'. Media containing 50 g/L potato extract (average rank was 479.9) gave best results on callus induction of *Gerbera jamesonii* 'Ruby red' and media containing 100 g/L watermelon extract with 3mg/L BAP (average rank was 538.3) and media contained 50 g/L watermelon extract with 3 mg/L BAP (average rank was 401.2) gave best results on callus induction and shoot initiation of Ruby red variety. Callus developed from these treatments were healthy, vigor and green in color. The regeneration from callus was quite complicated and time consuming, rather than direct shoot generation from the explants. Contamination was very high in the media containing potato extract (average of contamination was 31.5%) followed by watermelon media (average of contamination was 31%). Contamination rate was zero in the media containing avocado extract.

Keywords: *Gerbera jamesonii* 'Kilimanjaro'; *Gerbera jamesonii* 'Ruby red'; organic additives; callus induction; shoot initiation

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In Silico* Analysis of *PhyB* in Genus *Oryza

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Phytochromes are red and far-red light absorbing photoreceptors. They allow plants to sense light and express molecular and cellular responses specific to the genus *Oryza* at all developmental stages. In the current study, publically available whole genome sequence data of genus *Oryza* were used to conduct a comprehensive study on the evolution and diversity of the phytochrome genes within the genus *Oryza*. Nucleotide sequences of *PhyB* gene orthologous encoded by the genus *Oryza* were retrieved from Gramene database. The sequences were aligned and a phylogenetic tree was reconstructed using maximum likelihood analysis in MEGA 6 software to infer evolutionary relationships. *O. brachyantha* have diverged much earlier from the rest of the *Oryza* spp. and then *O. punctata*. The rest are closely related and are in two monophyletic clades. Jukes-Cantor estimate of nucleotide diversity (π) for *PhyB* was 0.03838 and the highest value was observed at around 600bp. Tajima's D value (-1.99633; $P < 0.01$) suggests an excess of low frequency polymorphisms than expected. This could possibly be a result of purifying selection or a sudden population size expansion. The comparison of K_a/K_s (ω) values between species have revealed the occurrences of positive, neutral and negative selections in their adaptive molecular evolution over a long time. The multi-domain architecture of *PhyB* gene in genus *Oryza* consists of highly conserved GAF, PAS, HisKA, HATPase_c and PHY functional domains, with potential non-synonymous single nucleotide polymorphisms. Analysis of the cis-regulatory elements at the promoter regions of *PhyB* revealed that the transcription regulatory network of *PhyB* gene in the genus *Oryza* is highly diverse. Out of the 136 cis-regulatory elements identified, ARR1AT, CAATBOX1, CACTFTPPCA1, DOFCOREZM, GATABOX, GTGANTG10, GT1CONSENSUS and WRKY71OS were the highest occurring elements.

Keywords: *In Silico*, Evolution, Gene diversity, *Oryza* spp., *PhyB*

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Development of a Greek-Style Yoghurt Sweetened with Kithul (*Caryota urens*) Treacle and Design to be Consumed as a Breakfast food along with Rice Crisps

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The objective of this study was to develop a Greek-style yoghurt sweetened with Kithul (*Caryota urens*) treacle and designed to be consumed as a breakfast food item along with rice crisps. Preliminary studies were conducted to determine the best level of incorporation (% w/w) of the “kithul” treacle (KT; 5%, 10%, 15%) and whey protein concentrate (WPC; 5%, 7.5%, 10%) to develop the non-fat Greek-style yoghurt and the wholesome Greek-style yoghurt. The sensory evaluation was carried out to determine the best Greek-style yoghurt by using forty untrained panelists with five point hedonic scale. Various determinations such as pH, titratable acidity and syneresis were determined during storage at $4^{\circ}\text{C} \pm 1$ and compared with the commercial set yoghurt. Furthermore, microbiological properties of yoghurt were also determined. The data concluded that both the pH and titratable acidity values of the tested yoghurt showed significant difference ($P < 0.05$). pH values decreased with the increasing of the storage period while titratable acidity increased with the increasing storage period of all yoghurt treatments. On the other hand, syneresis value of the whey protein fortified Greek-style yoghurts was significantly higher compared to the commercial set yoghurt. Results revealed that coliform, yeast and mould counts were in conformity to the Sri Lanka Standards limits. Shelf life of the Greek-style yoghurt sweetened with “Kithul” treacle was approximately 12 days considering the change in pH, titratable acidity, microbiological and sensory properties. The nutritional composition of the wholesome Greek-style yoghurt (KT:10%, WPC:7.5%) was 6.6 g protein, 7.0 g fat, 4.4 g total ash and 4.4 g total sugars in 100 g of Greek-style yoghurt on dry matter basis and the moisture content was 72.1% (w/w). In conclusion, wholesome Greek-style yoghurt tasted better than non-fat Greek-style yoghurt. Wholesome Greek-style yoghurt had a creamy and smooth texture while non-fat Greek-style yoghurt appeared upon spooning a granular and the opened surface was not shiny.

Keywords: Greek-style yoghurt, *Caryota urens*, Whey protein

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Investigate the Effect of Processed Mung Bean (*Vigna radiata* L.) Powder Incorporated Experimental Diets on Serum Lipid and Glucose Concentrations in Wistar Rats (*Rattus norvegicus*)

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High serum cholesterol level is a major risk factor for cardio vascular disease. The purpose of this study was to determine *in vivo* hypocholesterolaemic and hypoglycaemic effect of raw and processed mung bean powder (variety MI-6) incorporated high cholestreol diets with the comparison of control diet in rats. Seven weeks old 20 male Wistar rats were randomly allocated into groups (n=5) and fed with experimental diets *ad libitum* for 4 weeks. Diets were prepared according to the AIN-93G semi purified rodents diet and 5% cholestreol + 30% raw mung bean (RMD), 5% cholestreol + 30% boiled mung bean (BMD), 5% cholestreol + 30% sprouted mung bean (SMD) and 5% cholestreol + 10.15% casein powder (CD) were given as treatments. Blood was collected from rats at the beginning and at the end of the experiment and serum total cholesterol (TC), low density lipoprotein (LDL) cholesterol, high density lipoprotein (HDL) cholesterol, triglycerides, glucose and insulin concentration were measured. At the end of the experiment rats were sacrificed and liver and ceecal weight, kidney fat index, ceecal pH were measured. *Coliform* count in ceecal contents was enumerated. Serum LDL cholesterol concentration in rats fed with SMD and BMD diets were significantly ($P<0.05$) lower than the CD diet fed group. HDL cholesterol concentration in rats fed SMD and BMD diets was significantly higher than that in the CD diet fed group. Serum glucose and insulin concentration in rats fed RMD and BMD were significantly ($P<0.05$) lower than that in the CD fed group. *Coliform* count was significantly ($P<0.05$) higher in CD than mung bean incorporated diets. These results indicate that boiled mung bean incorporated diets modulate both serum lipids and glucose while sprouted mung bean incorporated diets modulated only serum lipids in rats.

Keywords: Cholesterol, Hypoglycaemic effect, Hypocholesterolaemic effect, Mung bean, Wistar rat

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A Study on Color Development of the Chicken Sausages in Smoking Chamber

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Meat smoke houses are used to add color, flavor and aroma to various meat products, including pork, beef, poultry and fish. The objectives of this study were to determine effect of Mechanically Separated Meat (MSM) from different sources, time-temperature combination (operator's manipulation) of smoking chamber, product density of sausage trolley, circulation rate of smoke and woodchip type (Oak woodchip and local woodchip) used to generate smoke in chamber on color development of chicken sausages. Samples were collected from pre-determined 9 locations of sausage trolleys from smoking chamber according to air flow movement inside the chamber. Woodchip burning efficiency of smoking chamber, shear value, external color, internal color and sensory characteristics (appearance, texture, color before fry, color after fry, taste and overall acceptability) of chicken sausages were evaluated. Woodchip burning efficiency of smoking chamber was gradually decreased in smoking chamber from day 1 to day 5. Shear values of sausages were significantly ($P < 0.05$) increased in smoking chamber during the smoking period from day 1 to day 5. There was no significant ($P > 0.05$) effect of Mechanically Separated Meat (MSM) from different sources on color development of chicken sausages. There was significant ($P < 0.05$) effect of time-temperature combination (operator's manipulation) of smoking chamber, product density of sausage trolley and circulation rate of smoke on color development of chicken sausages. Sensory evaluation shown that there was significant ($P < 0.05$) improvement on sensory attributes of chicken sausages by smoke generated from Oak woodchips.

Keywords: Chicken sausages, Color, Smoking chamber

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Physicochemical and Sensory Attributes of Chicken Sausages Fortified with Eggshell Calcium

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The purpose of this study was to develop a calcium fortified chicken sausage using hen eggshell powder and to evaluate physicochemical and sensory attributes of it. The eggshell powder (particle size $>32\ \mu\text{m}$) was prepared in sterile form and incorporated into chicken sausages. Four (0.50%, 0.75%, 1.00% and 1.25%) levels of Ca incorporated sausages were prepared and the best Ca level was determined through two sensory evaluations. The sensory data were analyzed according to Friedman non-parametric test. Selected Ca fortified sausage was subjected to laboratory analysis and compared with the control. The experiment design was Complete Randomized Design with 3 replicates and Duncan's Multiple Range Test was used for mean separation. Colour, water holding capacity, shear force, pH, 2Thiobarbituric acid-reactive substances (TBARS), and total aerobic viable counts (TAVC) were measured during 3- week of storage at $-18\ ^\circ\text{C}$. Proximate analysis and Ca contents of the sausage samples were also determined. The highest consumer acceptability was shown for 1.00% Ca incorporated sausages out of the 4 levels of Ca tested. In terms of lightness and yellowness, 1.00% Ca fortified sausages had significantly ($P<0.05$) low values and in terms of redness, 1.00% Ca incorporated sausages had significantly higher values in the first week than the control. The pH and shear force values were significantly high in 1.00% Ca fortified sausages ($P<0.05$). There was no significant difference in TBARS and TAVC analysis ($P<0.05$). The Ca level in 1.00% Ca incorporated sausages was 0.88% higher than the control ($P<0.05$). The optimum level of Ca from eggshell powder to be incorporated to the sausage is 1.00%, and it maintains physicochemical and sensory attributes of the sausage. Even though a significant difference was observed in pH, instrumental colour and texture in Ca fortified sausages, the sensory attributes of Ca fortified sausage were not affected.

Keywords: Calcium, Eggshell powder, Chicken sausages

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Comparison of Milk Coagulation Properties of Three Different Cattle Breeds in Sri Lanka: Enzymatic and Lactic Acid Bacteria Coagulation

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The aim of present study was to evaluate differences in coagulation properties between milk obtained from three major cattle breeds found in Sri Lanka. A total of 30 milk samples (400 mL from each individual) were collected from two Sri Lankan cattle breeds (Thamankaduwa white/TW and Local/ “*Batu*” cattle) and one European cattle breed (Friesian). Collected samples were subjected to enzymatic coagulation using commercial coagulant (Chymax, Christian Hansen, Switzerland) and lactic acid bacteria (LAB) coagulation using a commercial starter culture (YFL 8 12, Christian Hansen) to determine milk coagulation properties. Different properties of coagulum such as yield, curd firmness, syneresis and rheological properties were determined. The biochemical composition (lactose, protein, fat, solid-non-fat) of milk samples were determined and quality parameters e.g. titratable acidity and somatic cell counts were analyzed. Experimental design was Nested Completely Randomized Design (Nested CRD) with three treatments (Breeds). Milk coagulation time and curd firmness after enzymatic-coagulation of the samples were not significantly different ($P < 0.05$) among the breeds. Yield of enzymatic coagulum was significantly higher ($P < 0.05$) for the TW breed than for the other two breeds. The TW breed also showed the highest meltability value of enzymatic coagulum. Syneresis of enzymatic coagulum was significantly lower ($P < 0.05$) for the local breed in comparison with other two breeds. Lactose, protein and solid-non-fat levels were significantly higher ($P < 0.05$) in milk obtained from TW and local breed than from Friesian cattle. Coagulum yield was negatively correlated with β -caseinA1 and α -lactalbumin in both enzymatic coagulation (-0.58) and LAB coagulation (-0.69). Coagulum yield was positively correlated with β -casein B variant (0.70), protein (0.34) and lactose (0.36) contents ($P < 0.05$). Meltability value was weakly and positively correlated (0.34) with fat content of milk ($P < 0.05$). Therefore, these results support the conclusion that there is a difference in coagulation properties of milk among cattle breeds in Sri Lanka with the correlation between milk coagulation properties and genetic variants of milk protein.

Keywords: Milk coagulation, Enzymatic coagulation, Lactic acid bacteria, Genetic variants, Breeds

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Processing Method and *In vitro* Functional Properties of Mung Bean (*Vigna radiata*)

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Mung bean is an important grain legume in warm dry parts in the world. Like any other grain legume mung bean is also a rich source of nutrients and other bioactive compounds. However, the effect of processing on nutritional and functional properties of legumes is not widely studied. In the current study effect of processing on some nutritional and functional properties of mung bean was studied in comparison with raw mung bean. Antioxidant capacity was determined using DPPH and ABTS assays and total phenolic content (TPC) and total flavonoid content were determined by Folin-ciocalteu and Aluminium chloride method, respectively. Antidiabetic effect was determined by α -amylase inhibitory assay and microbial fermentation characteristics were measured using unadapted microorganisms obtained from swine caecum. Insoluble dietary fibre (IDF) and soluble dietary fibre (SDF) contents were also determined on dry matter basis. The results showed that processing significantly reduced antioxidant activity and phenol content compared to raw mung bean. However, flavonoid could be detected only in sprouted mung bean. IDF content in raw mung bean was significantly higher ($P < 0.05$) than that in sprouted and boiled mung bean. Whereas, SDF content in boiled mung bean was significantly higher ($P < 0.05$) than that in sprouted and raw mung bean. Results of fermentation study significantly correlated ($P < 0.05$) with IDF content. α -amylase inhibition in raw mung bean was significantly higher than that in boiled mung bean. These Results indicate that processing methods (boiling and sprouting) influence on antioxidant capacity, α -amylase inhibition, anticancer effect and dietary fibre content in mung bean.

Key words: Mung bean, Processing method, Functional properties, Dietary fibre, *In vitro* study

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Quality of Reduced-Fat Chicken Sausages with Added Hydrated Arrowroot (*Maranta arundinacea*) Flour

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Meat and meat products are rich in nutrients. However, high saturated fatty acid and cholesterol content keep the people away from meat products. Processors try on various fat reducing strategies, which is a serious challenge due to the superior contribution of fats on the organoleptic and processing properties of the final product. Fat replacers originated from plants as starches, flours and fibers have been applied successfully without sacrificing the quality. Present study, investigated the arrowroot flour as a fat replacer to develop a reduced-fat chicken sausages after hydrating at 1:1.5 (arrowroot flour: water) ratio. Mechanically deboned meat, boneless meat and loose meat were partially replaced in equal amounts by hydrated arrowroot flour at 10% (T₁), 15% (T₂) and 20% (T₃) from the total meat content to produce 3 treatment samples and a control sample without adding hydrated arrowroot flour. Samples were subjected to 3 sensory evaluations at first, second and third weeks after preparation while physicochemical, microbiological and shelf-life parameters were also measured. Total fat content was reduced in T₁, T₂ and T₃ at 8.14%, 20.53% and 26.87% respectively compared to control sample. Appearance, colour, taste and texture were significantly higher ($p < 0.05$) in T₁, T₂ and T₃ than control sample at first sensory evaluation ($P < 0.05$). In second sensory evaluation, appearance and colour were significantly higher ($P < 0.05$) in all three treatments compared to control. However, in third sensory evaluation, appearance, colour, aroma and overall acceptability were significantly higher ($P < 0.05$) in T₁, T₂ and T₃ than control sample ($P < 0.05$). Crude fat, crude protein contents were significantly lower in T₂ and T₃ than control sample while the total ash and Nitrogen Free Extract were significantly higher ($P < 0.05$). Thus, replacing 20% of meat by hydrated arrowroot flour produced consumer acceptable reduced-fat chicken sausages.

Keywords: Reduced-fat, Chicken sausages, Hydrated arrowroot flour

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Dietary Supplementation of Dried *Spirulina platensis* on Growth Performances and Meat Quality of Broiler Chicken

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Sri Lanka has a rising demand for broiler chicken products compared to other animal products. However, the cost of broiler production is comparatively high in Sri Lanka. Although *Spirulina platensis* is one of the cost effective feed resource with high nutritive value which can potentially be utilized in broiler feed industry, the effect of supplementing dried *Spirulina* on growth and meat quality parameters in broiler chicken has not been adequately evaluated. Therefore, the present study was undertaken to determine the effects of supplementing dried *Spirulina* on growth performances and meat quality of broiler chicken. Sixty male Cobb 500 day old chicks were randomly allotted into 3 treatment groups as control (commercial broiler feed), 4% *Spirulina* + commercial broiler feed and 8% *Spirulina* + commercial broiler feed. Each treatment group consisted of 4 replicates with 5 birds per replicate. Feed intake was measured daily, while body weight of each bird was measured weekly. At 35th day, blood was collected and birds were sacrificed. Then the weights of carcass and giblet, weights and lengths of parts of the digestive tract were measured. Ileal content was collected from 12 birds, one from each replicate. Meat quality parameters were analyzed by using the breast muscle stored under refrigerated conditions (4 °C). Both 4% and 8% *Spirulina* supplemented groups obtained, significantly ($P<0.05$) higher live weights, weight gains, water holding capacity, crude protein%, yellowness in meat and significantly ($P<0.05$) lower FCR than control group. Four percent *Spirulina* supplemented group obtained, significantly ($P<0.05$) lower cooking loss, total serum cholesterol and significantly ($P<0.05$) higher ileal crude protein digestibility than control group. Eight percent *Spirulina* supplemented group obtained significantly ($P<0.05$) lower crude fat% in meat than control group. In conclusion, supplementation of *Spirulina* (mainly at 4%) showed advantageous in relation to growth and meat quality parameters.

Keywords: *Spirulina platensis*, Broiler chicken, Growth performances, Meat quality

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Comparative Study on Nutritional Composition and Health Related Functional Properties of *Eleusine coracana* (Finger Millet) and *Oryza sativa* (Rice) *In Vitro*

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The purpose of this study was to determine the therapeutic effect of finger millet (FM) compared to rice, to encourage its future applications as a functional food. To investigate this, nutritional composition, antioxidant activity, alpha amylase inhibitory activity and fermentation ability of Rawana and Oshada FM varieties were measured against Basmati and BG-300 rice varieties under *in vitro* conditions. The results showed that both soluble and insoluble dietary fiber (DF) contents were higher ($P < 0.05$) in Rawana and Oshada than Basmati and BG-300. Moreover, soluble and insoluble DF contents of Oshada ($0.44 \pm 0.04\%$ and $11.62 \pm 0.35\%$, respectively) were higher ($P < 0.05$) than Rawana ($0.38 \pm 0.02\%$ and $10.67 \pm 0.19\%$, respectively). Total flavonoid content (TFC) of Rawana was similar to Basmati and BG-300. However, Oshada had the highest TFC (1.05 ± 0.08 Catechin equivalent mg/g). Total phenolic contents (TPC) of both FM varieties were higher ($P < 0.05$) than both rice varieties. Oshada had a higher ($P < 0.05$) TPC than Rawana (8.08 ± 0.17 and 6.40 ± 0.09 Gallic acid equivalent mg/g, respectively). Both FM varieties showed a higher ($P < 0.05$) 2, 2-diphenyl-1-picrylhydrazyl (DPPH) scavenging activity than BG-300 and Basmati. Similarly, 2, 2'-azino-bis-3-ethylbenzothiazoline-6-sulphonic acid (ABTS) scavenging activity was higher ($P < 0.05$) in both FM varieties than Basmati and BG-300. Furthermore, ABTS scavenging activity was higher ($P < 0.05$) in Oshada than Rawana. Alpha amylase inhibitory activity of Rawana and Oshada were higher ($P < 0.05$) than Basmati and BG-300. However, the IC_{50} values of both FM varieties were greater ($P < 0.05$) than acarbose which is a drug used to treat type II diabetes. The results of the microbial fermentation study revealed that Rawana and Oshada produced a higher amount of hydrogen and carbon dioxide than rice varieties during the incubation at 39°C with unadapted caecal microflora. Therefore, these results indicate that both FM varieties, particularly Oshada variety has more beneficial nutritional and health related protective effects than Basmati and BG-300 rice varieties *in vitro*.

Keywords: *Eleusine coracana*, *Oryza sativa*, Functional properties, Nutritional composition, *In vitro*

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Characterization of *Lactobacillus* Strain Isolated from Sri Lankan Curd

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Curd production is a traditional industry in Sri Lanka. However, very little work has been done to characterize the cultures used in the cottage level curd production. Thus, the present study was designed to perform molecular characterization of already isolated 24 isolates of *Lactobacillus* spp. and to test some functional properties of the isolated *Lactobacillus* spp. 16S rRNA gene of the 24 *Lactobacillus* strains were sequenced and phylogenetic analysis were performed using MEGA 6 genome analysis software. Using the genomic DNA of the isolates, Randomly Amplified Polymorphic DNA (RAPD) patterns were also investigated with 2 RAPD primers. All 24 isolates were genetically identified by matching their 16S rRNA gene sequence with deposited sequences in NCBI (BLAST) data base and following 6 major strains were identified. *Lactobacillus fermentum* strain LFW2, *Lactobacillus fermentum* strain JCM8581, *Lactobacillus fermentum* strain JCM 7754, *Lactobacillus plantarum*, *Lactobacillus acidophilus* strain CICC6074 and *Lactobacillus curvatus* PON46. In RAPD analysis, 6 band positions were identified and divided into 2 main clusters. *Lactobacillus fermentum* strain LFW2 showed high polymorphism. *Lactobacillus fermentum* strain JCM7754 showed different polymorphic banding pattern. However, *Lactobacillus acidophilus* strain CICC6074 showed similar polymorphism with *Lactobacillus fermentum* strain LFW2 and *Lactobacillus plantarum* showed different polymorphic banding pattern when compared to the other strains. Phylogenetic trees were constructed using Neighbor Joining method. Hot start for RAPD PCR appeared as very practical method to classify the strains. All the isolated *Lactobacillus* strain showed similar syneresis characteristics like standard control cultures. The present study identified potential *Lactobacillus* strains from local curd cultures that can be used in fermented dairy product processing and there functional properties should be investigated in detail before commercializing them.

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Key words: Curd, Molecular characterization, *Lactobacillus*, RAPD, Hot Start PCR, Syneresis

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Finger-millet (*Eleusine coracana*) Incorporated Egg Based Snack

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Consumers prefer to have snack with both high nutrient values and sensory attributes. The objective of this study was to develop a nutritionally balance, baked snack with high sensory characteristics. Wheat flour, spices, baking powder, sugar, salt and water were used for the snack preparation. Wheat flour was replaced by different levels (10%, 15% and 20%) of finger-millet (variety *Oshada*) flour and the best replacement level was selected through a sensory evaluation. Then different levels (15%, 30% and 45%) of egg white were incorporated to dough, to select the best incorporation level of egg white through sensory evaluation. Selected (only finger-millet, and both finger-millet & egg white incorporated) products were stored at the room temperature (28 °C) for a period of 3-week and physicochemical, microbiological and sensory parameters were evaluated. According to the sensory evaluation one, colour, appearance, crispness, mouth-feel, and overall acceptability among three snacks were significantly different ($P<0.05$). The 15% finger-millet incorporated snack scored the highest median values for colour, appearance, crispness, mouth feel and overall acceptability. In the sensory evaluation two, 15% finger-millet & 30% egg white incorporated snack scored the highest median values for color, appearance, crispness, mouth-feel, and overall acceptability. It scored significantly ($P<0.05$) higher median values for colour and the appearance in the first week, and higher median values for colour, appearance, crispness and overall acceptability after storage period of 3-week ($P<0.05$) than the snack with only 15% finger-millet. The pH, 2-Thiobarbituric acid reactive substances values and total viable plate counts among snacks were not significantly different ($P<0.05$) during the storage period. The 30% egg incorporated snack had significantly ($P<0.05$) lower bulk density ($0.3\pm0.01\text{gcm}^{-3}$) and higher protein content ($19\%\pm0.30$) than the snack with only 15% finger-millet. According to the study 15% finger-millet with 30% egg white combined snack gives the best sensory, nutritional and physicochemical characteristics.

Keywords: Snack, Finger-millet, Egg white, Sensory attributes

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Effect of Economas E[®] (EcoE) as a Vitamin E replacer on Performance, Nutrient Utilization & Immunity in Broiler Chicken

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An Experiment was undertaken to evaluate the effect of Economas E[®] as a vitamin E replacer on the performance, nutrient utilization, histomorphology of ileum, immune modulator functions and blood parameters of broiler chicken. A total of 180, day-old male broiler chicks (Cobb-500) housed in 15 deep litter pens were randomly assigned to three dietary treatments with 5 replicates. The control group (T0) received a basal diet and the two test groups received diets supplemented with 100 IU/kg Vitamin E (T1) and 200 g/ton Economas E[®] (T2). Broilers were vaccinated for infectious bursal disease (IBD) on day 7, 21 and 28 and antibody titer levels were determined on day 14, 21, 28, 35 and 42. Nutrient utilization was studied on day 19 and day 35 by indicator method. On day 14 and day 42 two birds were sacrificed to evaluate ileal histomorphology and weight of lymphoid organs. Both test diets significantly ($P < 0.05$) improved the growth, feed efficiency and nutrient utilization of birds. Economas E[®] diet fed birds showed the highest weight gain (2272 kg) and the lowest Feed conversion ratio (1.85). The highest metabolisable energy (11.28 MJ/kg) and net protein utilization (0.81) were recorded from the Economas E[®] diet. The relative weight of bursa was higher ($P < 0.05$) in birds fed with the Economas E[®] diet than that of Vitamin E diet and the control groups. Antibody response (4146.5 titer level) for IBD vaccine was significantly ($P < 0.05$) higher in Economas E[®] group than the control group. The villus height (767.5 μ m) and villus height:crypt depth ratio (6.76) were higher in Economas E[®] diet fed birds when compared to the control birds. It is concluded that Economas E[®] is a satisfactory or even a better replacement to supplementary vitamin E in broiler diets.

Key words: Economas E[®], Vitamin E, Broilers, Nutrient utilization, Immunity

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Egg Quality Traits and Functional Properties of Eggs of Some Backyard Chicken Ecotypes in Sri Lanka

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The egg quality traits and functional properties of three village chicken ecotypes (normal village chicken, naked neck and long leg) were evaluated along with the egg keeping quality under refrigerated condition. A total of 117 eggs were used to investigate internal qualities, external qualities and functional properties. Further ultra-structural analysis of egg shells of three ecotypes were compared with that of commercial chicken. The results revealed that egg weight, egg length, egg width, albumin height, yolk height, yolk diameter, haugh unit, yolk index, shell thickness, foaming stability and gelling strength were not significantly ($P>0.05$) different among three ecotypes. Shape index and air cell depth were significantly ($P<0.05$) differed among three ecotypes while long leg having the highest values of 76.64 and 5.69, respectively for the two traits. Yolk colour showed a significant ($P<0.05$) difference among three ecotypes showing the values of 5.19, 7.33 and 8 for naked neck, normal village chicken and long leg ecotypes, respectively. Comparisons of village chicken with commercial chicken, as well as among three ecotypes showed gradual changes in haugh unit, air cell depth and gel strength during the storage period. Mammillary thickness, palisade thickness, total thickness, mammillary% and palisade% did not demonstrate significant difference ($p>0.05$) among egg shells of three ecotypes. Interestingly, egg shell thickness of commercial chicken was significantly higher ($P<0.05$) than that of village chicken. Storage period had high adverse effect on haugh unit, air cell depth, yolk index and foaming stability of commercial chicken compared to village chicken. The quality parameters and functional properties of village chicken eggs would provide valuable information for the selection and breeding programs for improvement and conservation of indigenous chicken genetic resources of the country.

Financial assistance given by the GEF-UNEP-ILRI-FAnGR Asia project is greatly acknowledged.

Keywords: Village chicken, Ecotype, Quality traits, Functional properties

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Development of a Novel Lacto-Vegetarian Set Yoghurt by Incorporating Osmotically Dehydrated Aloe Vera (*Aloe Barbadensis* Millar) Gel as a Stabiliser Substitute for Sri Lankan Market

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Gelatin, an animal origin stabiliser, is most commonly used in yoghurt production in Sri Lanka. However, some lacto-vegetarians are reluctant to consume gelatin incorporated products due to several cultural and religious taboos. This study focussed on investigating the feasibility of low methoxy pectin in aloe gel to form a gel matrix with calcium in milk to be used in manufacturing set yoghurt. As aloe gel contains about 98.5-99.5% moisture, the gel pieces obtained after treating them with water for removal of aloin, were osmotically dehydrated (OD) in 50 °Brix sugar for 4 h at 40 °C. Three types of yoghurts were prepared incorporating 5%, 7.5% and 10% aloe gel, and 0.6% agar-agar was incorporated to each type of yoghurt to facilitate the setting. Preference for color, aroma, appearance, consistency, taste, texture and overall acceptability of the samples were analysed by forty untrained panelists using a ranking test. According to the median scores, 5 % gel was found to be the most suitable since it ranked superior among all other treatments in terms of most of the sensory attributes including color, taste, texture and overall acceptability. Selected aloe yoghurt was stored at 4 °C and physicochemical parameters such as syneresis, viscosity, pH and titratable acidity (TA) of the yoghurts were determined every three days during a storage period of 2 weeks in comparison to the control yoghurt with gelatine. Proximate composition of the selected aloe yoghurt was determined. Viscosity, pH and syneresis (except on day 10) of the aloe yoghurt was significantly higher ($P < 0.05$) than the control, while TA of the aloe yoghurt and the control were not significantly different ($P > 0.05$) throughout the storage. The sensory and physicochemical results revealed that it is possible to incorporate 5% OD aloe gel along with 0.6% agar-agar in place of gelatin for manufacturing yoghurt.

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Keywords: Aloe gel, Osmotic dehydration, Yoghurt

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Development of Ready to Eat Convenient Chicken Meal

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In recent years, there has been an increased demand for convenient food. Therefore an experiment was conducted to develop a ready to eat convenient chicken meal. Chicken breast meat, carrot, beans, potato and mushroom were used to produce 3 products and different spice mixtures were used. Through trial and error method 3 different chicken meals were developed and named as T₁, T₂ and T₃. They were vacuum packed in polythene bags and kept at -10°C for a month. pH, Thiobarbituric Acid (TBA) and total plate counts were measured at weekly intervals. Proximate analysis was conducted to assess the nutrient content of the 3 chicken meals. Subjective measurements were analyzed by using Friedman nonparametric method and ANOVA. Objective measurements were analyzed by Completely Randomized Design and using analysis of variance procedure while means were compared using Duncan's Multiple Range Test. Results of the sensory evaluation showed that T₂ was given highest median value for all sensory attributes. T₂ contained 25.07% dry matter, 14.04% ash, 13.40% crude fat and 9.57% crude fiber in dry matter basis. Crude protein content was highest (19.12%) in T₁ and lowest (10.45%) in T₃. The pH of three chicken meals were decreased with the storage and pH value of 3 chicken meals were significantly ($P < 0.05$) different. pH value of T₃ was the lowest. TBA values of 3 chicken meals were increased with storage at -10°C and TBA values were not significantly ($P > 0.05$) different between products. Total plate counts were increased with the storage at 10° C. Total plate counts were significantly ($P < 0.05$) different between products. Best proportion of rice to chicken meal was 10:6. T₃ was economically most viable product. T₁ and T₂ were best quality products based on physiochemical properties and palatability characters.

This study was funded by Farm's Pride Pvt. (Ltd), Gampola, Sri Lanka.

Keywords: Ready to eat, Convenient, Chicken meal

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Salt Content and Microbial Quality of Salted Sundried Skipjack Tuna (*Katsuwonus pelamis*) in Major Production Areas in Sri Lanka

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The aims of the current study were to determine the variations of salt content (NaCl %), microbial quality of salted sundried Skipjack tuna (SJT) (*Katsuwonus pelamis*) among major production areas and between beach and boat dried SJT in Sri Lanka (SL). Survey was conducted to determine the consumer preferences and attitudes towards dried fish in SL. Fifty SJT dried fish samples were collected from manufacturers in Chilaw, Kalpitiya, Negombo, Galle, Matara and Trincomalee. Moisture content (%), NaCl % (% w/w DM), halophilic bacteria count (HB) (log cfu/g) and yeast and mold count (YM) (log cfu/g) were analyzed. According to survey findings, many Sri Lankans preferred to eat dried fish over other animal proteins and SJT was the second preferred dried fish species. According to the main study findings, NaCl %, moisture %, HB count (log cfu/g) and YM count (log cfu/g) were 15.59 ± 0.63 , 40.85 ± 5.30 , 7.27 ± 0.89 and 8.35 ± 0.94 , respectively. The NaCl % of dried SJT from Galle was higher ($p < 0.05$) than that of Kalpitiya, Chilaw and Trincomalee. Higher ($P < 0.05$) HB count was enumerated in dried SJT from Kalpitiya than that of Galle. Higher ($P < 0.05$) YM count were found in dried SJT from Negombo than that of Trincomalee. Moisture % was higher in dried SJT obtained from Trincomalee than that of Matara, Kalpitiya and Galle. HB count of boat dried SJT and moisture % of beach dried SJT were high ($P < 0.05$) in Kalpitiya. These results support the conclusions that, the SJT dried fish in major manufacturing areas in SL are highly contaminated with HB, YM and heavily salted since they have exceeded the maximum allowable limits of Sri Lankan Standards specifications (NaCl %, HB count, YM count; 12 %, 4-5 log cfu/g, 3-4 log cfu/g, respectively). The NaCl % and microbial quality vary among some production areas in SL and only the HB count and moisture % vary between Kalpitiya boat and beach dried Skipjack tuna.

Keywords: Skipjack tuna, Dried fish, Salt, Halophilic bacteria, Yeast and mold

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Development of Marinated Breaded Chicken Meat Product

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In this competitive society, convenience is a way of life which leads to develop new convenient food products. Therefore it is vital to produce ready to eat high protein food item by incorporating spices which have medicinal values with best keeping qualities. Objectives of this study were to select the best formula with appropriate garlic, pepper and salt concentrations, and to study the keeping quality, nutritive values and sensory qualities of the final product. Different levels of garlic, pepper, salt and same level of turmeric, ginger, monosodium glutamate and water were added to prepare three marinade mixtures. Treatment 1 was contained 2.5% garlic, 0.25% pepper, 0.70% salt; treatment 2 was contained 3.25% garlic, 0.30% pepper, 0.75% salt and treatment 3 was contained 3.75% garlic, 0.325% pepper, 0.80% salt. Suitable batter mixture, cooking time and temperature were found by trial and error method. pH and thiobarbituric acid reactive substances (TBARS) values of products were tested during storage period at 4°C. Sensory data were analysed by Friedman non-parametric procedure using Minitab software package. According to the sensory evaluation, treatment 1 was significantly higher ($P>0.05$) than treatment 3 for aroma, texture, garlic flavour, flavour of product and overall acceptability. There was no significant difference ($P>0.05$) between three treatments in pH and TBARS values during the storage period. pH value was decreased in all treatment with the storage period. TBARS value and microbiological counts were increased in all treatment with the storage period. There was no significant difference between three treatments for proximate values. According to the sensory evaluation, treatment 1 was the best product. Addition of garlic, salt and pepper reduced the rate of rancidity development.

Keywords: Garlic, Marinade, Breaded chicken, Rancidity

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Determination of Breed Effect on Butter Quality Characteristics: A Comparison between Thamankaduwa white vs Friesian Breeds in Sri Lanka

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The aim of the present study was to determine the possible breed effect on variation in butter quality characteristics especially in terms of textural and microstructural attributes. Thamankaduwa white breed and Friesian breed in Sri Lanka were selected and a total of 33 L of milk ($n=3$) and 51 L of milk ($n=3$) was collected from the two breeds respectively. Randomly collected bulk feed samples ($n=5$) of the two breeds were analyzed for feed fat percentage. All the milk samples were processed into salted sweet cream butter having 1% (w/w) of salt. Microstructures were observed using inverted and phase contrast microscopes. Sensory analysis was performed mainly focusing texture and cold spreadability (at 5 °C) of butter using three untrained panels ($n=40$). Hardness of butter was analyzed using a texture analyzer. Proximate compositions were analyzed and the yield efficiency data were calculated. Objective data were statistically analyzed using completely randomized design with Analysis of Covariance (ANOCOVA) and the sensory data were analyzed using Friedman non-parametric test. Findings suggest that there is a difference in terms of overall texture, cold spreadability and hardness of butter samples ($P<0.05$). The butter samples from Thamankaduwa white breed were softer and the cold spreadability was higher than the butter samples from the Friesian breed. Consumer preference on overall texture of Thamankaduwa butter samples was lower than the butter made out of Friesian breed ($P<0.05$). The microstructural studies confirmed that there were no prominent differences between microstructure of butter samples. The efficiency of production of butter from raw milk was higher in Thamankaduwa breed ($P<0.05$). Therefore the major findings uphold the conclusion that there is a significant difference especially in terms of textural attributes of butters which are produced from two different breeds, and the Thamankaduwa white breed is more efficient than Friesian breed in terms of butter production process.

Key words: Breed effect, Salted sweet cream butter, Texture, Microstructure

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Evaluation of Physicochemical, Microbiological and Sensory Attributes of Maldive Fish Prepared with Different Levels of *Garcinia cambogia* (Goraka)

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This study focused on evaluation of physicochemical, microbiological and sensory attributes of Maldive fish prepared with different levels of heat treated ripened *Garcinia cambogia*. Maldive fish were prepared with 3 different levels of *G. cambogia* (GC) as 1.25% (T1), 1.67% (T2) & 2.5% (T3) and the treatments were compared with the control sample (CS). Commercially available Maldive fish samples were collected from 5 different areas in Sri Lanka. Physicochemical quality parameters such as 2-thiobarbituric acid-reactive substances (TBARS), histamine content and myoglobin contents of all the samples were determined. The salt content of the commercial Maldive fish samples was also evaluated. Halophilic bacterial count (HB), yeast & mold (YM) counts and sensory attributes such as color, surface appearance, tenderness and flavor were evaluated. The results were statistically analyzed for Duncan's Multiple Range Test by using SAS 91.1 program. The sensory data were analyzed for Friedman Test by using Minitab 14 program. The average salt % of commercially available Maldive fish was 2.85% on dry mater basis and the salt % of all the samples were within the SLS recommendation level of <5%. The highest histamine content of 1.08 ± 0.36 mg/kg was found in commercially available Maldive fish samples. Whereas no significant ($P < 0.05$) difference was observed between T2 and T3, for TBARS and histamine contents. Significantly ($P < 0.05$) higher level of myoglobin content (1.80 ± 0.54 mg/g) was found in T3 than all other samples. The highest levels of HB (9.27 ± 4.06 log cfu/g) and YM (7.86 ± 0.58 log cfu/g) were recorded in the CS. From the sensory scores, T3 showed the highest value for the tenderness and flavor ($\alpha = 0.05$). Both T2 & T3 had the highest preference for color while T2 scored the best surface appearance ($\alpha = 0.05$). According to the results, 2.5% of GC is the best level to be incorporated in Maldive Fish preparation with the highest physicochemical, microbiological and sensory attributes.

Key words: Maldive fish, *Garcinia cambogia*, Histamine, Halophilic bacteria

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Effect of Different Cooling Methods on Body Temperature, Milk Yield and Lactometer Reading of Milk in Crossbred Buffaloes

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Lactation performance in buffalo is adversely affected by heat stress. Information is lacking on the effects of cooling on performance of buffaloes in Sri Lanka. An experiment was conducted at the National Livestock Development Board Farm, Melsiripura, during a 40-day period from September to November using 18 Murrah crossbred buffalo cows in 100-200 days lactation to assess the effect of different cooling treatments on body temperature, milk yield and lactometer reading of milk in buffalo. Buffalo cows were randomly allocated to 3 groups (n=6). One group was allowed to wallow from 1.00 p.m. to 3.00 p.m. during day time and from 1.00 a.m. to 3.00 a.m. in the night time. During the same time periods, another group was allowed to wallow in day time and kept under water sprinklers in night time, while the third group was kept under water sprinklers in day time and night time. Data on skin temperature and rectal temperature were recorded twice weekly at 12.00 noon and 4.00 p.m. from 2 animals per treatment group. Morning and evening milk yield and lactometer reading of milk of each cow were recorded daily. Rectal temperature reduced ($P < 0.05$) by $0.72^{\circ}\text{C} \pm 0.04^{\circ}\text{C}$, $0.70^{\circ}\text{C} \pm 0.04^{\circ}\text{C}$ and $0.66^{\circ}\text{C} \pm 0.03^{\circ}\text{C}$ in response to wallowing, wallowing + sprinkling and sprinkling treatments, respectively. Skin temperature reductions were not significantly ($P > 0.05$) different among treatments. Daily milk yield of the wallowing group ($5.41 \text{ L} \pm 0.13 \text{ L}$) was significantly ($P < 0.05$) higher than that of the wallowing + sprinkling group ($4.46 \text{ L} \pm 0.13 \text{ L}$) and of the sprinkling group ($4.22 \text{ L} \pm 0.09 \text{ L}$). Lactometer readings were higher ($P < 0.05$) in wallowing group (28.39 ± 0.07), than the other two groups (27.49 ± 0.07 and 27.43 ± 0.09). These results suggest that while every cooling treatment reduced body temperature and improved milk yield in buffalo, wallowing was the most effective cooling method that produced the highest improvement in lactation performance.

Keywords: Heat stress, Wallowing, Water sprinkling, Body temperature, Milk yield, Lactometer reading, Buffaloes

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Development of a Wholesome Pasteurized Lassi by Incorporation of Pomegranate (*Punica granatum*) Juice of the Most Common Local Variety (*Nimali*)

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This investigation was an effort to develop a lassi with added health benefits of antioxidants by incorporation of pomegranate (*Punica granatum*) juice. The most common local (*Nimali*) and the imported (*Wonderful*) pomegranate varieties were selected for this purpose. Pomegranate juices were added at 10%, 15% and 20% in to the lassi. According to sensory evaluation, 10% *Nimali* pomegranate juice and 20% *Wonderful* pomegranate juice added lassi were selected as the most preferred final products. Those selected products were analyzed for their physicochemical properties, storage stability and microbiological properties. Fat, crude protein, crude fiber, dry matter and pH did not show any significant difference between the two treatments. However, *wonderful* lassi had significantly higher ($P < 0.05$) ash content. On tenth day, titratable acidity of *Nimali* lassi was significantly higher ($P < 0.05$). Yeast and mold count was significantly higher ($P < 0.05$) in *Wonderful* lassi on fifth day. Both pomegranate juices and two lassi samples were subjected to High Performance Liquid Chromatography (HPLC) to determine the presence of hydrolyzable tannins (HTs) and other phenolic compounds. According to HPLC profiling, total number of phenolic compounds in 40% methanolic extracts were identified based on retention times and that of *Nimali* juice was significantly higher ($P < 0.05$) when compared to *Wonderful* juice. However, there was no significant difference between lassi samples. There is no significant difference in the concentration of most common HTs, punicalagin α and β levels in *Nimali* and *Wonderful* juices and pasteurization did not change ($P > 0.05$) their concentration. Both lassi samples did not show detectable levels of punicalagin α and β while new peaks including shorter peaks of normal juice profiles appeared. Further testing and identification of newly appeared compounds are essential before commercial scale production.

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Keywords: Lassi, Pomegranate, *Punica granatum*, Punicalagin, HPLC

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Effect of Scavenger Fish Meal (*Hypostomus plecostomus*) Included Diets on Performance of Broiler Chickens

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This study was conducted to find out the effect of diets containing Scavenger fish meal on growth performance of broiler chickens compared with local and imported fish meals. Three isonitrogenous and isocaloric diets were formulated according to the least cost diet formulation method using computer software varying in three fish meal types (scavenger fish meal, local fish meal and imported fish meal). Feeding trial was conducted in complete randomized design with 140 male Cobb broiler chicks to observe the effect of three different types of fish meals containing diets on broiler performance. The experimental diets were fed *ad libitum* to broiler chicks for 35 days. No significant differences ($P>0.05$) were observed on weight gain, feed intake, FCR (feed conversion ratio) and mortality until third week among birds in three experimental groups. After third week diets with Scavenger fish meal and local fish meal fed groups showed significantly lower ($P<0.05$) weight gain and feed intake compared with birds fed imported fish meal diet. Mortality and FCR were higher ($P<0.05$) in local fish meal and scavenger fish meal treatments compared to imported fish meal treatment. In ileal counts, diet fed with Scavenger fish meal and local fish meal groups had higher ($P<0.05$) coliform counts than diet with imported fish meal group. Moreover, coliform counts were significantly higher in Scavenger and local fish meal containing feeds than that of imported fish meal containing diet. Ileal fat digestibility and *in vitro* pepsin digestibility were lower ($P<0.05$) in Scavenger fish meal compared with imported and local fish meals. Ileal protein digestibility was not different ($P>0.05$) between three treatment groups. It can be concluded that broiler feed prepared by using Scavenger fish meal showed poor performance compared to imported fish meal.

Keywords: Fish meal, Broiler performance, Scavenger fish, *Hypostomus plecostomus*

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Effect of Different Feeding Systems on the Quality and Functional Properties of Backyard Chicken Eggs; a Case in North Western Province

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A study was conducted to determine the effect of different feeding systems on the quality and functional properties of eggs of backyard chicken reared under three different feeding systems. Normal village chicken eco-type belongs to nine selected households in Tenuwara and Tabbowa villages in Puttalam district was used for the study. Nutritional analyses of different feed ingredients of each feeding system were carried out. Different feeding systems included green materials and scavenged feed (GMS), scavenged feed only (S) and commercial feed and scavenged feed (CS). A total 81 eggs were evaluated for haugh unit, yolk index, albumin index, shape index, depth of air cell, gel strength and foaming stability. Twenty seven eggs collected from each feeding system were taken for keeping quality measurements at weeks 0, 1, 2, 3 and 4. Eggs from a commercial strain (Shaver brown) were also analyzed for egg quality parameters for comparison. Egg weights were significantly different ($P<0.05$) among feeding systems. Shape index of GMS feeding system (0.88 ± 0.01) was significantly high ($P<0.05$) compared to other two systems. Haugh unit, gel strength, foam stability, yolk colour values of village chicken eggs were significantly high ($P<0.05$) compared to those of commercial strain. Gel strength of GMS feeding system was significantly higher ($P<0.05$) than that of eggs from other two feeding systems during storage. The Haugh unit and yolk index declined with storage in both village and commercial eggs while commercial egg showed a drastic decline during storage compared to village chicken. Gel strength of village chicken eggs increased in increasing rate compared to commercial chicken during storage. Accordingly, there is an influence of feeding system on quality and functional properties of village chicken eggs which has better storage ability than commercial eggs.

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Keywords: Egg parameters, Backyard chicken, Feed compositions

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Substitution of Artificial Colourings in Value Added Dairy Products

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The artificial colourings used in the common value added dairy products were substituted with natural colourings with an aim of desired health attributes. Two natural colourings (Em- Seal Carotene_OF1071 and Carmine extract_OF0063) were selected for substituting of the commonly use artificial colouring (Egg yellow, Porceau 4R- E 124 and Carmoisine- E122) of value added dairy products (Yoghurt, Vanilla flavoured sterilized milk, Vanilla flavoured Ice- cream and Strawberry flavoured Ice- cream). Several batches of products were prepared with different colouring percentages. Best concentration of natural colourings for each product was selected from a sensory evaluation of 35 panellists. Physicochemical parameters such as pH, titratable acidity, colour value and microbiological parameters were analyzed during storage period according to standard methods. Dairy products substituted with natural colouring Em- Seal Carotene with percentages of 0.08, 0.023, 0.12 in vanilla flavoured yoghurt, sterilized milk and Ice- cream were respectively selected as the most preferred vanilla flavoured products. Also, Carmine extract 0.12% added strawberry flavoured Ice- cream was the best for that colouring. It is notable, that there was no significant ($P>0.05$) changes in colour value with changing physicochemical parameters of the products during processing and storage. Further there was no significant ($P>0.05$) effect on other organoleptic properties except colour of these dairy products from the natural colourings. However, it is advisable to add natural colouring before heat treatment to overcome any possible microbial contaminations in natural colourings.

Keywords: Value added dairy products, Natural colourings

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Development of a Low Cost Dairy Beverage using Buttermilk and Recombined Whey Powder (RWP) in order to Mitigate Environmental Pollution under Small and Medium Scale Local Cheese Manufacturing

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This study was carried out to develop and to determine the storage stability of a dairy beverage using buttermilk and recombined whey powder. Buttermilk and whey are the most important and abundant by-products in milk processing industry. RWP is an improved recombined product of whey and skimmed milk. Buttermilk and Recombined whey powder were utilized at the level of 83 ml and 11 g respectively, for the preparation of healthy dairy beverage and evaluated for various sensory attributes and physico-chemical properties during storage. The dairy beverage prepared from 82.25% buttermilk, 11% RWP, 6% sugar and 0.75% Mandarin juice concentrate had significantly ($P<0.05$) increased sensory attributes such as flavour, aroma, mouth feel and overall acceptability when compared with that of the dairy beverage prepared from 82.25% buttermilk, 11% milk powder, 6% sugar and 0.75% mandarin juice concentrate. Protein content was significantly ($P<0.05$) higher in RWP based beverage while it's fat content was less than 1%. A reducing trend was observed in pH and increasing trend was observed in titratable acidity during the storage of the beverage at refrigeration temperature over a period of 7 days. This beverage is most suitable for adults and athletes due to the high nutritional characteristics of buttermilk and whey.

Keywords: Dairy beverage, Buttermilk, Recombined whey powder

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Quality Attributes of Table Chicken Eggs in Retailer and Supermarkets in Sri Lanka

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The main purpose of this study was to assess the quality attributes of table chicken eggs available in retailer and supermarkets in Sri Lanka. Total of 125 eggs from retailer markets and 120 eggs (medium size) from 4 different supermarket brands were collected to assess the internal, external and functional qualities of the eggs. The eggs from different supermarket brands showed a significant difference ($P < 0.05$) in egg weight, and yolk colour. Whereas no difference ($P < 0.05$) was found among other quality attributes. The average egg weight, shell strength, shell thickness, air cell depth, yolk colour (Roche colour value), shape index, yolk index, Haugh Unit (HU), foaming stability and gel strength of retailer market eggs were 57 ± 0.52 g, 33 ± 0.00 N, 0.15 ± 0.01 mm, 7 ± 0.18 mm, 5, $72 \pm 0.01\%$, 0.32 ± 0.00 , 51 ± 1.69 , $79 \pm 5.10\%$ and 10 ± 1.19 N respectively. The average values of the supermarket eggs for the above mentioned characteristics were 56 ± 0.57 g, 37 ± 1.14 N, 0.15 ± 0.01 mm, 6 ± 0.19 mm, 9, $74 \pm 0.01\%$, 0.34 ± 0.01 , 55 ± 1.55 , $76 \pm 5.22\%$ and 13 ± 1.33 N respectively. Sixty eight percent of the retailer market eggs had desirable shape index. Only 13% of retailer market eggs and 13% of supermarket eggs had desirable HU values according to SLSI specifications for the chicken eggs 959:1992. Moreover based on SLSI egg weight grade classes most of the eggs (54%) in the retailer market were belonged to large grade class and, 28%, 14% & 4% of eggs belonged to the extra-large, medium and small grades respectively. Based on the results of this study it can be concluded that, only low proportions of eggs available in retailer markets (13% based on HU, 4% based on air cell depth) and supermarkets (13% based on HU, 12% based on air cell depth) in Sri Lanka are within the desirable range according to the SLSI specifications.

Keywords: Table chicken eggs, Egg quality, Retailer market, Supermarket, Sri Lanka

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Welfare and Meat Quality of Broiler Chickens during Transportation: Effects of Transport Distance and Location within the Truck

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This study was conducted to evaluate the effect of transportation distance and location within the truck during transportation of broiler chickens (Age, 32-40 days). A standard commercial broiler transport trailer was used in the study. The birds were transported under 3 different distances: short (14 km–21 km), medium (30 km–42 km) and long (59 km–64 km). Nine locations within the trailer were evaluated for each distance: front (top, center and bottom), middle (top, center and bottom) and rear (top, center and bottom). Birds were starved 10 h before transportation and at the end of the journey, severity of panting as an indicator of stress imposed during transportation was evaluated. Bruises in the carcass (wingtip, wing, back, thigh and drumstick) and ultimate pH (24 h following slaughter) and meat drip loss (24 h following slaughter) were studied. The severity of panting behaviour after the end of the journey was increased ($P < 0.05$) with the increasing transportation distance. There was no difference ($P > 0.05$) in panting behaviour within the locations of the trailer. Bruises in the wing tip were significantly ($P < 0.05$) lower in the short compared with medium and long journeys, where as in the back it was significantly ($P < 0.05$) higher for long journeys. Locations of birds within the trailer did not significantly affect ($P > 0.05$) carcass bruises. Ultimate pH was significantly higher ($P < 0.05$) for the short distance compared with long and medium distance transportation. However, the ultimate pH values in all three distances were within the acceptable level. Meat drip loss values were significantly higher ($P < 0.05$) for medium distance group compared with long and short distance transportation. No difference in ultimate pH and the drip loss were found among the locations within the trailer. In conclusion, meat and carcass quality of broiler chickens were affected by the transportation distance and the location within the trailer had no effect.

Keywords: Broiler chicken, Stress behavior, Transport distance, Location within the truck, Carcass and meat quality

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Nitrogen Absorption and Utilization Efficiency of Selected Lowland Rice (*Oryza sativa* L.) Varieties Differing in Their Response to Soil Nitrogen Availability

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Nitrogen (N) is the nutrient most limiting the productivity of rice and contributes substantially to its cost of production. This study was conducted to identify rice varieties that perform better under low-N availability. Furthermore, the diversity of N absorption and utilization efficiencies was examined to elucidate their role in determining the N response of lowland rice. Eleven (Bg250, Bg300, Bg357, Bg358, Bg359, Bg369, At354, Bg403, Bg379-2, BG90-2, *Kaluheenati*) rice varieties were grown in 12 L pots in lowland conditions on an inherently low N soil under three N application rates (recommended rate at 140 kg N ha⁻¹; 50% and 150% of the recommended) in a randomized complete block design in a rain sheltered planthouse. Plants were harvested at elongation stage. Response of different varieties to N was examined by establishing relationships between absolute growth rate (AGR, total dry weight increase per unit time) and N rate. Significant quadratic relationships ($P < 0.0001$) were observed between AGR and N for selected varieties. Nitrogen responsiveness, defined as the slope of the relationship between AGR and N at 140 kg N ha⁻¹, was used to identify varieties with minimum growth reduction when N rate decreases below the recommended. Accordingly, *Kaluheenati* and Bg357 were identified as suitable varieties to be grown under lower N rates as they showed minimum growth reductions while maintaining higher AGRs. The higher AGR of *Kaluheenati* was due to its higher N-absorption efficiency in terms of N absorption per unit root dry weight (NAE_{RDW}) and per unit root length (NAE_{RL}). However, its N-use efficiency (NUE, biomass per unit N uptake) was relatively lower. In contrast, the higher AGR of Bg357 was due to its higher NUE and intermediate NAE_{RDW}. Bg300 can be recommended for high N conditions as it showed the highest N responsiveness combined with higher AGR due to high NUE.

Keywords: Absorption efficiency, Nitrogen response, Rice, Utilization efficiency, Varietal variation

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Evaluation of the Impact of Different Organic Fertilizers on Effective Growth of *Centella asiatica* (Gotukola)

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Cultivation of *Centella asiatica* is often associated with contamination through runoff water, bacteria, chemical fertilizer and heavy metals. Therefore introducing the appropriate method and organic fertilizer recommendation for cultivation of *Centella asiatica* is essential. The experiment was conducted at University Experimental Station in *Dodangolla* during September to November, 2014. Plants with small leaves (*Wel Gotukola*) were planted on the herbal mats which were 1.5m long and 1 m wide. Then growing media of top soil, coir dust and sand was added up to 5 cm. 54 plantlets were planted per plot at 15 cm × 15 cm spacing. CRD was used as the experimental design with 3 replicates. 0.1% Albert solution, 10% Vermiwash, 10% Gliricidia leaves extract, 10% Wild sunflower leaves extract, 5% Jeevamrutha, 1% Cow urine and 0.2% HERBAGREEN was used as treatment 1, 2, 3, 4, 5, 6 and 7, respectively. All treatments were foliar fertilizers. Plots without application of fertilizer were used as control. Treatments were applied in two weeks intervals and data were collected in one week intervals. Yield was obtained 60 days. Data were analyzed using ANOVA procedure. Significant means of treatments were separated using the Duncan's Multiple Range Test (DMRT). The plants treated with Gliricidia leaf extract showed the highest yield which is 15% more than the yield of Albert solution treated plots. Least incidence of pest and disease was recorded in HERBAGREEN applied plots. Highest nitrogen content of leaves was obtained by Albert solution followed by Gliricidia leaf extract. Highest phosphorus content was recorded in Wild sunflower leaf extract whereas highest potassium content was recorded in HERBAGREEN applied plots. Carbon and Organic matter content in the growing media had been increased in Jeevamrutha treated plots followed by Albert solution and HERBAGREEN. The results indicate the role and importance of liquid organic foliar fertilizer in leafy vegetable production.

This work was founded by the Agro Lanka Organic Solution Company (PVT) Ltd.

Keywords: *Centella asiatica*, Gliricidia leaves extract, Organic fertilizers

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Impact of Elicitors in Inducing Defence Against Pests: A Comparative Analysis between Tea (*Camellia sinensis* (L.) O. Kuntzu) and Tomato (*Solanum lycopersicum* L.)

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Enriching host plant resistance using elicitors that addresses environmental concerns can be an effective pest control strategy. Therefore, the overall objective of this study was to induce natural chemical pest resistance ability in tea and tomato plants through application of some selected elicitors, and determine the changes in the tea and tomato plants following the application. Tea cultivars TRI 2025 and TRI 2024, and tomato (*Solanum lycopersicum* L., variety Thilina) was used for this study. There were five treatments, i.e. salicylic acid (SA), methyl salicylate (MS), benzoic acid (BA), neem seed extract (NSE) and distilled water (DW, control). These solutions of 100ppm concentration at 350ml for 30 plants were applied at an interval of 7 days for 3 months. Chemical parameters of tea leaves were measured two times, 30 and 45 days after treatment application, and for tomato at 30 days. Leaf total amino acid (TAA), total polyphenol (TPP) and total sugar contents were measured as biochemical parameters in tomato and tea separately. Plant height and total number of leaves were measured in both species, each week. In addition, number of active and banji shoots was measured in tea. The results showed that there were significant ($P < 0.05$) increments in TAA and TPP contents between elicitor applications. These increments were significantly ($P < 0.05$) largest with SA application, followed by MS and BA, which were significantly ($P < 0.05$) larger than that of NSE and control, in both species. There were no significant ($P > 0.05$) differences in growth parameters between treatments. The interaction between the cultivar and elicitor also was not significant ($P > 0.05$). These results conclude that elicitors do not affect to the growth parameters of both tea and tomato. TAA and TPP directly affect pest resistance of plants. Hence, elicitors in crop protection and pest management can be used as a new control strategy, as an environmentally friendly approach.

Key words: Amino acid, Elicitors, Induced plant defense, Pest resistance, Polyphenol

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Screening of Tomato (*Lycopersicon esculentum* Mill.) and Chilli (*Capsicum annuum* L.) Varieties for Heat Tolerance

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Long term climate change will increase future global temperatures. This study was conducted to identify varieties that perform well under increased temperature. Seven varieties of chilli and 17 varieties of tomato were screened under ambient (AMB) and elevated (ELEV) air temperatures created in ventilated field open top chambers (OTCs). Air temperatures within elevated OTCs were 4.8–5.6°C higher than in ambient OTCs, which were warmer by 2.9–4.3°C than the open field. In tomato, the variety x temperature regime interaction effect ($V \times T$) was significant ($P < 0.05$) on net photosynthetic rate (P_n) and transpiration efficiency (T_E), combined flower and fruit numbers (N_F) and fruit yield (Y). $V \times T$ effect was not significant on total vegetative dry weight (W_{veg}) and leaf area (LA). At both temperature regimes, significant ($P < 0.05$) varietal variation was observed in all measured variables. A majority of the 17 tested varieties showed increased W_{veg} and LA , T_E and N_F in ELEV than in AMB. In contrast, P_n and Y increased in only 3 and 4 varieties respectively under ELEV. In chilli, significant varietal variation was observed in all measured characters except W_{veg} and LA . ELEV increased W_{veg} , LA and Y and decreased N_F , P_n and T_E in the majority of chilli varieties tested. Based on total fruit yield in ELEV, the tomato varieties *Bhathiya*, *Ravi* and *Tharindu* were identified as relatively tolerant to high temperature. Based on total pod yield in ELEV and the relative pod yield (i.e. ratio between pod yield in ELEV and AMB), the chilli varieties, *MI-2*, *Galkiriyagama Selection* and *MI Varaniaya* were identified as heat tolerant. Based on Principal Component Analysis, W_{veg} , LA and P_n at ELEV in chilli and relative W_{veg} , relative N_F and relative Y in tomato were identified as characters that can be used for identification of heat tolerant germplasm.

Key words: Tomato, Chilli, Elevated temperature, Heat tolerance, Varietal variation

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Influence of Supplementary Illumination for Greenhouse Gherkins to Reduce the Pre-Mature Fruit Drop and to Increase Fruit Yield

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Gherkin (*Cucumis sativus*) is a popular commercial “cash crop”, recently introduced to greenhouse vegetable sub sector in Sri Lanka. The industry experiences a problem of greater pre-mature fruit drop, resulting lower crop production, hence this research was undertaken to investigate the influence of supplementary illumination for greenhouse gherkins to reduce the pre-mature fruit drop and to increase Grade-1 fruit yield. This study was conducted at a commercial production greenhouse in the Low Country Wet Zone during September to November, 2014 (*Maha* season). Four treatments were applied 3 weeks after sowing (WAS); T₁ (supplementary lighting to extend day length during 5.00 - 7.00 a.m. and 5.00 - 7.00 p.m. using LEDs (light-emitting diode), T₂ (supplementary lighting under rainy/cloudy weather in between 7.00 a.m. and 5.00 p.m.), T₃ (supplementary lighting to extend day length during 5.00 - 7.00 a.m. and 5.00 - 7.00 p.m. using combination of fluorescent lamps and incandescent lamps at the ratio of 2:1) and T₄ (without supplementary lighting). The research was laid out as a Complete Randomized Design (CRD) with three replicates, assigning 20 plants per each experimental plot. Results revealed that fruit drop in T₁ (109 fruits/plant), T₂ (105 fruits/plant) and T₃ (111 fruits/plant) has significantly reduced through supplementary lighting when compared to the control (159 fruits/plant). However, no significant differences were observed among the supplementary lighting treatments related to fruit drop. Grade-1 fruit yield was significantly ($P \leq 0.05$) greater in T₂ (885.3 g/plant) as a result of increased overall fruit yield (993.3 g/plant) and reduced fruit drop, compared to that of T₁ (747.5 g/plant) and T₃ (709.4 g/plant). Given T₂ was more cost effective than T₁, I conclude T₂ as the most appropriate solution to address the pre-mature fruit drop as well as to increase Grade-1 fruit yield of greenhouse gherkin cultivation in the low country wet zone of Sri Lanka.

Key words: Fruit drop, Gherkin, Grade-1 yield, Greenhouse, Supplementary lighting

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Variability of Seed Imbibition Rates of Maize (*Zea mays* L.), Bean (*Phaseolus vulgaris* L.), and Okra (*Abelmoschus esculentus* L.) as Influenced by the Water Quality

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A study was carried out to investigate the variability of seed imbibition rates of maize (*Zea mays* L.), beans (*Phaseolus vulgaris* L.), and okra (*Abelmoschus esculentus* L.) as influenced by the water quality. Specific varieties were tested in the experiment: Beans - 'Sanjaya', Maize - Rambo and Okra - Haritha. Water absorption/uptake rates of Bean, Maize and Okra seeds during imbibition with three qualities of water (Tap water, Distilled water and Physically Structure Altered Water) were determined at 2-hour intervals until constant weight was achieved. At each sampling time, the seed dry weight and the germination percentage was determined. Initial and final (after 24 hours of soaking) Electrical conductivity (EC) and pH in the solution were also measured in all three treatments. Data were analyzed using SAS statistical package, Paired t-test was performed for each treatment. Significant differences were not found ($P > 0.05$) among three water treatments in terms of water absorption rate over the imbibition time. Increase of dry weight showed the similar pattern across the treatments throughout the experiment. Two hours soaking time was not enough to germinate Beans and Okra while Maize needed more than 12 hours soaking time to germinate. Solution pH was significantly decreased over the time whereas, EC was increased ($P < 0.05$). Releasing of CO_2 as a result of respiration is the main reason for the decrease of pH. During the water uptake process, cell membrane permeability increased. Due to that reason, different kinds of solutes leach out from the seed to medium, such as sugars, ions, proteins, amino acids and organic acids, resulting in an increased EC in the solution. Even though there were variations among species, the water quality did not have any influence on the imbibition rate, hence the germination.

Keywords: Imbibition, Tap water, Distilled water, Physically structure altered water

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Glycerin Preservation and Flower Drying to Enhance the Keeping Quality and Exactness of Different Textured Flowers

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Flowers are perishable in nature thus very difficult to store for long period of time. Therefore flower preservation has been introduced. There are many problems related to flower drying because drying change natural color and texture, the shape and exactness in particular. In the present experiment, three differently textured flowers were evaluated by using glycerin with microwave drying to minimize the color and textural changes. The used flowers were *Anthurium andrianum*, *Bougainvillea glabra* and *Gerbera hybrida*. Treated Glycerin concentrations were 1, 3 and 5% with red color food dye. Flowers were treated with combined solutions for Three days and finally microwave-dried for three minutes. The results were analysed using SAS. According to the results, glycerin with dye treated flowers showed a significant difference ($P<0.05$) in their shape, exactness and color. With all three types of flowers, when treated with glycerin, petal ends were rolled and petals became more pliable and became smooth compared to water treated flowers. In high glycerin concentrations (5%), petal rolling was higher than low glycerin concentrations (1%). When microwave drying was done, flower shrinkage and color fading was observed. However, dye treated flowers were not faded remarkably. Glycerin helps increase the color absorption rate thus; dye absorption is needed to practice after dissolving in glycerin solution. When flowers are microwave-dried after glycerin treatment, the color fading and browning can be reduced due to high heat, and the reduction of effective surface area of a particular flower can also be reduced and the weight reduction can be increased. However, due to glycerin, flower brittleness is increased after microwave drying. Only glycerin treatment without microwave drying minimizes the brittleness and flowers become soft and pliable. Flowers with hidden blemishes and damages on the petals cannot be preserved by the Glycerin+dye treatment, because it causes scars on flower petals. From the tested flower types, Gerbera outperformed the other two in all the aspects investigated.

Keywords: Anthurium, Gerbera, Bougainvillea, Glycerin, Microwave drying

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Impact of Temperature Variation on Quality Parameters of Organically and Conventionally Managed Tea (*Camellia sinensis* L. O. Kuntze)

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Global Warming and the resulting climate changes will effect on physiological processes resulting crops losses in the future. The objective of the study was to assess the temperature variation on growth, and yield, and quality of made tea of organically and conventionally managed tea. Fully enclosed (40 tea bushes) to naturally raise ambient temperature and partially enclosed poly tunnels were established at the OR-CORN trial field (20 years old) with the clone DT1, St. Coombs estate, Tea Research Institute, Thalawakelle, Sri Lanka. Inside the fully enclosed tunnels, average maximum temperature raised by 3.5-4.5 °C than the ambient temperature. Fresh leaf production, leaf chlorophyll content, dry matter percentage, inter-nodal length, and active and bungi bud ratio were measured at regular intervals. Tea leaf were manufactured using the miniature manufacture unit and measured theaflavin (TF), thearubigin (TR), total polyphenols (TPP), amino-acids, total colour, brightness and caffeine as essential chemical parameters. The results revealed that TF, TR, brightness were reduced significantly ($P<0.05$) under higher temperature than ambient temperature. Reduction was comparatively higher in conventional system than organic system. TPP, amino acids, caffeine, and colour were significantly ($P<0.05$) increased under higher temperature than ambient temperature. Increment was similar in both organic and conventional system. Inter nodal length was significantly ($P<0.05$) decreased under elevated temperature. However, reduction was similar in both management systems. Therefore, quality of made tea was significantly ($P<0.05$) reduced under raised temperature in both conventionally and organically managed tea, however, the quality reduction tend to be lower in organic system than conventional system.

Keywords: Tea, Climate change, High temperature, Organic system, Conventional system, Quality parameters

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1-Methylcyclopropene (1-MCP) on the Postproduction Quality Attributes of Rooted Cuttings of *Pleomele reflexa* and *Codiaeum variegatum*, and Cut Greens of *Scindapsus aureus*

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Rooted Song of India (*Pleomele reflexa*) and Croton (*Codiaeum variegatum*) cuttings, and Pothos (*Scindapsus aureus*) cut greens are high value ornamental commodities which are regularly exported from Sri Lanka. To earn high profits, these types of commodities should be transported without quality deteriorating even though the markets are overseas. During overseas transportation, plants are subjected to accelerated ethylene, causing postproduction losses such as 'excessive leaf fall, leaf yellowing, leaf wilting and chlorophyll degradation. Thus the current study was carried out to identify effect of 1-Methylcyclopropene (1-MCP) on the quality attributes for above plant commodities. Three experiments were carried out separately. Different concentrations of 1-MCP and exposure times (0, 0.5, 1, 1.5 ppm for 12 and 24 h), (0, 1, 3 ppm for 24 h) and (0, 1, 3, 6 ppm for 20 h) were used for above three species respectively. The experiment periods for these three species were 25 d, 22 d and 12 d, respectively. First two were done for the rooted cuttings to find out the suitable concentrations and the exposure times. Chlorophyll content was not significantly different ($P>0.05$) within treatments and exposure times on Song of India. Treatment with 0.5 ppm 1-MCP for 24 hours increased the leaf retention on Song of India and 1 ppm 1-MCP for 24 hour increased the leaf retention on Croton at $P<0.05$. The third experiment was done for cut greens of Pothos. The lowest mean score of leaf yellowing was received for cut greens with a water base (12.3) and without a water base (14.3) as 3 ppm and 1-MCP treatment for 20 hours respectively. 1-MCP with 3 and 6 ppm for 20 hours with a water base did not show a significant difference ($P>0.05$) between mean scores. The lowest mean score of leaf wilting (11.3) was given for cut greens without a water base at 6 ppm 1-MCP. Weight loss percentages were not significantly different at $P>0.05$ for both types of cut greens with and without the water base. Thus it was proved that there is a positive effect of 1-MCP treatment in protecting quality attributes of rooted cuttings and cut greens. This is economically and practically viable to Sri Lankan conditions, however further experiments are needed.

Keywords: 1-MCP, Cut greens, Postproduction, Rooted cuttings

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Effect of Nano-Urea on Growth, Development, Yield and Quality Variation of Finger Millet [*Eleusine coracana* (L.) Gaertn.]

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To examine the different sources of nitrogen (N) on the growth, development, yield and the quality of finger millet, two varieties (*Rawana*, *Oshada*) were exposed to nano-urea (40% N) and urea (46% N) fertilizers. Harvested yield was milled using domestic grinder for chemical analysis. Antioxidant content of finger millet compared to rice (*Oryza sativa*), wheat (*Triticum spp.*) and maize (*Zea mays*) was evaluated. The same varieties were subjected to three fertilizer mixtures (nano-urea, urea and half urea from department recommendation) to estimate pollen viability with elevated temperature (by placing plants in a glass house). Application of nano-urea did not significantly increase plant height, number of leaves per plant, number of tillers per plant, time to 50% flowering, time to maturity, chlorophyll content, mean flag leaf blade width and length, thousand grain weight and yield compared to the Department of Agriculture recommended fertilizer level ($P>0.05$). Leaf area at vegetative stage, 50% flowering and maturity and dry matter partitioning to the plant parts were also not showed any significance ($P>0.05$). Percentage of dry matter partition for the leaves, stem and roots were increased up to flowering stage and afterwards started to decline while increasing the dry matter amount in the panicles. Pollen viability of ambient ($26\pm3^{\circ}\text{C}$) vs naturally raised temperature inside a glass house ($29\pm2^{\circ}\text{C}$) was not significantly different ($P>0.05$). Nano-fertilizer was significantly influenced in increasing the protein content of finger millet flour ($P<0.05$). Calcium and potassium contents in flour of the variety *Rawana* were higher than *Oshada* ($P<0.05$). Carbohydrate, ash, phosphorous and antioxidant content were not different between varieties ($P>0.05$). However, antioxidant content of finger millet was significantly higher than rice, wheat and corn ($P<0.05$). Hence, use of nano-urea as nitrogen fertilizer is not significantly influence the yield, however, it has improved some of the grain quality characters.

Keywords: Antioxidant, Finger millet, Nano-fertilizer, Quality difference

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Potential Application of Biofilm Bio Fertilizer, Bio Char and Nano Fertilizer for Mature and Immature Tea (*Camellia sinensis* L. O. Kuntze)

in Mid Country, Wet Zone

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Long term use of chemical fertilizers in conventional tea plantation affects soil properties adversely influencing crop productivity. In compatible combinations of biofilmed bio fertilizer (BFBF), biochar and nano fertilizer with reduced chemical fertilizer doses are alternatives in increasing yield without causing above damages. Investigations have been carried out with immature and mature fields of cultivar TRI 3014 respectively at Tea Research Institute Mid Country Center in Kandy using treatments; recommended chemical fertilizer/control (T1), BFBF + 50% control (T2), BFBF + 75% control (T3), biochar + 60% control (T4), biochar + 40% control (T5) and urea-modified nano fertilizer + recommended phosphorous and potassium levels (T6). Yield, growth parameters and soil fertility status of treatment combinations were compared with control during first three months. Mature field results revealed that the fresh leaf yield of T2, T3 and T4 were not significantly different ($P>0.05$) from control (T1). Soil cation exchange capacity of T2, T3, T4 and T5 treatments were significantly higher ($P<0.05$) than the control. Since, T2 and T4 treatment combinations were more economically viable than other potential combinations. Results of immature field showed that cumulative mean height increment of T2 and T3 were not significantly different ($P>0.05$) from control. Hence, T2 was more economically viable than T3. Mean diameter increment of the treatments were not significantly different ($P>0.05$). Soil cation exchange capacity of T2, T3, and T5 treatments were significantly higher ($P<0.05$) than control. Since, it was evident that application of BFBFs and biochar had a positive effect on soil fertility improvement. Yield and growth parameters of under some treatment combinations were not significantly different from control. Thus, it could be concluded that there is a potential of reducing conventional chemical fertilizer inputs in tea cultivation, when the BFBFs and biochar are coupled with the chemical fertilizer respectively.

Key words: Biofilmed biofertilizer, Biochar, Nano fertilizer, Soil fertility, Tea

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Effect of Seed Rhizome Weight on Growth and Yield of Ginger (*Zingiber officinale* Rose)

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Ginger (*Zingiber officinale* Rose) is a spice crop grown for its aromatic rhizomes. Rhizome size is an important characteristic of production system of ginger. The study conducted to determine the effect of weight of rhizomes on growth and yield of ginger, was conducted for four months at the Intercropping and Betel Research Station, Narammala. Five different weights of seed ginger (15 g, 25 g, 35 g, 45 g and 55 g) of variety Rangoon were planted at 25 cm × 25cm spacing. The Randomized complete block design was used with three blocks. The number of days taken for germination of rhizomes, total leaf area, total dry weight and the total fresh weight, per plant were not significantly affected ($P>0.05$) by the adopted treatments. There was a significant effect ($P<0.05$) on the number of days taken for leaf initiation of rhizomes and the lowest average number of days were 23 and in 55 g seed rhizome. Tiller number per plant was significantly affected ($P<0.05$) by the adopted treatments. The highest average tiller number per plant was 9 and was in 55 g seed rhizome. There was a significant effect of the adopted treatments on plant height. The highest average plant height was 42 cm and was in 25 g seed rhizomes. The number of leaves per plant was significantly affected ($P<0.05$) by the adopted treatments. The highest average number of leaves was 85 and in 55 g seed rhizome. There was a significant effect of adopted treatments on fresh weight and dry weight of new rhizomes per plant. The highest average fresh weight and dry weight of new rhizomes per plant was 92.03 g and 7.18 g, respectively and was in 45 g seed rhizome. There was an effect of seed rhizome weight on the growth and yield of ginger. It can be concluded that 45g seed rhizome is the best size for establish ginger.

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Keywords: Ginger, Seed rhizome weight, Yield.

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Effect of Tuber Size on Growth and Yield of Potato Variety Granola Microtubers in an Aeroponics System

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The main objective of the study was to evaluate the growth and yield of three diameter classes of micro tubers (2.5-5 mm, 5-7.5 mm and 7.5-10 mm), in comparison with mini tubers (10-15 mm) of the potato variety, Granola for the pre-basic seed potato production in the aeroponics system. Initially micro tubers and mini tubers were planted in sand trays. After 2 weeks plants were established in the aeroponics system in Completely Randomized Design (CRD). Plant growth parameters, leaf fresh and dry weight, shoot fresh and dry weight, root fresh and dry weight, shoot height, root length, number of branches per plant, number of main stolons per plant and tuber number per plant were determined once in fortnight from September to November 2014. Most of the growth parameters were not significantly different between microtuber grown plants and mini tuber grown plants. However, number of branches per plant was significantly higher in micro tuber grown plants than mini tuber grown plants. Even though the mean tuber yield per plant was slightly higher in mini tuber plants (18.17 ± 2.29) it was not significant when compare with microtuber propagated plants (17.69 ± 4.56). Overall results indicate that the growth and tuber yield of plants propagated by different microtuber sizes were not significantly different while it was not significantly different from conventional mini tubers grown plants.

Key words: Microtubers, Granola, Mini tubers, Seed potato, Aeroponics system

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Effect of Major Nutrients on the Yield, Quality and Shelf Life of the Oyster Mushroom

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A research experiment was carried out to investigate the effect of major nutrients on yield, quality and shelf life of the Oyster mushroom (*Pleurotus ostreatus*) using sawdust medium. The main ingredients using for the mushroom cultivation are rice bran, calcium carbonate, and soy bean and magnesium sulphate. Sawdust is the most popular substrate used among the Sri Lankans. The major nutrients are absorbed by the fungi from these ingredients. Growers were applied these ingredients according to the recommendation of Department of Agriculture (DOA) in the Sri Lanka. The present study was carried out to change the amount of soy bean (T1, T2, T3, and T4), Calcium carbonate (T7, T8), MOP (T5, T6), Eppawala rock phosphate (T9) in the mixture. Sawdust, spawned with *Pleurotus ostreatus* were examined for spawn running (mycelia development), pinhead formation and fruit body formation, mean yield, and biological efficiency, shelf life of packed mushroom under room (24-28°C) and at 4°C. The experiment was designed as a complete randomized design (CRD) with 10 treatments and three replicates. Results revealed that the T0 spawn produced an acceleration of spawn running, pinhead formation and fruit body formation compared to other types of ingredient mixtures (treatments). T8 (sawdust+ rice bran+ Calcium Carbonate (600 g) + soybean + Magnesium sulphate) had the highest biological efficiency. Calcium carbonate percentage was high in the T8. The result concludes that calcium carbonate can increase the yield. The best shelf life was observed in T4 treatment for 5 days at 4°C, and T6 for 3 days at room temperature.

Keywords: Oyster mushroom, Quality, Shelf life, Yield

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Effects of Increasing Soil Cadmium and Application of Biochar on the Growth and Yield of Two Rice (*Oryza sativa* L.) Varieties in Different Age Classes

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Cadmium (Cd) is increasingly found in rice soils, as an impurity coming from inorganic fertilizers and synthetic agrochemicals. This study was conducted to determine the effect of different soil Cd levels on growth and yield of rice and to determine, whether application of biochar could minimize possible adverse effects of Cd on rice. Two rice varieties (Bg250 and Bg300) were grown in 50 cm deep soil columns (15 cm diameter) under four levels of Cadmium application (0, 5, 10 and 25 mg Cd kg⁻¹ of soil) with (0.5%) and without biochar in a Randomized Complete Block Design (RCBD) with four replicates in a rain-sheltered plant house. At heading, Cd or biochar did not have any significant effect on total dry weight in both varieties. In Bg300, biochar increased post-heading net photosynthetic rate (P_n) at zero Cd, but decreased at all other Cd levels. However, in Bg250, the effect of biochar on P_n was not consistent. Despite having a significant ($P < 0.0001$) Cd effect, P_n did not show a consistent variation pattern with increasing Cd in both varieties. At ripening, biochar application reduced total vegetative dry weight (TVDW) and seed dry weight (SDDW) in Bg300, but not in Bg250. Both TVDW and SDDW showed significant linear decreasing trends with increasing Cd. TVDW decreased at a greater rate in Bg300 than in Bg250. However, SDDW of Bg250 was more sensitive to increasing Cd than in Bg300. While biochar application increased the Cd sensitivity of TVDW in Bg300, the opposite was shown in Bg250. In contrast, biochar application increased the Cd sensitivity of SDDW of both varieties. It is concluded that increasing soil Cd has a negative effect on vegetative growth and yield of rice. Application of biochar did not reduce the negative impacts of Cd, but increased the Cd sensitivity of rice.

Keywords: Soil Cadmium, Biochar; Rice, Photosynthetic rate, Seed dry weight

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Use of Chemical Growth Inhibitors for Extension of Storage-Life of Seed Ginger (*Zingiber officinale*)

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Ginger (*Zingiber officinale* Roscoe) is a traditional and contemporary natural medicine. To overcome seasonality in ginger cultivation, short dormancy period should be eliminated in seed ginger. In this study 1-Methylcyclopropene (1-MCP) was used to delay sprouting in ginger. The High Performance Liquid Chromatography (HPLC) procedure was tested for analyzing of active ingredient and the major pungent compound, [6]-gingerol. Rhizomes of 45 ± 15 g were treated in two concentration of 1-MCP 1ppm and 5ppm for 24 hours of exposure time and stored in dried paddy husks under $27 \pm 1^\circ\text{C}$ temperature and $76.5 \pm 7.5\%$ relative humidity (RH) for eight weeks. Variation of physical and chemical changes were analyzed during storage and transferred to soil by aiming test the germination. 6-Gingerol was analyzed (HPLC) by testing alternative sample preparation and mobile characteristics of the analytical procedure. 1-MCP 1ppm treatment resulted significantly high PH values ($P \leq 0.05$) throughout the storage while glucose content was as significantly ($P \leq 0.05$) higher value only in 2 weeks after storage. 1-MCP 1ppm treatment, caused to increase electrical conductivity significantly ($P \leq 0.05$) in 8 weeks after storage. 100% Germination was observed across all the treatment and a significant difference could not be observed. The tested concentrations of 1-MCP were not significantly impact on delaying sprouting of ginger rhizomes. In HPLC analysis sample preparation was done by ethanol extraction using crushed fresh ginger samples, after freeze drying at -80°C for two hours. A reversed phase C-18 column was used with a mixture of acetonitrile and water as the mobile phase at 0.4 mL min^{-1} flow rate. 6-Gingerol was detected at 282 nm wavelength.

Keywords: Ginger, 1-Methylcyclopropene, 6-Gingerol, HPLC

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Identification of Suitable Local Casing Material for White Button Mushroom (*Agaricus bisporus*) Cultivation in Sri Lanka

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Casing is the covering of spawned compost with a suitable material. The stress provided by the casing layer will stimulate the fungus to convert from vegetative growth to reproductive growth to form and develop primordia. Peat moss is considered as the best casing material for button mushroom, which is not available in Sri Lanka. At present, the casing peat is imported from Netherlands for cultivation of white button mushroom in Sri Lanka. Therefore, Sri Lankan white button mushroom industry is facing a main problem of high cost of production. The aim of this study was to reduce the cultivation cost of white button mushroom industry, by introducing a local casing material. In this study, different raw materials were selected and tested for their effect on *Agaricus bisporus* productivity. Tested raw materials were paper pulp, decomposed coir dust, decomposed compost, Sri Lankan peat and red yellow podzolic sub soil. Mean weight of harvested mushrooms per m² day, mean girth of harvested mushrooms (cm), mean number of days for initiation of primordia and cost spend per each treatment were determined. According to the results, the sub soil: decomposed coir dust (1:1) treatment had given approximately similar results to Netherland peat moss. Therefore sub soil: decomposed coir dust (1:1) treatment, can be suggested as a local alternate casing layer instead of imported Netherland peat moss.

Keywords: *Agaricus bisporus*, Casing material, Peat moss, *Primordia*

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Physico-chemical and Functional Properties of Wala and Waraka Seeds and Seed Flour (*Artocarpus heterophyllus*)

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Jackfruit is belongs to family *Moraceae* that is widely cultivated in countries such as, Asia and South East Asia. In Sri Lanka identify two major varieties, which are firm fleshed variety called Waraka and a soft fleshed variety called Wala. This research was conducted to compare physico-chemical properties, functional characteristics and proximate composition of both Waraka and Wala seed flour. Nevertheless physical properties of seeds were also compared. There was a significant difference ($P < 0.05$) between Wala and Waraka seeds in physical properties. Length, width and thickness of seeds were higher in Wala than Waraka. But Waraka seeds were more spherical than Wala seeds. There were no significant difference ($P > 0.05$) between compositional properties and functional properties between Wala and Waraka seed flour. Pasting properties of Waraka and Wala seed starch was compared by developing an alternative method to Visco-amylograph method, using coaxial Brookfield viscometer. The method was standardized by using 8% potato starch. There was no significant difference ($P > 0.05$) between gelatinization temperatures and peak viscosities of Wala starch and Waraka starch. Gelatinization temperature of both Wala and Waraka starch was 95°C. Wala showed a peak viscosity of 4.4 ± 0.46 Pa s where Waraka starch showed a peak viscosity of 3.67 ± 0.06 Pa s. Both Wala and Waraka show a pseudo-elastic behavior. Both Wala and Waraka are susceptible to the sheer force, but Wala starch is more susceptible to the sheer force than Waraka.

Key words: Physico-chemical properties, Wala, Waraka, Pasting properties, Gelatinization temperature

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Investigation of Thermal Treatments for Bottling of Tender Jackfruit (*Artocarpus heterophyllus*) Curry

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Tender jackfruit curry is an acidified low acid canned food and available in the form of canned product in the market. Canning time-temperature combinations have been designed accounting it as a low acid canned food. The aim of the project was to develop a suitable time temperature combination that is most appropriate to produce bottled tender jackfruit curries which is similar to the canned product. In the research, four different time temperature combinations were tested with two different levels of temperature 90 °C and 103 °C and two different levels of time 70 min and 90 min. Five different levels of hot filling temperatures were tested to determine the appropriate temperature. Headspace vacuum, pH of the curry and tenderness of the jackfruit cubes were measured soon after the production and throughout 7 weeks in every one week interval. According to the results 90 °C was selected as appropriate hot filling temperature and there was no influence of time-temperature combinations on pH of the curry and headspace vacuum. These bottled tender jackfruit curry was not changed with storage time according to the study. The time-temperature combination of 103 °C for 90 min was selected as the best. This combination was most appropriate to produce bottled tender jackfruit curry which is similar to the metallic canned product.

Keywords: Tender jackfruit curry, Hot filling, Time-temperature combination

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Development of Cereal and Pulse Based Yoghurt

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The study was focused on developing a modified yoghurt formula to introduce cereals and pulses to their diet in an appealing format. Ranking test for four different ratios of rice, corn, mung bean and soya bean were tested using 5 trained panelists for the flavour and texture of the yoghurt by incorporating 3% of the flour mixture. The selected flour mixture was incorporated in different percentages of 5%, 7.5% and 10% to the yoghurt with 5% mixed berry fruit puree. Hedonic and ranking tests for colour, fruity flavour, overall taste, texture and overall acceptability were conducted using 30 untrained panelists having children of 1-3 years old to select the best percentage. The probiotic culture was added as specified. The proximate composition of the yoghurt was determined. A storage study at 4 °C was conducted using two types of preservatives; potassium sorbate and *preservative culture* (*Lactobacillus rhamnosus* and *Propionibacterium freudenreichii* subsp. *Shermanii*) where growth of yeast and mold, coliform and syneresis were evaluated in each 4 days interval. After 21 days, a hedonic test was conducted to study the acceptance of the yoghurt samples in flavour, colour and texture using 5 trained panelists. Rice: Corn: Soya: Mung bean mixture at ratio of 10:5:2:3 was significantly ($P < 0.05$) preferred. All the treatments were significantly different ($P < 0.05$) for tested attributes except texture whereas yoghurt containing 5% of flour mixture was the most acceptable treatment. The contents of ash, protein, vitamin C, fibre, fat, total soluble solids, milk solid non-fat and moisture were 0.69 ± 0.5 mg, 5.98 ± 0.13 g, 0.62 ± 0.29 mg, 0.92 ± 0.09 mg, 3.17 ± 0.02 g, 26.04 ± 0.01 g, $8.21 \pm 0.04\%$, $73.96 \pm 0.01\%$ respectively. Growth of yeast and mold and coliform was absent in any of the tested time intervals and syneresis was not observed. There was no significant difference ($P > 0.05$) in the acceptance for both yoghurt samples compared to the freshly prepared yoghurt in all the attributes.

Keywords: Yoghurt, Flour mixture, Fruits, Storage study

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Methods Comparison and Method Development to Detect Sugar Adulteration in Black Tea

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Tea (*Camellia sinensis* (L.) O. kuntze) is one of the major foreign exchange earning crops in Sri Lanka. Sugar adulteration in black tea has become a significant problem in tea industry which adversely affects the reputation of "Ceylon black tea". During black tea manufacture, some of the manufacturers add sugar to withered tea leaves to improve the blackness and organoleptic properties of made tea. Standard procedure to detect sugar adulteration in black tea has yet to be established. Thus the present study has been conducted to find the applicability of the existing test methods in determination of sugars and to develop a convenient method to quantify sugar adulterations in black tea. Polyphenols are the major group of compounds which interferes with the detection of sugars in black tea. More than 99% of polyphenolic compounds present in the initial hot water extract of black tea were effectively removed by treating the tea extract with (50% w/v) neutral lead acetate followed by 9% (v/v) sulfuric acid. Black tea samples were prepared from five different tea cultivars (TRI 777, TRI 2025, TRI 3015, TRI 4052 and TRI 5000) with different levels of sugar (0g, 2.5g, 5g, 7.5g, 10g per 1kg of withered tea leaves). Internal calibration graphs for ungraded black tea were prepared for Anthrone, Phenol Sulfuric, Modified Lane and Eynone methods. All methods showed linear relationship with sugar levels. Sugar levels of unadulterated black tea samples were not consistent. Therefore to use these methods in determination of sugar adulteration in black tea, base line data has to be established for different tea grades, seasons and regions.

Key words: Black tea, Sugar adulteration, Internal calibration graphs, Polyphenols, Tea grades

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Development of Spice Incorporated Fermented Milk Beverage

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Spices are known for their appetite stimulating effect and often used as active ingredients in appetizers in which pepper, ginger, cinnamon and cumin are much popular. Ginger (*Zingiber officinale*) and Pepper (*Pepper nigrum*) play an important role in alleviating indigestion whereas cinnamon (*Cinnamomum zeylanicum* L.), is known for its anti-microbial, anti-diabetic and anti-arteriosclerotic properties. Fermented milk products have many nutritional benefits, including probiotic effects. This research was conducted to develop a fermented milk based beverage with optimal organoleptic properties by incorporating spices. According to the sensory analysis, the optimised fermented milk formulae to develop the spice incorporated milk beverage contained 0.3% gelatine, 5% sugar, 2.7% Skim Milk Powder, 92% fresh milk and 0.1% starter culture. Ginger, pepper and cinnamon were hot water extracted (54.12 °C for 6 h) and incorporated in different proportions to the above mixture to develop this beverage. The beverage consisting 61% fermented milk, 16% ginger (1×10^3 mg/ml), 3% pepper (0.5×10^3 mg/mL), and 4% cinnamon (0.25×10^3 mg/mL), received the highest preference according to the sensory evaluation. It reported 2.83% fat content, 1.75% protein content, 0.52% of titratable acidity, 17.5×10^{-3} Pa s of viscosity and 4.43 pH at 25 °C. There was a slight increase in the acidity of this beverage after 21 days of storage resulting in a decrease in pH from 4.43 to 4.03. Microbiological studies were carried out for 21 days. Total plate count and yeast and mould count were below the permitted limits and *E. coli* was absent during the 21 days storage period.

Key words: Fermented milk, Organoleptic properties, Ginger, Pepper, Cinnamon

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Effect of Varietal Differences on Processing, Cooking and Antioxidant Properties of Rice (*Oryza sativa* L.)

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This experiment was carried out to investigate the effect of varietal differences, polishing levels, parboiling and antioxidant properties of rice (*Oryza sativa* L.). The types of rice varieties that tested were CIC red basmathi improved (RBI), CIC red basmathi (RB), CIC white basmathi (WB), At 405 and Suwadel (SUW). Both parboiled and non-parboiled rough rice varieties were polished 10%, 60% and 100% polishing levels. Milling out turn, head rice yield, proximate composition and cooking characteristics were determined for the parboiled and non-parboiled rice. Total phenolic content (TPC) of non-parboiled, parboiled and cooked sample were determined using Folin-Ciocalteu method and the antioxidant capacity was examined by DPPH (2, 2-diphenyl -1-picrylhydrazyl) scavenging method. Results relived that the highest milling out turn was from At 405 and was high in all parboiled rice. Parboiling increased the both ash and crude fiber content but those were reduced significantly ($P < 0.05$) with the polishing level. According to the results, TPC was highest in RBI followed by RB. It was not significantly ($P < 0.05$) different among At 405 and Suwadel. Highest antioxidant activity was also observed in RBI. Antioxidant activity and TPC significantly ($P < 0.05$) decrease with increasing polishing level. Parboiling of rice also reduces the TPC and antioxidant activity of the rice. Cooking reduced the total phenolic content but showed high antioxidant activity.

Key words: Rice, Antioxidant, Phenolic content, Parboiling, Milling, Cooking

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Identification of Critical Control Points for a Vegetable Dehydration Plant

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Dehydrated vegetables, which constitute a basic ingredient of ready meals, have captured a good market worldwide. In Sri Lanka, instant noodles are becoming popular and industries focus on development of dehydrated vegetable sachets for these products. However, the quality and safety aspects are vital in these products considering the method of preparation and food safety management systems, such as Hazard Analysis Critical Control Point (HACCP) and ISO 22000 are applied in most production lines. This study was conducted to identify the critical control points for a vegetable dehydration plant to ensure the quality and the safety of the dehydrated vegetable products following HACCP principles. Initially, all potential hazards were identified and risk assessment matrix was used to analyze the significance of hazards. A decision tree was used to determine critical control points (CCPs). Initial washing with water added with chlorine, dehydration and metal detection processes were identified as CCPs. Regulatory specifications available in other countries and scientific scenario considering the local food processing conditions were given attention in determining critical control limits. In deciding the chlorine concentration in initial washing, 90 ppm, 70 ppm, 50 ppm, and 25 ppm free chlorine solutions were used and microbiological quality of the product was assessed by conducting total plate and *Enterobacteriaceae* counts. Based on the results, critical control limit was decided as 70 ppm and it complies with dehydrated vegetable specifications. Critical limits for dehydration and metal detection determination was done according to the regulations. The parameters of the level of dehydration of the product were 0.398 ± 0.061 water activity and 6% moisture content. Suitability of the packaging material to ensure the safety obtained through the management of CCPs was assessed by microbiological tests and moisture determinations. Swab test was conducted to evaluate the efficiency of the cleaning programs in processing plant that fall as components of the prerequisite program in having a HACCP system.

Keywords: Dehydrated vegetables, Critical control points, Critical control limits

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Effect of Postharvest Handling Operations of Palm Oil Fruits (*Elaeis guineensis*) on Quality of Crude Palm Oil

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In Sri Lanka, palm oil cultivation and processing of palm oil fruits has been operated as a commercial scale since last decade. Effect of postharvest handling operations of palm oil fruits such as transportation, temporary storage at the ramp, damages occurred during the transport and handling of fresh fruit bunches (FFB) were investigated in crude palm oil (CPO). The quality of CPO is mostly determined based on free fatty acid (FFA), moisture and impurities content. FFB of oil palm stored for 6, 12, 18 hours with different percentage of fruit damages (0%, 20%, 40% and 60%) were determined. There was a direct relationship between FFA content and storage period ($r^2 = 0.993$). There was a significant effect of fruits received by normal transportation on FFA content ($P < 0.05$). The interactive effect of oil palm fruits damage and storage period on FFA was significant ($P < 0.05$). There was a significant effect of fruit damage on FFA content of CPO ($P < 0.05$). The FFA and moisture content of CPO is positively correlated with the storage period of palm oil fruits and moisture content is negatively correlated with the damage percentage of oil palm fruit. Harvested palm oil fruits at 0 % surface damage can be stored for 57 h which comply with the quality standard (FFA $< 5\%$, moisture $< 0.3\%$ and impurities $< 0.2\%$).

Kew words: CPO, FFA, Storage period, Fruit damage, Moisture

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Comparative study of Antioxidant Properties of Selected Medicinal Plants in Sri Lanka

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The main objective of the present study was to investigate the total phenolic content (TPC), antioxidant efficacy and free radical scavenging activity of leaves of five selected medicinal plants grown in Sri Lanka, namely, *Costus speciosus*, *Adhatoda vasica*, *Acalypha indica* (L.), *Jasminum officinale* (L.), *Adenanthera pavonina*. Three different *in-vitro* models: 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging assay, ferric ion reducing antioxidant power (FRAP) assay and ABTS [2,2'-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid)] radical scavenging assay. Total phenolic content was determined using Folin Ciocalteu colourimetric method. The highest TPC was observed in *J. officinale* (17.64 ± 0.07 mg GAE/g of dry weight) while the lowest TPC was observed in *A. indica* (4.37 ± 0.03 mg GAE/g of dry weight). The lowest IC₅₀ value was shown by *J. officinale* while the highest value was shown by *A. indica*. The FRAP followed the order of *J. officinale* > *C. speciosus* > *A. vasica* > *A. pavonina* > *A. indica*. The highest ABTS radical scavenging activity was exhibited by *J. officinale* extract while the lowest was exhibited by *A. indica* extract. The antioxidant efficiency of all the samples displayed a positive correlation with TPC. The correlation (r^2) between TPC and DPPH, FRAP and ABTS were 0.658, 0.538 and 0.558, respectively. *J. officinale* showed the highest overall antioxidant property among 5 herb species studied while *A. indica* showed the lowest antioxidant activity.

Keywords: ABTS, Antioxidant activity, DPPH, FRAP, TPC

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Development of a Table Spread Using Locally Available Vegetables; Pumpkin (*Cucubita pepa*), Carrot (*Daucus carota*), and Potato (*Solanum tuberosum*).

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Table spreads made out of vegetables are currently unavailable in the Sri Lankan market. Therefore present study aims to evaluate the suitability of locally available vegetables such as Pumpkin (*Cucubita pepa*), Carrot (*Daucus carota*), and Potato (*Solanum tuberosum*) to develop a table spread incorporated with virgin coconut oil. Five table spread samples containing different oil phase:vegetable puree phase (10:90, 20:80, 30:70, 40:60, 50:50) were prepared. In vegetable puree phase ratio of Pumpkin: Carrot: Potato was 2:1:1 and each table spread sample was analyzed for its microbiological characteristics and sensory properties by 30 untrained panelists using a scale of 5 points ranking test followed by a 5 point hedonic test for the optimization of the product. Three (3) formulations with three (3) levels of spices (garlic, chili, and pepper) of the table spread were evaluated. From the first sensory evaluation three samples were selected and those were analyzed for moisture, crude fat, crude protein, crude fiber, ash and carbohydrate content, together with pH and viscosity. Based on sensory analysis data from the ranking test, sample containing oil phase: vegetable puree phase of 10: 90 (moisture 73.8%, crude fat 8.4%, crude fiber 0.1%, crude protein 0.87%, ash 3.17%, carbohydrate 14.17%, pH 4.9, and viscosity 33250) was identified as the most preferred sample while samples containing chili: pepper: garlic ratios of 1:0.5:0.25 and 0.5:1:0.25 were recognized as best samples. The results obtained from microbiological analysis showed that all formulated table spread samples without spices were of acceptable microbiological quality in comparison to the table spread samples with spices. Further development of the spread is needed in order to ensure the microbiological quality of table spreads with spices.

Key words: Table spread, Oil phase, Vegetable puree phase

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Development of Suitable Processing Conditions to Hot-Smoke Marine Fish and Determination of Physico-Chemical Properties and Sensory Qualities of Smoked Fish

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Smoked fish is a traditional method of preserving fish with improved sensory attributes in many parts of the world. Locally produced smoked fish mainly utilizes fresh water fish and is not up to the quality expected by the consumers. This study was carried out to develop suitable conditions for producing hot-smoked marine fish and to assess their sensory and physico-chemical properties. Marine fish, Indian scad (*Decapterus russelli*) was directly exposed to woodchip smoke in a fish-smoker for 2.5 h after separately dry-salting with 0, 2 and 4% (w/w) powdered salt for 2 h. Fish smoked with 4% salt pre-treatment had a significant ($P < 0.05$) preference over the other treatments tested, following a ranking sensory test with 30 untrained panelists. To improve the flavour, fresh Indian scad were separately pre-treated with two seasoning mixtures including garcinia, black pepper and salt (2:1:1 and 4:2.5:1.5 respectively) for 2 h with a ratio of 10:1, fish:seasoning mixture before smoking for 2.5 h. Paired comparison sensory study revealed that, fish pre-treated with 2:1:1 seasoning mixture had a significant ($P < 0.05$) preference over the other treatments. The fish separately pre-treated with 4% salt and 2:1:1 seasoning mixture were separately smoked with woodchip smoke and coconut husk smoke for 2.5 h. Sensory analysis carried out with a paired comparison test exhibited a significant ($P < 0.05$) preference for the fish exposed to woodchip smoke after pre-treating with either salt or the seasoning mixture. Moisture, pH and Total Volatile Basic Nitrogen (TVB-N) contents of the above 4 smoked fish samples stored at refrigerated temperature were determined weekly for 8 weeks. The pH, TVB-N and moisture content of all 4 samples increased throughout the study period from 5.4-6.0, 31-67 mg/100g fish and 42%-59% respectively regardless of the pre-treatment and the smoke source. The most preferred conditions identified for hot-smoking were employed for three different marine fish namely, Indian mackerel (*Rastrelliger kanagurta*), Japanese threadfin breams (*Nemipterus japonicus*) and Indian scad. Lipid oxidation of the stored fish was determined after 4 weeks of storage using Thiobarbituric Acid Reactive Substances (TBARS) assay and, 4% salted and exposed to woodchip smoke had a significantly ($P < 0.05$) higher lipid oxidation compared to all the other smoked fish. Total plate count of fish smoked with coconut husk smoke after 4 weeks of storage had a significantly ($P < 0.05$) lower bacterial count compared the other treatments. It can be concluded that 4% salt pre-treatment or seasoning with spices and smoking with woodchip smoke produces quality smoked fish with improved sensory characteristics.

Keywords: Hot-Smoking, Seasoning, Sensory evaluation, TVB-N

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Development of Low Cost Pet Food: a Value Addition to Biscuits Waste

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Almost all pet foods available in Sri Lankan market are imported, and are of high cost. A palatable dry pet food for adult dogs using biscuit waste incorporating other ingredients satisfying the main nutritional requirement for a lower price was developed in this study. A Basic dry adult dog food formulation was prepared by using biscuit waste, and soybean meal, rice bran, poultry offal meal, fish meal, corn flour, ascorbic acid, vitamin and mineral supplements were mixed with the basic formulation. In the formulation, energy, crude protein, and crude fat, crude fiber was balanced using the linear programming method. Soy bean meal, biscuit waste and offal meal were ground, all ingredients were mixed together, and hot water was added to the mixture to facilitate dough preparation. The dough prepared was extruded using a hand extruder and dried in an oven at 105 °C, for 4 h. Total plate count and yeast and mold count were determined in the prepared product. pH and water activity were measured for four weeks at weekly intervals. Local cross breed 10 adult dogs were selected and a palatability test was conducted for the pet food. Two-pan free choice tests were used for determining palatability. Proximate composition analysis showed that the developed pet food contained crude protein 22 %, crude fiber 7 %, crude fat 16 %, ash 4 % and energy 20515 kJ/kg. The crude protein and energy in the dry pet food were significantly higher ($P < 0.05$) than the market available pet food and it exceeded the requirements of the minimum standard of Associations of American Feed Control Officials adult dog profile. Water activity and pH value was not significantly ($P > 0.05$) changed during the 4 week time period. The Total plate count (1550 cfu/g) and yeast and mold count (590 cfu/g) of pet food were found to be at acceptable levels. The total cost of production based on raw material cost had been Rs 203.75/kg. Palatability of the new pet food was not significantly different ($P > 0.5$) when compared with the imported pet food. This study reveals the ability to utilizing biscuit waste as a raw material in palatable low cost dry pet food for adult dogs.

Key word: Biscuit waste, Proximate Analysis, Low Cost, Palatability, Dog Food

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Development of Storage Stability and Quality of Coconut Milk

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Coconut milk is a natural oil in water emulsion. Layer separation in processed coconut milk during the storage leads to reduced stability and quality of products. The demand for such product is generally low and unsatisfactory. Therefore addition of emulsifiers and stabilizers is considered as a requirement in commercial processing of coconut milk. The objective was to determine the best stabilizers and emulsifiers to prevent the layer separation of coconut milk. The relationship between mixing temperature and quantity of stabilizers with functionality of stabilizers was investigated. Mixing temperature and quantity of stabilizers were altered to obtain 9 treatment combinations. Creaming index, viscosity and optical microscopic photographs were measured at each treatment combinations. Combination of xanthan gum and guar gum, 3:2 ratio was selected as the best stabilizer combination that reduces the layer separation of coconut milk. There were significant differences ($P < 0.05$) in creaming index and viscosity in treatment combinations. The lowest value of creaming index and highest value of viscosity was obtained at 0.5 % quantity and 80 °C temperatures. Sensory evaluation was done to determine the effect of stabilizer for sensory properties of coconut milk. From the ranking test, determine the best quantity of stabilizer that retained the organoleptic characters. There were significant differences ($P < 0.05$) among treatments based on taste, appearance, texture and overall acceptability. Treatment with 0.3% stabilizer was given the least rank except for taste. The most preferred sample contained 0.3% stabilizers and 80 °C temperature.

Keywords: Coconut milk, Stabilizer, Xanthan gum, Guar gum, Stability

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Antioxidant Properties of Peptide Hydrolysates Derived from Selected Traditional Red Rice Varieties (*Oryza sativa* L.) Cultivated in Sri Lanka

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Antioxidant activity of peptide hydrolysates derived from bran and endosperm of 4 traditional red rice varieties (*Oryza sativa* L.) namely *Masuran* (M), *Goda Heenati* (GH), *Sudu Heeneti* (SH) and *Beheth Heenati* (BH) were examined. Rice bran protein hydrolysates (RBPH) and rice endosperm protein hydrolysates (REPH) were prepared using three digested techniques: hydrolyzed with Alcalase(A) only, hydrolyzed with Alcalase and Pepsin(A+P) and hydrolyzed with Alcalase, Pepsin and Pancreatin (A+P+PN). The alcalase treated protein hydrolysates were digested in simulated gastrointestinal juices using pepsin and pancreatin to simulate the process of human gastrointestinal (GI) digestion. Freeze-dried 70% ethanolic extracts of bran and endosperm of selected red rice varieties were used in this study. Antioxidant properties of selected rice varieties were evaluated using 2-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid (ABTS) radical scavenging, ferric reducing antioxidant power (FRAP), Ferrous iron chelation and oxygen radical absorbance capacity (ORAC) assays. According to mean FRAP, ORAC, ABTS and chelation capacity, the order of the antioxidant activity of 3 treatments was A+P+PN > A+P > A for both bran and endosperm extracts. For all treatments RBPH demonstrated the highest antioxidant activity than REPH. Furthermore, significant differences ($P < 0.05$) were observed among bran extract as well as endosperm extracts of selected rice varieties. In general, the order of the antioxidant activity was $M > GH > BH > SH$. The results showed that the digestion by gastrointestinal proteases enhance the antioxidant efficacy of rice protein hydrolysates that mimics physiological digestion in GI tract.

Key words: Antioxidant, Sri Lankan traditional rice, Protein hydrolysates, Rice bran and endosperm, Simulated gastrointestinal digestion

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Effect of Different Stabilizers on Melting Property of Vanilla Ice cream

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Melting is the characteristic textural property of ice cream. Stabilizer is the major ingredient used to inhibit the formation and growth of ice crystals responsible for the meltdown property. The structural defects of ice cream resulting from its higher melting rate, is one of the most common problems experienced by the Sri Lankan consumers. The objective of this study was to optimize the meltdown and textural properties of vanilla ice cream by using different stabilizers. Both higher and lower melting rates can lead to structural defects of ice cream. In this research study xanthan gum, guar gum, Carboxy Methyl Cellulose (CMC), carrageenan and gelatin were used in different amounts individually and in different combinations. Sensory properties and physical characteristics, such as hardness, viscosity and fat agglomeration were assessed. Ice cream made of the stabilizer mix (0.34%) with 25% xanthan gum, 59% guar gum and 12% CMC, received the highest overall preference in the sensory evaluation which formed creamy drips and had a smooth melting surface similar to that of the reference sample containing the commercial stabilizer. This stabilizer mix resulted in less melting percentage ($1.08 \pm 0.11\% / \text{min}$) compared to the reference sample ($2.16 \pm <0.01\% / \text{min}$). The ice cream sample with least melting rate had the highest viscosity 5.766 Pa s, and fat agglomeration. The sample which had the highest melting rate, which was lower than the reference sample, had the least viscosity 2.698 Pa s and fat agglomeration. However, the reference sample resulted in highest melting rate, but medium fat agglomeration and viscosity 3.266 Pa s. There was no significant relationship between hardness and melting rate. Using different stabilizers in the form of blends, resulted in better quality ice cream which is economically viable than the commercial sample.

Key words: Meltdown behaviour, Fat agglomeration, Stabilizer, Ice cream

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Investigation of Formaldehyde Content in Selected Fish Species from Fish Markets of Kandy and Kegalle Districts by Using Modified AOAC 931.08 Method

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Fish is the principle source of protein which provides some of the basic nutritional needs for many Sri Lankans. A growing body of evidences reveals that some of the fresh fish available in Sri Lankan markets are deliberately added with unpermitted chemical, formaldehyde (FA) to extend their shelf-life. Present study was carried out to determine the natural FA content in selected fish species and to confirm whether the fish collected from selected market places are added with FA. Formaldehyde not added, reliable samples of four different fish species, namely herring, (HR), sail fish (SF), bigreef fin squid (BF) and shark (SK), collected from Negambo fish market were analyzed for natural FA content using modified AOAC 931.08 method. In addition, fish samples from different wet markets in Kandy and Kegalle districts, where fish is suspected for added FA were analyzed for total FA content. Fresh fish samples extracted with an aqueous distillation process were evaluated for their absorption at 412 nm to determine FA. Detection limits of standard FA solution and the samples were 21.7 µg/L and 108.4 µg/L respectively with a recovery of 84.9%. Average natural FA content detected in SF, BF and SK were 255.2±0.06, 435.7±0.06 and 3357±0.55 µg/kg respectively and FA was not detected in HR. It was also found that the FA contents of samples collected from Kandy and Kegalle markets, were 261.8±0.05, 488.6±0.08 and 3572.5±0.45 µg/kg for SF, BF and SK and not detected for HR. There was no significant ($P>0.05$) difference for FA content among fish samples analyzed from different wet markets in Kandy and Kegalle districts. The low concentration of FA detected in fish from Kandy and Kegalle districts can be due to natural accumulation in tissues after death. This study confirmed that FA content in all studied fish samples from Kandy and Kegalle markets were far below the safe limit (5 mg/kg) identified by Sri Lankan Food Act No. 26 of 1980.

Keywords: Formaldehyde (FA), Spectrophotometry, Distillation

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Antioxidant Properties of Selected Sri Lankan Traditional Rice (*Oryza sativa* L.) Varieties

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The present study was carried out to determine the antioxidant activity of eight traditional rice varieties cultivated in Sri Lanka. Traditional rice varieties namely Suwandel, Kahamala, Kahawanu, Madathavalu, Kuruluthuda, Pachchaperumal, Beheth heenati and Vedha heenati were collected from a local farm. They were ground and sieved to 200 μ m mesh and extracted using water and 80% methanol. The extracts were freeze dried and taken for the analysis. The extracts were analyzed for Total Phenolic Content (TPC) using Folin-Ciocalteu method, 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity, Ferric ion reducing antioxidant power (FRAP) and 2,2'-Azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) radical scavenging activity. The results revealed that there are significant differences ($P < 0.05$) in TPC, DPPH radical scavenging activity, FRAP and ABTS radical scavenging activity for the water extraction and the methanol extraction. Mean TPC contents were in the range of 1.119967 ± 0.016196 - 3.506482 ± 0.02915 mg gallic acid equivalents per g for the water extracts and 4.745546 ± 1.010569 - 34.61134 ± 1.269688 mg gallic acid equivalents per g for the methanol extracts. The mean percentage inhibition values for DPPH were in the range of 13.91 ± 2.13 - 30.08 ± 5.85 % for the water extracts and 14.47 ± 4.52 - 85.71 ± 2.66 % for the methanol extracts. Mean values of FRAP were in the range of 429.43 ± 89.18 - 968.97 ± 79.28 mM FeSO_4 per g for the water extracts and 1430.32 ± 110.10 - 4339.90 ± 103.81 mM FeSO_4 per g for the methanol extracts. The mean ABTS values were obtained in the range of 0.0242 ± 0.0012 - 0.0317 ± 0.0003 mg gallic acid per ml for the water extracts and 0.0223 ± 0.0006 - 0.0352 ± 0.00003 mg gallic acid per ml for the methanol extracts. Among all the varieties analyzed, red rice varieties had higher antioxidant activity compared to white rice varieties.

Keywords: Traditional rice, Antioxidants, Antioxidant assays

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Quality Improvement in Virgin Coconut Oil Process

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High moisture content (MC), free fatty acid (FFA), unacceptable colour and clarity of oil are main quality concerns in virgin coconut oil (VCO). Experiments were conducted to minimize above quality defects in VCO during industrial operation. Grated coconut kernel (GCK) was dried in a cross flow air convection drier and VCO is yielded by expelling dried GCK. Composite samples of GCK were drawn at initially and one hour intervals for 5 hours of drying from top, middle and bottom layers of the drier. Air inlet temperature was 60°C. Moisture fluctuation and colour deviation of GCK during drying were investigated. Fluctuation of moisture and FFA in crude VCO in the settling tank were tested at 4, 14, 24, 34 and 44 cm height from the bottom of the settling tank. A new filtration method was developed by modifying the existing centrifugation method where crude oil mixed with water 1:1 ratio prior to centrifuge. The samples of VCO yielded from the modified filtration method were tested on MC, FFA, viscosity and haziness (absorption at 280 nm). Moisture and colour deviation during drying was not significantly different in batch wise investigation. MC of dried GCK on top, middle and bottom layers of the drier reached 4% at 4 h & 48 min, 3 h & 24 min and 4 h, respectively. By the end of 5th hour, L-value decreased from 64.69±2.45 to 50.68±1.02 in middle layer and from 65.20±2.54 to 55.92±1.36 in the bottom layer, denoting decreased whiteness and b-value increased from 1.81±0.74 to 4.24±0.97 in middle layer and from 1.91±0.64 to 5.76±0.51 in bottom layer, denoting increased yellowness. Based on MC and FFA determinations in the settling tank, 22 cm height from the bottom was the optimum height to draw the crude VCO oil. There was no significant difference ($P<0.05$) in filtered VCO obtained by the modified filtration method in terms of MC, FFA and viscosity values measured. Improvement of clarity of VCO was observed in modified filtered method.

Keywords: Free fatty acid, Moisture fluctuation, Virgin coconut oil

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Assessing the Probiotic Effect of Buffalo Milk Curd

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Curd is one of the most commonly consumed fermented milk products of Sri Lanka. This research was performed with the objective to identify probiotic *Lactobacillus* spp. present in curd and to determine whether the minimum level of probiotics as specified by the International Dairy Federation ($>10^7$ cfu/g) is achieved. Isolation of probiotic *Lactobacilli* was carried out by using de Man Rogosa and Sharpe agar (MRS). Commercially available pure cultures of *Lactobacillus acidophilus* (LA-5), *Lactobacillus bulgaricus* (YC-X11) and *Lactobacillus casei* (431) were used to compare the colony morphologies. However, *Lactobacillus casei* was not identified. There was a gradual decrease in colony count with time. *Lactobacillus acidophilus* count was higher than the minimum required level during the 12 days of shelf life. According to the statistical analysis ($P<0.05$), there was a significant difference between the mean count of the *Lactobacilli* spp. and its required minimum level. Following 6th day of storage, the count of *L. bulgaricus* decreased below the minimum level. Each of the curd samples showed a gradual decrease in pH from 4.24 to 3.83, throughout the storage period. Low pH tolerance of identified *Lactobacillus* spp was checked by adjusting the pH of the curd from 4.24 to 3, 2.5 and 1.5, respectively. *L. acidophilus* showed good survival ability in low pH range (1.5 – 4.24). *L. bulgaricus* grew when the pH was 3 and 4 and a significant increase in growth was observed, respectively. *L. acidophilus* showed bile salt tolerance at 0.15% and 0.3% bile salt concentrations. According to these results, it can be concluded that *L. bulgaricus* has drawbacks as a probiotic bacteria whereas the presence of *L. acidophilus* in curd showed excellent probiotic activity under low pH and bile salt concentration.

Key words: Probiotic, *Lactobacillus* species, pH, Bile salt, Curd

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A Study on the Changes of Water Quality Parameters of Bottled Drinking Water upon Storage under Different Lighting Conditions

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Bottled drinking water is a popular beverage all over the world due to its convenience, availability, safety and aesthetic qualities. The study was carried out to determine whether 3 brands of bottled drinking water available in Sri Lankan market comply with SLS 894: Specifications for bottled drinking water, throughout its shelf life. Three brands (A, B, C) were studied under 3 different storage light conditions namely ambient light, dark light condition and sunlight condition. From each brand, 9 bottles comprised of 3 bottles from each storage condition, were analyzed monthly for aerobic plate count (APC), electrical conductivity (EC), pH, total dissolved solids (TDS) and heavy metals (Cd, As and Hg). Brand A showed a significantly lower ($P < 0.05$) than the standard limit (100 cfu/1mL) while brand B and brand C were significantly higher ($P < 0.05$) than the standard limit. The average value of pH of all three brands were not significantly different ($P < 0.05$) and they were always between the standard limits (5-8.5). The average values of EC of all three brands were significantly lower ($P < 0.05$) compared to standard limit (750 μ S/cm). The average values of TDS of all three brands were significantly lower ($P < 0.05$) compared to standard limit (1000 mg/L). All three brands were negative for As and Hg. Brand B contained 0.001mg/L of Cd, but it was lower than the maximum permissible limit of SLS 894 (0.003 mg/L). Algae identification was done by visually observing and microscopic observation. Brand B kept under sunlight condition contained *Microcystis kutzing* and *Chroococcus naegeli*.

Keywords: Aerobic plate count, Algae, Bottled drinking water, Electrical conductivity, Total dissolved solids

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Antioxidant Properties of Palmyrah (*Borassus flabellifer* L.) Fruit Pulp and Effect of Heat Treatment on Bitterness

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Sri Lanka is well-known for its palmyrah (*Borassus flabellifer* L.) plantations which are densely available in the northern part of Sri Lanka. Though palmyrah has the future potential for industrial applications, it is considered as an underutilized crop mainly due to the bitterness of the fruit pulp, which suspends its extensive use in industrial applications. The principle component responsible for the bitterness of palmyrah fruit pulp is a steroidal saponin called flabelliferin II. Specimens from the two morphological types, type III and type IV were selected for this study. Palmyrah pulp samples were subjected to heat treatment at 60 °C, 80 °C and 100 °C for 1 h and evaluated for the level of bitterness. Extraction with organic solvents followed by spectrophotometric analysis was used to quantify the total carotenoid content, total polyphenolic (TPP) content and total antioxidant activity. Sensory evaluation showed that there was a significant difference ($P < 0.05$) between the samples treated at different temperatures and the control based on bitterness. Total carotenoid contents were relatively low in both type IV (34.99 mg/ 100 g dry weight (dw)) and type III (30.23 mg/100g dw). Heat treatment and total carotenoid contents had an inverse relationship. The TPP content of type IV and III were 137.4 mg gallic acid equivalent (GAE)/ 100 g dw and 124.65 mg GAE/100g dw, respectively. According to DPPH (1,1-diphenyl-2-picryl-hydrazyl) assay, antioxidant activity of pulp, expressed as IC₅₀, was 0.85 mg/ml for type IV, and 0.82 mg/ml for type III. Palmyrah pulp heat treated at 80 °C showed significantly reduced bitterness.

Keywords: Palmyrah palm, Flabelliferins, Bitterness, Antioxidant activity, Phenolic compounds, Carotenoids

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Total Phenolic Content and Antioxidant Efficacy of Selected Herbs Grown in Sri Lanka

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In this study, methanolic extracts of five herbal plants namely, *Aegle marmelos* (Beli), *Vitex negundo* (Nika), *Asparagus falcatus* (Hathawariya), *Abrus precatorius* (Olinda) and *Azadirachta indica* (Neem) were evaluated for their Total Phenolic Content (TPC) and antioxidant activities. Total phenolic content was determined using Folin Ciocalteu (FC) assay while the antioxidant efficacy was determined using 2, 2-diphenyl-1-picrylhydrazyl (DPPH), Ferric Reducing Antioxidant Power (FRAP) and Total Antioxidant Capacity (TAC) assays. Total phenolic content of herbal samples ranged between 2.27 ± 0.14 and 19.41 ± 1.08 gallic acid equivalents per g dry weight. The highest phenolic content was observed in *Vitex negundo* while the lowest TPC was observed in *Asparagus falcatus*. The IC_{50} values of herbal samples ranged from 0.08 ± 0.007 and 1.39 ± 0.08 mg/ml. *Aegle marmelos* showed the highest DPPH radical scavenging activity while *Vitex negundo* showed the lowest. Total antioxidant capacity of herbal species tested showed the following order; *V. negundo* > *A. marmelos* > *A. indica* > *A. precatorius*, *A. falcatus*. The FRAP of herbal samples tested ranged from 122.5 ± 4.95 to 2971 ± 3.33 (Fe (II) μ mol/g of dry weight with the highest antioxidant activity observed in *V. negundo* and the lowest observed in *A. indica* and *A. falcatus*. Total phenolic content and the antioxidant activity of the tested species were well correlated. The strength of the relationship between TPC and DPPH, FRAP, TAC assays were 0.245, 0.6841 and 0.7932, respectively.

Key words: DPPH, FC, FRAP, TAC

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Improvement of Texture and Flavour of a Deep-Fried *Keeraminbadum* Fish Product by Modifying Salting and Frying Conditions

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Fish and fishery products are important sources of good quality dietary protein and are popular among many Sri Lankans. Development of value-added products from fish, employing simple preservation techniques is a successful means of meeting their demand throughout the year. The objective of this study was to improve the texture and the flavour of a deep-fried *Keeraminbadum* fish product developed from salt-dried fish. Salt-dried *Keeramin* fish supplied for the production of above product is hard in texture, high in salt content and comparatively less in flavor. Therefore before frying, desalting is required to remove excess salt in the dried fish. In this study fresh *Keeramin* fish were dry-salted with 1%, 2%, 3%, 4%, and 5% (w/w) salt for 1 h and 2 h separately to find the best salt level after drying and to void desalting. All fish samples were oven dried providing with the same conditions and salt contents were analyzed. Fish dried with 1% (w/w) salt for 2 h had the same level of salt (0.16%) compared with the fish obtained from the suppliers after desalting. Above samples were fried separately with olive oil, soybean oil and vegetable oil at 70 °C for 2, 3 and 4 (± 10 s) min and the texture and flavour were studied using a 5-point hedonic scale sensory study with thirty untrained panelists. Fish salted with 1% (w/w) salt for 2 h and fried with olive oil for 3 min was significantly ($P < 0.05$) preferred by the panelists. Hardness of the fried fish were determined using an instron machine and the force required to break desalted and fried fish (86.83 ± 3.94 N) was significantly ($P < 0.05$) higher than that of above preferred fish (43.60 ± 3.56 N). It can be concluded that fish develop an irreversible hard textured tissue when salted with excessive high salt levels and that can't be removed even after adequate desalting. Moreover frying temperature and the type of oil altered the flavor characteristics of the product. *Keeramin* fish salted with 1% (w/w) salt for 2 h reduced the production cost by Rs. 162.75/kg of the final product by avoiding desalting process and, frying with olive oil for 3 min developed the best flavour.

Keywords: *Keeraminbadum*, Salting, Desalting, Hardness

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Changes on Quality Parameters of Chilli (*Capsicum annum*) During Commercial Level Processing and Storage

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Chilli powder which is one of the major spice in Sri Lankan cuisines undergoes chemical, physical and microbiological changes during milling of raw chilli and during the shelf life. The current study was conducted to determine the changes occurring in chilli due to milling and during storage. Samples of raw chilli and chilli powder just after milling were drawn using stratified random sampling from 5 batches of processing. Total Plate Count (TPC), Yeast and Mould counts (YMC), moisture contents and surface color of raw chilli and chilli powder were determined respectively using colony count technique, moisture analyzer and colorimeter. Chilli powders at difference *mill out* temperatures of 35 °C, 45 °C and 55 °C were tested for the preference of pungency and color using a ranking test with 30 untrained panelists by preparing coconut *sambol* with similar quantities of chilli. The latter was further analyzed by colorimeter. Changes of moisture, surface color, YMC and TPC of processed chilli powder under the storage condition were evaluated for 6 weeks in 2 weeks interval. All the chilli samples were below 3×10^3 in TPC and YMC. There was no significant different ($P > 0.05$) within five batches of raw chilli and chilli powder for TPC and YMC. Effect of milling on TPC was not significant ($P > 0.05$) while YMC reduced significantly ($P < 0.05$). Preference for pungency at different *mill out* temperatures was not significant ($P > 0.05$) while preference for color was changed significantly ($P < 0.05$) with *mill out* at 55 °C showed the highest preference. With the increasing *mill out* temperature a^* and b^* values increased while L^* and hue values decreased. During the period of storage both TPC and YMC were increased whereas TPC increased more rapidly. Color L^* , b^* and hue values were increased with time while a^* value decreased. There was no significant change in the moisture content with time of storage.

Keywords: Chilli processing, Chilli storage, Quality parameters, Color, Pungency

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Effect of Different Thermal Treatments on the Inactivation of Microorganisms and Retention of Ascorbic Acid in King Coconut (*Cocos nucifera* var. *aurantiaca*) Water

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Consequent efforts have been made to extend the shelf-life of king coconut water. Application of sterilization temperatures destroys the majority of its nutritive components and imparts undesirable sensory attributes. Thus, the objective of this study was to find out the optimum sub-sterilization temperature that can be applied for the thermal preservation of King coconut water, without drastically affecting its components. 80, 85, 90 and 95 °C were applied to 7-8 months matured King coconut water and samples were retrieved at 5 minutes intervals for the determination of total microorganisms and ascorbic acid content for the time period of 30 minutes. The derived D values at each temperature ranged from 64.4±9.6 to 4.3±0.1 minutes and 55.9±3.7 to 28.2±4.1 minutes for the total microorganisms and the ascorbic acid content, respectively with increasing temperature. Plotting the D values against the temperature showed that two Z values of 41.7 and 6.2 °C exist for the total microorganisms. It indicated that inactivation mechanisms varied at low and high temperature regions. Ascorbic acid was showed a constant Z value of 49.9 °C over 80-95 °C range. This study was revealed that the optimum temperature for the preservation of King coconut water was 90 °C. Accelerated Shelf-life study was showed that the shelf-life of King coconut water was 45 days at ambient temperature. Storage study at ambient temperature up to 6 weeks was showed that the pH and titratable acidity were not significantly ($P < 0.05$) changed and total soluble solid was significantly reduced ($P < 0.05$) in samples which treated at 90 °C. It was explained due to sedimentation and utilization of soluble solids by microorganisms. A Hedonic test was conducted using 40 untrained panelists to determine the overall acceptability of thermally processed King coconut water. The obtained result was suggested that there was no significant difference ($P < 0.05$) among the samples which processed under 85, 90, 95 and 100 °C.

Keywords: King coconut water, Thermal preservation, D value, Ascorbic acid, Shelf-life

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The Potential of Increasing Ground Biscuit Powder Percentage in a Cream Sandwich Puff Biscuit

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Broken and misshapen biscuits are a problem to the industry and reusing them in ground biscuit powder (GBP) form in the processing is done. Manufacturer presently used 2% of GBP in their formulation. Present study was conducted to increase reuse percentage of GBP by modifying the dough of an existing cream sandwich puff biscuit without affecting physical, textural and organoleptic properties of the biscuits. Analysis of fat, sugar and moisture in biscuit powder were carried out in order to balance them in biscuit formulations to be prepared. Biscuits with different levels of GBP in 2%, 2.39%, 2.77%, 3.16%, 3.54%, 3.92% with two levels of NH_4HCO_3 in 1.35% to 1.45% (w/w) were evaluated for bake weight, bake height, pH value, moisture content, hardness, total fat content and colour to select the acceptable treatment combination in 6×2 factorial with GBP % and NH_4HCO_3 % as the factors in completely randomized design. Duo-trio sensory test using 32 untrained panelists was conducted with the selected treatment and standard biscuit. Proximate composition of the selected treatment was determined. GBP % x NH_4HCO_3 % interaction was not significant ($P > 0.05$) for any parameters. Baked height and moisture content of biscuits decreased significantly ($P < 0.05$) with increasing GBP while pH and baked height were increased significantly at higher level of NH_4HCO_3 . The biscuit with 3.92% of GBP and 1.45% of NH_4HCO_3 was chosen as best treatment. Its moisture content and pH were significantly different ($P < 0.05$) compared to the standard biscuit though within manufacturer's specifications. New formulation of biscuit was not significantly different ($P > 0.05$) in all sensory attributes and proximate composition was found within the accepted range.

Keywords: Biscuit, Ground biscuit powder (GBP), Ammonium bicarbonate

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Productivity Improvement of Virgin Coconut (*Cocos nusifera L.*) Oil Processing in Jars

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Virgin Coconut Oil (VCO) is an edible oil which obtained from the fresh, matured kernel of coconut (*Cocos nusifera L.*) with or without applying heat. Due to the high amount of medium chain fatty acid (MCFA) and oxidative compounds it is positively used as a nutraceutical and for food purposes. This study was done to identify the factors to improve the productivity of processing of VCO jars. Reducing the oil leakage from the final product, determination of optimum machinery parameters and mitigating the degradation of chemical and physical properties are the major productivity improvement factors in processing of VCO jars. Among three tested volume levels (500 ml, 505 ml and 510 ml) 505 mL provides the mechanically safe filling volume. Among three tested temperature ranges of heat tunnel (150 °C-160 °C, 160 °C-170 °C and 170 °C-180 °C) and speed of the conveyor in the heat tunnel (10 rpm, 5 rpm and less than 5 rpm) 160°C-170°C and 5 rpm were founded as the optimum level of processing. Normal filling (20-30 °C) of VCO was given high quality oil than hot filing (50-60 °C) and there was no significant vacuum development in both filling methods. Free fatty acid as lauric acid was less than 0.2% and there was no high amount of volume expansion of oil due to the density deviation because of the heat tunnel operation over jars.

Keywords: VCO jars, Productivity improvement, Acid Value, Density

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Determination of Bioactive and Nutritional Properties of Aerial Parts of *Trichosanthes cucumerina* Linn.

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Snake gourd (*Trichosanthes cucumerina* Linn.) is one of the medicinal plants grown in tropical Asia. Aerial parts of Snake gourd are often used in Sri Lankan traditional systems of medicine for the preparation of formulations to treat a variety of disease conditions while they are in the use as vegetables. In this study aerial parts of *T. cucumerina* (TA-2 variety) were evaluated for total phenolic content, flavonoid content, antioxidant and free radical scavenging activity, α -amylase inhibitory activity, mineral and dietary fiber contents by Folin-Ciocalteu's method, Aluminium chloride colorimetric assay, 2,2-Diphenyl-1-picrahydrazyl (DPPH) assay, 2,2'-Azinobis(3-ethyl-benzothiazoline-6-sulfonic acid) (ABTS) assay, 3,5-Dinitrosalicylic acid (DNSA) method, Atomic absorption spectrophotometry and Enzymatic gravimetric method, respectively. Water extracts of freeze dried samples were used for determination of bioactive properties. Antioxidant activity and total phenolic and flavonoid contents were significantly ($P < 0.05$) higher in leaf samples than that in flowers followed by fruits. Total phenolic content and total flavanoid content in aerial parts were significantly ($P < 0.05$) correlated with antioxidant activity measured by ABTS assay and values being ($r^2 = 0.9934$) and ($r^2 = 0.9977$), respectively. Total phenolic content was further correlated ($P < 0.05$) with antioxidant activity measured by DPPH assay ($r^2 = 0.9926$). Aerial parts of *T. cucumerina* did not possess the α -amylase inhibitory activity. Significantly ($P < 0.05$) higher soluble and insoluble dietary fiber contents were observed in fruits than that in flowers followed by leaves. Significantly ($P < 0.05$) higher Ca and K contents were observed in leaves followed by fruits followed by flowers in fresh weight basis. Significantly ($P < 0.05$) higher Mg, Fe and Zn contents were observed in leaves than those in flowers followed by fruits in fresh weight basis. This study shows that leaves of *T. cucumerina* possess higher bioactivity, phytochemical potency and nutritional properties than other aerial parts while fruits possess the highest dietary fibre content. In conclusion, *Trichosanthes cucumerina* can be regarded as a promising candidate with many bioactive properties and high nutritive value.

Keywords: *Trichosanthes cucumerina* Linn., Antioxidant activity, Amylase inhibitory activity, Total phenolic content, Total flavonoid content, Dietary fiber

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Development of Mango Pulp (*Mangifera indica*) Incorporated Set Yoghurt

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Yogurt is one of the most popular dairy products consumed worldwide by all age groups, and it has nutritional benefits beyond those of milk, including its probiotic activity. Mango is one of the major tropical fruits that give numerous health benefits to the humans. This study was conducted to develop a mango pulp incorporated set yoghurt through investigation of the optimum concentration of natural mango pulp that can be added into a standard set yoghurt mixture (9% of sugar, 0.8% of gelatin and 9.5% of milk solid nonfat). A pure mango pulp prepared using “*totapuri*” variety was added into the standard mixture in 3 different percentages (5%, 8% and 12%), and the samples were assessed for their organoleptic properties. The results suggested that the firmness of the samples were lower than the desirable level for that of set yoghurt. Thus, the formula of the standard set yoghurt mixture was modified step-wise to obtain the expected texture of the set yoghurt. The modified formula had 9% sugar, 0.9% gelatin, and 10.6% milk solids non-fat. Physiochemical characteristics, namely pH, acidity, syneresis and water holding capacity of the yoghurts with the modified formula and the three percentages of the mango pulp were assessed over a period of 4 weeks. No significant differences ($P>0.05$) prevailed among samples in terms of all the attributes over the above storage period, except syneresis. A sudden decrease in syneresis was observed after the second week. Yeast and mold count of the yoghurt samples was found be zero over the above period of time. A ranking test was conducted using 40 untrained panelists to determine the overall acceptability for the yoghurts with the three different percentages of mango pulp samples. Again, the results suggested that there is no significant difference ($P>0.05$) among the samples for the preference. Shelf-life was assessed for the above three samples by considering the physical, chemical microbiological and sensory attributes, and they showed that all the samples are stable for a period of 3 weeks at 4 °C.

Keywords: Yoghurt, Mango pulp, Physiochemical Characteristics, Storage stability

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Development of a Spicy Cheese Dip with Improved Sensory Properties and Longer Shelf life

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A great demand exists currently for cheese dips in the global food market, with the increased popularity in consuming different types of chips. However, in Sri Lanka there are no cheese dips available in the market and in place consumers use cheese spreads. The objective of this research was to develop a spicy cheese dip for the local market with improved sensory qualities and longer shelf life. Four initial treatments were prepared by changing ingredients in the first step. Sensory attributes of these were evaluated using 9- point hedonic scale test. The sensory attributes were significantly different ($P < 0.05$) among treatments. Formulation with 14% cream, 10.55% butter, 10.55% milk, 1.14% corn flour, 0.28% sodium citrate, 0% carrageenan and 0.1% guar gum was selected as the best considering the pH and sensory attributes. In second stage, four cheese dip formulations were developed by adjusting the level of ingredients selected from the first step. The sensory properties were significantly different ($P < 0.05$) among four treatments according to the ranking test conducted. Formulation in treatment two was selected as the best formula and comprised of 5.75% tomato puree, 2.88% bell pepper, 1.43% jalapeno, 0.6% onion, 0.58% cheese flavor, 0.4% garlic, 0.15% pepper, 0.14% MSG and 0.03% cardamom. In the next step, three formulations were developed by changing level and types of preservatives. In here, the treatment having 0.08% sodium benzoate and 0.08% potassium sorbate was selected and it resulted in the highest stability according to the chemical and microbial parameters tested. Finally, the newly developed and a cheese dip served in Domino's pizza outlets were compared for the sensory attributes using 9-point hedonic scale test. Significant differences were observed in four quality parameters ($P < 0.05$) but not for appearance and color. According to the proximate composition analysis, newly developed spicy cheese dip contained 48% moisture, 29.35% fat, 1.04% Ash, 2.79% protein and 1% fiber.

Keywords: Cheese pepper dip, Potassium sorbate, Sodium benzoate

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Formulation and Proximate Analysis of Finger Millet Cookies

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The research was conducted to develop cookies using finger millet flour which contain higher amounts of fiber, calcium and gluten free. Wheat flour was substituted with finger millet flour at levels of 15, 25, 35, and 45 % in formulation of finger millet cookies. Sugar, butter, egg white, milk powder, baking powder, ammonium bicarbonate and salt were added with finger millet and wheat flour. Raw cookies with same height and shapes were prepared and baked at 180 °C for 40 min. The sample of cookies was subjected to the sensory evaluation on color, texture, taste, flavor and overall acceptability using 30 untrained panelists. The best preferred cookies was analyzed for its proximate composition. A storage study (one month) was conducted under ambient conditions using three different packaging materials, Polypropylene (75 µm), BOPP (30µm) + CPP (25µm) and metalized polyester. Moisture content, water activity (a_w) and total plate count were determined weekly intervals. The stored samples were subjected for ranking test after one month. Four treatment of finger millet flour were significantly different ($P < 0.05$) for color, texture, flavor and overall acceptability except taste. It was concluded that cookies formulated with 25 % finger millet flour was selected as the best formulation based on preference test. It contained 54.94 % of carbohydrate, 16.56 % protein, 32.05 % fat, 0.25 % fiber, 1.67% ash, 4.78% moisture, 0.011 mg/g Ca, 0.091 mg/g Mg. Total plate counts of cookies were less than 10^4 CFU/g in all packaging materials for one month of storage.

Keywords: Finger millet, Cookies, Sensory evaluation, Shelf life

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Effect of Substitution of Milk Fat in Vanilla Ice Cream with Plant-Based Fat Sources on its Melting Behaviour, Structure and Preference

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Substitution of milk fat using cheaper alternatives is becoming the common practice in commercial scale ice cream production due to economic concerns. Use of alternative fat sources possesses two major disadvantages, and they are faster melting rate and alterations of the authentic flavor. This study was aimed at investigating the feasibility of a variety of plant-based fat sources to totally or partially substitute the milk fat component in vanilla ice cream, without adversely affect its melting behavior and flavour profile. The samples were made by total substitution of milk fat with plant-based fat sources namely palm olein, vegetable fat (mixture of palm and palm kernel oil), soybean oil, coconut oil and sunflower oil. Melting behavior of samples was evaluated under controlled environmental condition in comparison to the samples made with either butter or cream as the sole source of fat. Among the ice cream produce using plant-based fat, highest melting resistance was observed the sample made with vegetable fat and it was selected for the second set of experiment to determine the level of milk fat substitution that can be achieve with a minimum impact on melting behavior. Among the different level trialed, a 50% of substitution of cream gave a higher melting resistance. The ice cream was further evaluated fat droplet size, Fat destabilization, viscosity, hardness and color in order to assess their structure and other physical properties, and their relationship with the melting behaviour. Ranking test was conducted with vanilla ice cream sample made by partially substitution of milk fat in comparison to vanilla ice cream samples that has been prepared using only milk fat. Results indicated that there is no significant difference ($P < 0.05$) between commercial sample and the fat substituted ice cream samples for all the tested attributes. Thus, we conclude that the vegetable fat can be successfully used for the partial substitution of milk fat in ice cream without compromising the melting resistance and sensory characteristics.

Keywords: Ice cream, Melting behavior, Fat, Substitution

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Effect of Substitution of Milk Fat in Vanilla Ice Cream with Plant-based Fat Sources on its Melting Behaviour, Rheology and Sensory

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Abstract: The effect of substituting milk fat with plant-based fat sources on the melting behaviour, rheology and sensory of vanilla ice cream was studied. The plant-based fat sources used were coconut oil, palm oil, and sunflower oil. The results showed that the melting behaviour of the ice cream was significantly affected by the type of fat source used. The rheology of the ice cream was also significantly affected by the type of fat source used. The sensory evaluation of the ice cream was also significantly affected by the type of fat source used. The results indicated that the substitution of milk fat with plant-based fat sources could be used as an alternative source of fat in vanilla ice cream.

Keywords: Ice cream, Melting behaviour, Fat Substitution

Natural Resources and Technological Interventions

Effect of 'Calcite Foliar Fertilizer' on Growth, Yield and Nutritional Composition of Maize (*Zea mays* L.) and Sorghum (*Sorghum bicolor* (L.) Moench) as Fodder for Dairy Cattle

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An experiment was conducted to find out the effect of calcite foliar fertilizer on growth, yield and quality of Maize (*Zea mays* L.) and Fodder Sorghum (*Sorghum bicolor* (L.) Moench) as fodder for dairy cattle in wet zone of Sri Lanka. For this study, Maize (Pacific 984) and Sorghum (Sugargraze) were planted in pots and, four levels of calcite foliar fertilizer were used as treatments. Treatments were control (T₀; 0% of calcite foliar fertilizer), T₁:50% (1 g/L of water), T₂: 100% (2 g/L of water) and T₃: 200% (4 g/L of water) of calcite foliar fertilizer. It was randomized complete block design with four replicates for each species. Data were statistically analysed using SAS software package and means were separated with Duncan's new multiple range test. Application of calcite foliar fertilizer increased ($P<0.05$) the height of plant, circumference of stem, number of leaves, total leaf length, fresh and dry matter yield in both crops compared to the control. However, no significant differences were observed between T₂ and T₃ on number of leaf and circumference of stem of both crops. Dry matter yield of Maize at 8th week was 169, 186, 213, and 194 g/plant whereas dry matter yield of Sorghum was 118, 149, 177, and 158 g/plant for the control, T₁, T₂, and T₃, respectively. Application of calcite foliar fertilizer increased ($P<0.05$) the crude protein, crude fibre, crude fat and energy value of crops compared to the control. Crude protein content of the maize was 7.3, 8.1, 9.5, and 8.3% whereas crude protein values of sorghum was 9.3, 10.2, 11.6, and 10.7% for the control, T₁, T₂, and T₃, respectively. However no significant differences were observed between T₂ and T₃ on crude fibre, ash and energy value of both crops. Based on these results, it can be concluded that application of 100% of calcite foliar fertilizer is more effective on growth, yield and quality of both maize and sorghum compared to other treatments.

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Keywords: Maize, Sorghum, Calcite fertilizer, Yield, Nutritional composition

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Present Status of Indigenous White Cattle in Trincomalee District: The Morphology and Production

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This study was conducted to evaluate current farming activities and the breed status of White cattle in Trincomalee district. A total of 57 households were surveyed in 11 veterinary ranges. Information on management aspects, breed characteristics and socio economic status were collected using a pre-tested structured questionnaire. The results revealed that, the contribution of White cattle to the total earning of the farm mainly comes through the sales milk and meat. Farming system analysis revealed that, indigenous White cattle rearing was based on traditional livestock practices and operates under limited input basis. Grazing is the main feeding (78.9%) in dry season while tethered and grazing provide in wet season, and freely available pond water is used in both seasons. Most of the farmers provide paddocks for spending the night. Indigenous White cattle morphometric measurements explained specific phenotypic characteristics. White cattle carry plain white coat colour with short and glossy mostly curly hair type, long and narrow head with flat fore head and angular body shape with small hump. According to the body measurements data the body length, height at wither, heart girth, head length, head width, ear length, height at rump, rump width and rump length at female adult White cattle were (cm) 107.35 ± 9.29 , 107.25 ± 8.17 , 140.63 ± 10.60 , 40.42 ± 4.02 , 17.31 ± 1.66 , 20.96 ± 1.81 , 114.68 ± 7.52 , 35.06 ± 3.28 and 31.58 ± 3.27 respectively, where, those of adult male White cattle were (cm) 116.31 ± 9.28 , 114.75 ± 11.96 , 148.25 ± 7.33 , 42.0 ± 2.78 , 17.50 ± 1.37 , 22.50 ± 1.15 , 122.44 ± 9.06 , 36.50 ± 3.31 and 32.69 ± 2.15 , respectively.

Keywords: Farming system, Indigenous White cattle, Morphometric measurement

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Usage of Palm Kernel Cake as a Potential Feed Ingredient for Dairy Cattle

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Use of palm kernel cake (PKC) as a feed ingredient in concentrate feed for dairy cattle was investigated. The experiment was conducted in a commercial farm in Galle, Sri Lanka. Six Friesian cross bred cows (initial body weight=332.26±6.33 kg) were allocated for 3 experimental diets in a 3 × 3 Latin Square Design with 3 periods. They were fed with 40% PKC based feed, 20% PKC based feed and 0% PKC feed (commercial feed) as the concentrate feeds. It was rotated by 3 time periods with 24 days for each period, including 10 days evaluation period. Cows were milked twice per day by hand milking. Milk yield was recorded daily and milk samples were tested for milk fat (MF) and Solid non-fat (SNF) weekly and body weight was recorded weekly for each cow. All feeds were analysed for dry matter, crude protein, ether extract, crude fibre and ash. There was no significant difference ($P>0.05$) between animals fed on test diets and control feed on solid non-fat, milk fat and body weight gain. But milk yield was lower ($P<0.05$) in with 40% PKC diet as compared to other treatments. There was no significant difference ($P>0.05$) between animal fed with 20% PKC diet and the control feed. Based on the experiment, the 20% of PKC feed improved the performances of dairy cattle cost effectively and it may be an effective mean of utilizing local feed resources for dairy industry.

Keywords: Palm kernel cake, Concentrate feed, Dairy cattle, Milk

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Growth Performance and Nutritive Value of Ratoon Crop of Fodder Sorghum (*Sorghum bicolor*)

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There is a growing interest for cultivation of fodder sorghum (*Sorghum bicolor* (L.)) because of its high yield, drought resistance and potential for ratoon crop. This experiment was conducted to study growth performance and changes in nutritional composition of the ratoon sorghum crop there by to decide the best age for harvesting the ratoon crop. Yield and the nutritive value of ratoon crop at the best harvesting age were also compared with those of the main crop. The experiment was carried out in Galewela Veterinary Division. Study of the main and ratoon crops were according to complete randomized design. The main crop was harvested at 10 weeks in September and ratoon crop was studied during subsequent 8 weeks of the experiment. Four 1m² replicates were randomly harvested from the main and ratoon crop for estimation of the yield using a quadrat. From each quadrat, 4 sorghum plants were randomly selected to study the variation in growth and nutritive properties of the crops. Height, leaf number and leaf area of the plants of sorghum ratoon crop was significantly increased ($P < 0.05$) up to 7 weeks and no significant difference ($P > 0.05$) was observed afterwards. However, the highest ($P < 0.05$) fresh (98.3 ± 1.66 t/ha) and dry (21.4 ± 0.67 t/ha) matter yields were recorded at 8 weeks. Dry matter (DM), CF, NDF, ADF and gross energy (GE) contents were also significantly greater ($P < 0.05$) at the 8th week compared to seventh week. Therefore, eighth week is the best age to harvest a ratoon sorghum crop. Significant differences were not ($P > 0.05$) observed between main crop harvested at 10 weeks and ratoon crop harvested at 8 weeks in terms of yield, and DM, CF, EE and GE contents. Therefore, farmers could save at least 2 weeks cropping time by continuing for first ratoon sorghum crop instead cultivating a new fodder sorghum crop.

Keywords: Sorghum, Ratoon, Plant growth, Nutritive value

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Effect of Night Feeding of Guinea Grass or Paddy Straw Based Mix Ration on Production Performance of Lactating Buffalos

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Production from genetically improved buffalos in semi-intensive production systems in Sri Lanka could be improved by introducing suitable night feeding supplementation programme. The present study was conducted to evaluate the effect of supplementation of Guinea grass (*Panicum maximum*) based and urea supplemented paddy straw based mix ration on milk production and composition of buffalos in dry zone. The study was conducted using semi-intensively managed, 20 lactating cows having 454 ± 33.3 kg of body weight, between 1-5 parity and producing 4.42 ± 0.65 L/d of milk. A concentrate mixture was formulated using coconut poonac, rice polish, maize, urea and mineral mixture. Two experimental diets were formulated using Guinea grass (*Panicum maximum*) or paddy straw and formulated concentrate mixture. The experimental diets were balanced to contain 9.5 MJ/kg of energy. Urea was added into the paddy straw based ration to increase the CP content to 11.5%. The experiment was on a 2x2 Latin Squire Design where a group of randomly selected 10 buffalos sifted between dietary treatments. During the day time cows grazed on *Bracharia mutica* abundant pasture. During the night, each group was supplemented with the respective experimental diet for 14 days adaptation period followed by 12 days collection period. Dry matter intake, milk yield and milk fat, SNF and total solid contents were compared using ANOVA procedures. Significant ($P > 0.05$) differences were not observed in buffalo milk composition between two treatments. However, dry matter intake (6.50 ± 0.23 vs. 5.87 ± 0.53 kg/d) and milk yield (8.05 ± 0.85 vs. 7.37 ± 0.76 kg/d) of the cows supplemented with Guinea grass based mixed ration were significantly greater ($P < 0.05$) than those received urea supplemented paddy straw mixed ration. Therefore, Guinea grass based concentrate mix ration could be recommended as a suitable night feeding supplement for semi-intensively managed, crossbred buffalos to increase milk production.

Keywords: Buffalo, Night feeding, *Panicum maximum*, Paddy straw, Milk production

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Evaluation of Acrosin Activity and Lipid Peroxidation in Chilled Boar Semen during Storage

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In Sri Lanka, Artificial Insemination (AI) in swine using chilled semen is getting popular among mid and large-scale swine industries. Thus, the aim of the present study was to evaluate the acrosin activity and lipid peroxidation of chilled boar semen preserved in a newly formulated extender when compared with a commercial extender. Semen samples were collected by glove-hand method, and volume, colour, initial motility and concentration were evaluated. Each sample was separated into 2 fractions, 2 extenders were added, and stored in 17 °C. The acrosin activity was evaluated using gelatine coated film technique. Acrosin index was calculated using the halo-diameter and halo-forming rate. Thiobarbituric Acid Reactive Substances (TBARS) test was done to evaluate the lipid peroxidation on day 1, 3, 5 and 7, respectively. During the storage acrosin activity, acrosin index and motility were gradually reduced and had the same pattern of reduction in both extenders. However, maintained 60% motility until day 5. TBARS values of the commercial and newly formulated extenders on day 5 were 0.1 and 0.06 mmol/L, respectively. In conclusion the newly formulated extender preserve the boar semen comparable with the commercial extender and thus, can be efficiently utilized in the boar semen preservation up to 5 days for used in AI.

Keywords: Chilled boar semen, Extender, Storage time, Lipid peroxidation, Acrosin activity

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Correlation of Migratory Sea Turtle Landing & Egg Hatching with Lunar Cycle

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Through numerous marine animals sea turtles have been exhibit advantage cues from the 29.53 day lunar cycle to harmonize their migration, landing and egg hatching events. Lunar month (29.53 days) was divided into new moon, first quarter, full moon and third quarter, and landing, hatching events tested beside the four lunar phases to find correlation. Thus, number of individuals landing to egg laying and hatching data (from 2002 to mid-2014) obtained from Uraniya nesting sites in Hambantota district, southern province regarded to five migratory sea turtles species into Sri Lanka. Landing data of different sea turtles with four lunar phases have been analyzed by Turkey Studentized Range Test in Complete Randomized Design and Significant differences ($P < 0.05$) observed in overall tested years, and 33.69, 26.38, 20.38 and 19.58 mean values reported full moon, first quarter, third quarter and new moon respectively. Hatchability data were analyzed using PROBIT test, and analyzed estimate values for each and every year, quarter, and combinations. Significant differences ($P > 0.0001$) have been observed all combinations of new moon- third quarter, first quarter- third quarter, full moon- third quarter, new moon- full moon, first quarter- full moon and new moon- first quarter; each estimate values -0.2639, 0.7004, 1.3000, -1.5639, -0.5996 and -0.9643 respectively. Hence, found that sea turtle landing and hatching are more frequently around full moons, but less frequently during the new moon and positively related to the lunar periodicity. Sea turtles may be adapted to respond lunar cycle or may have lunar-synchronized migration manifestations. Significant synchronization of arriving in this way may function to maximize fortification success by ensuring the temporal and spatial proximity of rapid extinct turtle population in present. Few studies of reptilian breeding phenology consider lunar phase and our results have important implications for the prediction of reptilian reproduction successiveness, mass movements and conservation strategies.

Keywords: Lunar phases, Lunar cycle, Lunar month, Reptilian, Lunar periodicity

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Morphological Parameter Analysis of Indigenous Goat Populations in Batticaloa District of Sri Lanka

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This study was conducted to evaluate morphological parameters of indigenous goats dwelling in Kiran and Vahari veterinary divisions of Batticaloa district. A total of 35 households were used to obtain information of breed characteristics and management practices of indigenous goats using a pre-tested structured questionnaire. Goats in the study area were kept mainly for animal sale. The study revealed that herded grazing was practiced as the main feeding method (>95%), where 54.3% of animals find their own water resources. The average herd size was 32 heads. The results identified that indigenous goats in the study area were small in size, with 98.9% of animals were having angular bodies. The black and white coat colour was the most predominant (37.6%). When morphometric characters were considered, the mean height at withers of bucks and does were 53.30 ± 0.47 and 51.91 ± 0.35 , respectively whereas high morphometric measurements were shown by bucks. Pearson's correlation coefficient analysis revealed a significant ($P < 0.01$) relationship between body weight and other body measurements. Principle component analysis indicated that body weight (BW), heart girth (HG) and body length from neck to hip (BL) were the morphometric measurements, which explain the variation among the goats in the population. Accordingly, the relationship between BW, HG and BL could be explained by the regression equation of $BW = 0.221 HG + 0.130 BL - 4.22$, $R^2 = 0.355$, which could be used to predict body weight from heart girth and body length. The study further revealed that the valuable indigenous goat genetic resources could be lost as a result of indiscriminate cross breeding with Jamnapari breed. Morphological characterization of indigenous goats in the study needs to be supported by molecular characterization to identify the uniqueness of indigenous goat population.

This work was funded by International Atomic Energy Agency (IAEA), Vienna, Austria.

Keywords: Indigenous goats, Morphological parameters, Correlation

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Coloration of Guppy (*Poecilia reticulata*) with Carotinoids from Marigold Flower (*Tagetes erecta*) and Water Spinach (*Ipomoea aquatica*)

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Among many thousands of ornamental fish species, Guppy (*Poecilia reticulata*) is one of the most popular fish species. Immense attractive colors of Guppy create huge demand in the market. Hence, the present experiment was carried out to evaluate the effect of natural carotenoid pigments on coloration of Guppy fish. A fish feed with similar composition to general fish feeds was prepared using commercially available ingredients and used as the control diet. This formulated feed was supplemented with (1%) carotenoid pigments from petals of Marigold flowers (treatment 1) or leaves of Water Spinach (treatment 2). Sixteen days old male red Guppies from the same brood stock were allocated into 12 glass tanks (4 replicates per treatment) each with 18 fish. Tank volume, aeration and other conditions were maintained uniformly among treatments and fish were fed *ad libitum* for 30 days. Fish (both control and treated groups) were photographed in a standardized light condition ($K^{\circ}=3200$) using a digital camera (Nikon D200, $f=55\text{mm}$) at second, third and fourth weeks. Redness of photographs was measured using MatLab® 2008 software. Results revealed that, the redness was significantly enhanced in both treated groups than the control group ($P<0.05$). Moreover, treatment 2 showed significant ($P<0.05$) increase in redness of fish compared to the treatment 1 and control. According to the results, the natural sources of carotenoid pigments such as Marigold flower and Water Spinach had positive effect on redness of fish while Water Spinach was more effective than Marigold flower when enhancing redness of fish.

Keywords: *Poecilia reticulata*, Carotinoid, *Tagetes erecta*, *Ipomoea aquatica*, Pigments

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Determination of Conditions Required for Breeding of *Lepidocephalichthys thermalis* (Common Spiny Loach) under Captive Condition

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Lepidocephalichthys thermalis (Common spiny loach) is an aquarium fish which is indigenous to Sri Lanka. The wild catch is not enough to supply the fish to export market according to the increasing demand. Main objective of this study was to determine the optimum conditions required for breeding common spiny loach under captive condition while discovering the physiological conditions of a brood stock and larval growth and development. Brood stock was sorted based on their sex and they were conditioned for 5 weeks. Fish were introduced to tanks in the male : female = 2:1 ratio having 5 different captive conditions such as aeration, aquatic plants, aquatic plants with aeration, aquatic plant with water flow, aeration with artificial rain. All tanks were provided with sandy bottom. Water quality parameters of the tanks were 7.5-8 of pH and 23.5-26 °C temperature in day time and water was free from Ammonia and Nitrite. 86.42% fries could be obtained from the tanks conditioned by artificial raining and 13.5% of fries from the tanks with aquatic plant and aeration. The difference among each condition was analyzed according to the number of fries gained using Kruskal Wallis method and there was a significant difference among each condition ($P < 0.05$). The mean condition factor of the brood stock at their breeding stage was $0.012 \pm 0.002 \text{ gm}^{-3}$. Gonadal Somatic index of the brood stock was calculated measuring their gonadal weight and somatic weight. Mean Gonado somatic index was 12.59 ± 2.78 . Larval fin development was observed day from their birth using light microscope. At the seventh day dorsal, pectoral, anal fins with lateral and dorsal black dots had been developed. This study showed that the optimum conditions for *Lepidocephalichthys thermalis* breeding under captive conditions are artificial rainy condition with sandy substrate having aquatic plants and aeration.

Keywords: *Lepidocephalichthys thermalis*, Captive breeding, Artificial rain, Water quality parameters

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Production Performance of Dairy Cows Fed on Maize or Sorghum Silage Based TMR

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Production performance of feeding of sorghum or maize silage containing total mixed rations (TMR) to temperate crosses of dairy cows were compared in the current experiment. Sorghum silage based TMR (SST) consisted of 10 kg sorghum silage, 30 kg CO3 grass, and 2.8 kg concentrate mix and Maize silage based TMR (MST) consisted 10 kg Maize silage, 30 kg CO3 grass, and 2.5 kg concentrate mix on the fresh matter basis. Two diets were formulated to be identical in energy and protein and predicted to fulfill daily nutrient requirements of a dairy cow producing 8 L/milk/day. Six cows were randomly allocated for each treatment based on milk production milk quality, body weight, stage of lactation and parity. Diets were fed *ad libitum* in a 2×2 Latin square design with 18 days adaptation period followed by 3 days sample collection. At the end of each period, milk production was recorded, milk samples collected for composition analysis, body weight taken and dry matter intake measured. Data were analyzed as Duncan's Multiple Range Test using SAS statistical software. Compared to SST with MST, milk yield (6.47 vs 6.68 L/day), fat% (5.22 vs 5.10%), TS% (13.90 vs 13.70%), SNF% (8.63 vs 8.60%), CP% (3.38 vs 3.36%), MUN (20.0 vs 19.5 mg/dL) and BW (305.84 vs 310.71 kg) were not affected ($P>0.05$) by the treatment. However, dairy cows on SST diet had higher ($P<0.05$) DMI compared to the animals fed on MST (12.73 vs 12.23 kg/day for SST and MST, respectively). It can be concluded that production performance of feeding sorghum silage to dairy cows is similar to that of feeding Maize silage. Cultivation of sorghum is more economical than maize because it is more drought resistance and can have few ratoon crops. Therefore, it can be suggested that popularization of sorghum as a fodder grass is more useful under our conditions.

Keywords: Sorghum silage, Maize silage, TMR, Feeding dairy cows

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Nutritional Quality and Fermentation Characteristics of Sugarcane (*Saccharum officinarum*) Tops with Urea, Rice (*Oryza sativa*) Bran and Molasses under Local Conditions

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An experiment was conducted to study the ensiling characteristics and nutritive value of Sugarcane (*Saccharum officinarum*) tops (SCT) compared to Guinea "A" (*Panicum maximum*) grass. Sugarcane tops at 12 months of age and Guinea grass at 50% early bud stage were harvested and chopped using a multichopper and ensiled alone or with 3 additives namely 1% urea, 1% urea with rice (*Oryza sativa*) bran (RB), and 2% molasses for a period of 5 weeks in 1 kg laboratory silos. Proximate analysis was done for forage and other feed ingredients. Dry matter (DM), crude protein (CP), pH value, lactic acid (LA), ammonia nitrogen and soluble carbohydrate of silage were measured. Data were statistically analyzed using analysis of variance procedure by the SAS computer package and means were compared using Duncan's Multiple Range Test. Physical characteristics of silage without additives and ensiled with molasses were satisfactory and, had an olive green color, fruity aroma, and moist texture. The pH value of SCT silage ranged from 4.5 to 6.2 and was significantly lower ($P < 0.05$) compared to that of Guinea grass silage (from 5.2 to 9.0). Addition of urea or urea with RB resulted higher CP values (14.72 and 16.02% respectively) of SCT silage than the control and addition of molasses (4.4 and 5.38% respectively), but the variety had no significant ($P > 0.05$) effect. The LA content ranged from 14.76 to 15.35% in SCT silage compared to the range from 14.71 to 15.58% in Guinea grass silage. Results revealed that ensiling characteristics of SCT were superior compared to that of Guinea grass silage. Inclusion of 3 additives improved the ensiling characteristics of SCT compared to SCT alone. Besides, SCT ensiled with molasses had good fermentation characteristics with low pH value and high soluble carbohydrate content.

This study was funded by the Sugarcane Research Institute, Udawalawe, Sri Lanka.

Keywords: Sugarcane tops, Silage, Urea, Rice bran, Molasses

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Leaves of *Tragia involucrata* Act as an Indicator for Pregnancy Detection in Cattle

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The colour changes of *Tragia involucrata* (*Kahabilia*) leaves soaked overnight in pregnant cattle urine was evaluated as an indicator for pregnancy detection. Urine from 12 pregnant and 8 non-pregnant cattle were collected early in the morning were used in the study. One square centimetre punch of mature leaves were soaked in 3 mL cattle urine for 24 h. Urine samples without leaves and leaves soaked in 3 mL distilled water were served as positive and negative controls. After the experimental period the presence of red colour dots on leaves was considered test positive. Urine and leaves colour were recorded using score systems at 0 and 24 h. The sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were 75 ± 0 , 83.33 ± 4.16 , 87.27 ± 2.72 and 68.89 ± 1.10 , respectively. Non-parametric correlation between urine and leaf colour showed no significance ($P > 0.05$) of urine colour on the leaf colour changes. Moreover, microscopically, veins of leaves soaked in pregnant urine detected positive were stained red. In the second experiment, urine from 6 pregnant and 6 non-pregnant cattle was incubated with distilled water extract of *Tragia involucrata* leaves (0.25 %DM of leaf extract to final volume of 10 mL urine). Adjusted difference of spectrophotometric absorbance (450, 550 and 650 nm) at 0 and 24h showed a significance difference ($P < 0.05$) between pregnant and non-pregnant groups. In conclusion, the colour changes of *Tragia involucrata* leaves soaked in pregnant urine may indicate pregnancy status. However, further experiments are proposed to improve the accuracy of the methods.

Keywords: *Tragia involucrata* (*Kahabilia*), Pregnancy diagnosis, Cattle, Urine, Traditional method

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Effect of Lactic Acid on Total Aerobic and Fecal Coliform Bacteria Counts of Fresh Whole Malabar Grouper (*Epinephelus malabaricus*) Fish

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Decontamination methods are used in fish processing industry to reduce microbial count on fish, to gain maximum health and economic benefits. The objective of this study was to determine the effect of lactic acid as decontaminating agent to control Aerobic Plate Count (APC) and Fecal Coliform count (FC) in fresh Malabar Grouper fish (*Epinephelus malabaricus*). Fresh whole reef fish were treated with chilled of Lactic Acid (LA) containing 1, 2 and 3 % solutions (w/v) by dipping for 5 and 10 minutes. Chilled water containing 0.5-1 ppm chlorine was used as the control. APC, FC count and sensory characteristics (odor, color, texture and overall appearance) of fresh whole reef fish and cooked flesh samples were evaluated. APC and FC count before the decontamination were 5.9 log₁₀ CFU/g and 13.9 MPN/100 g. After the treatment with 2% LA (w/v) for 5 minutes APC and FC count were reduce to 3.9 log₁₀ CFU/g and 0.5 MPN/100 g respectively. Fish dipped in 2% LA solution showed significant (P<0.05) reduction of APC and FC count. There was no significant (P>0.05) effect of dipping time on APC and FC counts. Also no significant (P>0.05) interaction between duration of dipping and LA concentrations of treatment on bacterial counts. Color of gills and transparency of eyes of fish adversely affected by LA treatment. Redness value of gills significantly (P<0.05) reduced and converted to greenish brown color in treated fish. Sensory evaluation shown that there were no significant (P<0.05) effect of LA on sensory attributes of cooked fish samples.

Keywords: Lactic Acid, *Epinephelus malabaricus*, Decontamination, Aerobic plate count, Fecal Coliform

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Effect of Two Different Water Sources on Growth Performance of Cultured Black Tiger Shrimp (*Penaeus monodon*) in Puttalam Area

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Sustainable shrimp farming in Sri Lanka has stagnated due to unavailability of the high quality water sources during culture period and less awareness about water quality on growth performance of shrimp. Hence, the objective of this study was to analyze the effect of two different water sources on growth performance of cultured black tiger shrimp (*Penaeus monodon*) in Puttalam area which are already in use. In this study, day 15 post larvae (PL₁₅) were reared up to harvesting stage (15 Weeks) in 03 commercial farms as 03 treatments (T1; tube well water, T2; tube well with lagoon water and T3; lagoon water) with 04 replicates for each in Mee Oya and Manativu sub zones, Puttalam. Initially 100,000 PL₁₅ were stocked in 0.4 ha ponds in each replicates and provided same feeding, aeration and water exchange practices for all the treatments during culturing period. Total production, average biomass, feed utilizations, feed conversion ratio (FCR), survival rate and water quality parameters were recorded weekly. The results of average biomass, total production, total feed utilization, FCR and survival rates were significantly different ($P < 0.05$) among treatments. Especially the lowest survival rate ($51.55 \pm 5.35\%$) was observed in T1 compared to the T2 ($72.82 \pm 3.65\%$) and T3 ($80.85 \pm 2.13\%$). Similarly, the major water quality parameters (pH, dissolved oxygen, salinity and total alkalinity) were indicated greater differences among 3 treatments during experimental period. Moreover, the results indicated a significant difference ($P < 0.05$) between tube well water and lagoon water on growth performance of black tiger shrimp (*P. monodon*) in Puttalam area and lagoon water showed the best performance for shrimp farming among 3 conditions. However, tube well water and mix treatment also has greater potential for shrimp farming when the ecological conditions are balance within optimum range.

Keywords: Tube well water, Lagoon water, Growth performance, Cultured black tiger shrimp (*Penaeus monodon*)

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Manufacturing of a Commercial Preparation for Canine Mange Using Indigenous Herbal Material

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Effectiveness of Herbal shampoo for controlling re-infestation of mange after Ivermectin treatment was evaluated in dogs. The Herbal shampoo was manufactured using an indigenous recipe. Ingredients possess antiparasitic properties against mange mites, as well as antibacterial and antifungal properties against secondary infections. The mange-infested dogs (n=30) brought to veterinary clinics around Kandy & Ruwanwella area were selected for the study. Two weeks after Ivermectin treatment the shampoo was applied at least twice week. Dogs (n=30) that were not applied shampoo were served as control. Progression of the recovery was evaluated every 2 weeks for 3 months and apparent clinical signs and behavioural manifestations were recorded. A score from 0 to 100 was used to evaluate the severances of the condition. The application of the shampoo resulted in significant reduction ($P<0.05$) of re-infestation. No apparent adverse reactions were reported after applying the shampoo. In the shampoo, zero total bacterial count was observed at even at 100 days after preparation. Ideal body condition, frequent bathing, high care, no contact dogs at vicinity, dogs rearing indoor in tile floors speeded up the recovery and reduced the re-infestation rate. Goldern Retriever, German Shepherd, Crosses, Doberman, Belgium Shepherd and Pomeranian were shown the fast recoveries, respectively. The results of this study indicate that the prepared herbal shampoo is clinically effective to control re-infestation of manage in dogs. Thus, has a potential to commercialize the preparation.

Keywords: Canine, Indigenous herbs, Shampoo, Mange control

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Effect of Feed Grade Antibiotic on Sub-clinical Necrotic Enteritis and Dietary Soybean Trypsin Inhibitor Activities in Broiler Chickens

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Sub clinical Necrotic Enteritis (NE) is an economically important disease in broiler chickens. *C. perfringens* is a commensal in chicken intestine and is the major cause of NE. Dietary proteins affect the proliferation of *C. perfringens* and high trypsin inhibitor activity (TIA) is a causative factor in NE. The TIA levels are not being monitored in the importation of soy products for animal feeding. Antibiotics are used excessively in broiler chicken industry to improve the weight gains. Therefore, the objectives of the study were to identify the effect of trypsin inhibitors on the growth performance and also, the extent that antibiotics can ameliorate the negative impact of TIA. The experiment was carried out with 480 broilers. Four treatment diets were formulated with different inclusion rates of raw soybean (RS): 0%, 5%, 10%, 20%. Each diet was fed with or without antibiotics into 6 replicate pens containing 10 birds in each pen. Data were analysed using SPSS 20 and the means were compared using turkey HSD. Results revealed no difference ($P>0.05$) in 35day body weights (BW) in the 0% or the 5% RS diet fed birds without antibiotics: 2.2 and 2.1kg, respectively. BW of the birds fed 10% and 20% RS (2.0 and 1.6 kg, respectively) were lower than ($P<0.05$) the control (0% RS) fed birds. In addition, the BW was inversely proportional to the dietary TIA. Pancreas weight proportional to the BW of the birds fed 10% or the 20% RS was higher ($P<0.05$) compared to the control. The proportional pancreas weights of the birds fed 5% RS diet (0.28g/g) was marginally higher ($P>0.05$) compared to the control (0.23g/g). No difference ($P>0.05$) was identified in antibiotic fed birds in 0, 5 and 10% RS fed birds. Therefore, feed grade antibiotics ameliorated the adverse effects ($P<0.05$) of trypsin inhibitors on growth performance, however, only up to 10% RS in diet.

Keywords: Antibiotics, Broilers, Sub-clinical necrotic enteritis, Trypsin inhibitors

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Establishment of an *in vitro* Model with Primary Ovine Granulosa Cells Culture to Evaluate the Effect of Endocrine Disruptor Bisphenol A on Ovarian Functions

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Endocrine disruptors have some major effects on reproductive biology of male and female animals including human beings. Many substances found in the environment have shown various degrees of endocrine disruptive functions. Bisphenol A (BPA) has already been classified as a potent endocrine disruptor on reproductive biology. Hence, the present study was designed to evaluate the effects of endocrine disruptor Bisphenol A on ovarian function using an *in vitro* primary ovine granulosa cells culture model. An *in vitro* ovine granulosa cells culture model was successfully established. Sub-confluents cells in the first passage of culture were treated with three different concentrations (0.3, 3.0, 30 $\mu\text{g/mL}$) of BPA to investigate the effect of BPA on cell viability and cell doubling time. Cell viability percentage decreased significantly ($P < 0.05$) with increasing concentrations of BPA and normal cell morphology was also changed with the increasing BPA concentration but no significant different ($P < 0.05$) on cell doubling time (control; $2.13 \text{d} \pm 0.05$ vs 30 $\mu\text{g/mL}$; $2.38 \text{d} \pm 0.09$). The minimum dose of BPA with significant effects on the cultured cells was 3.0 $\mu\text{g/mL}$. The present study demonstrated that exposure to low concentration of Bisphenol A can affect the ovarian granulosa cell viability altering the normal cells functions thus; more studies should be carried out to elucidate exact effect of BPA on granulosa cells.

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Keywords: Granulosa cells, Bisphenol A, Cell culture, Endocrine disruption, Cell viability

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Effect of Endocrine Disrupting Fungicide Mancozeb (Manganese Ethylene Bis-dithio Carbamate) on Oviductal Functions: An *in vivo* Mice (*Mus musculus*) Model

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Endocrine disrupting effects of various pesticides have become a major concern all over the world. Mancozeb is the broad spectrum fungicide which has recently classified as an endocrine disruptor which can interfere with endocrine functions and cause adverse effect on reproductive functions. Therefore, the present study was designed to develop a model to evaluate the effect of Mancozeb on oviductal function using mice as an animal model. Vaginal smears were collected and observed under microscope for identify estrus cycle phase of the mice. The mice at diestrus were exposed orally to different doses (0.3 mg/kg BW/day, 3 mg/kg BW/day and 30 mg/kg BW/day) of Mancozeb in olive oil starting from the diestrus stage as day 1 up to metestrus stage as day 4. Mice in group 1 served as the control and were treated Dimethyl Sulfoxide (DMSO) with olive oil since Mancozeb was dissolved in DMSO. At the day 5, mice were weighed then sacrificed and length of reproductive tract and weights of ovaries were measured and oviducts were stored for RNA extraction and histology studies. We examined parameters such as tissue histology of oviduct and p53 gene expression levels in the treated oviducts. Haematoxylin & Eosin stained digital micrographs of oviduct tissues were captured and analyzed for structural abnormalities using imagej software. Body weight increment and Length of Reproductive tract were significantly lower ($p < 0.05$) in mice treated with 30 mg/kg BW/day (T3) compared to control. Histological abnormalities in tissue were observed in 3 mg/kg BW/day and 30 mg/kg BW/day Mancozeb treated group compared to control. The expression level of p53 mRNA decreased in comparison with control. Mice can be successfully used as an animal model to evaluate the effect of Mancozeb on oviductal functions. The administration of Mancozeb with the dose of 30mg/kg BW/day may adverse effect in oviductal gene expression and structure of oviduct in ICR mice leading to impaired oviductal functions.

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Keywords: Endocrine Disruptors, Mancozeb, Mice model, Oviduct, p53 gene expression

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Hepatoprotective effect of *Osbeckia octandra* (Heen bowitiya) against CCl₄ induced chronic liver damage in ICR mice

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Osbeckia octandra (Heen bowitiya) is an endemic plant in Sri Lanka and it is used in traditional medicine to treat various liver disorders. The present study is aimed to evaluate the hepatoprotective effect of *Osbeckia octandra* leaf extract against CCl₄ induced chronic liver damage. Forty-eight mice were divided into 4 groups of 12 and CCl₄ (1 mL/kg BW in 1:1 in olive oil), *Osbeckia octandra* leaves extract (0.5 g DM/kg BW) and CCl₄+leaves extract were gavaged twice a week for 4 weeks. The mice group received distilled water was served as control. After the experimental period, body weights were taken and blood was collected using cardiac puncture. Gross pathological and histopathological examination of all liver specimens of sacrificed mice was performed. A trend of low total protein and albumin values were observed in CCl₄ group than that of CCl₄+leaves extract group. Histopathological observations conducted according to modified Ishak hepatic activity index, showed a lower degree of perivenular necroinflammatory activity in CCl₄+leaves extract treated group compared to CCl₄ group. Both CCl₄ and CCl₄+leaves extract groups showed stage 3 fibrosis according to the modified Scheuer classification. Both the distilled water and leave extract only groups showed normal liver architecture. The results of the present study indicate that the extract of *Osbeckia octandra* leaves exerts hepatoprotective effects against CCl₄ induced chronic hepatotoxicity.

Keywords: Mice, *Osbeckia octandra*, Hepatoprotective action, CCl₄ induced chronic liver damage

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Pre- and Post- Milking Practices and Relationship of Time Taken for Pre-Milking Practices and Body Parameters with Daily Milk Yield in Buffalo Cows

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A study was conducted in Embilipitiya area using 41 smallholder buffalo farmers who regularly milked 133 buffalo cows, to document pre- and post- milking practices, estimate the time taken for each practice and examine the relationship between time taken for pre-milking practices and body parameters with daily milk yield. Information on individual farmers, feeding practices, pre- and post- milking practices, time taken for each practice was recorded. Data on age, parity, daily milk yield, breed, heart girth, height at withers and body weight of each cow were collected. 63.56% farmers practiced free grazing, 68.3% produced curd, while 19.5% farmers had participated in dairy training programs. Age, body weight, heart girth, height at withers and milk yield of the buffalo cows were 6.73 ± 2.77 years, 548.9 ± 109.49 kg, 188.72 ± 12.86 cm, 126.08 ± 3.99 cm and 2.72 ± 0.90 L/d, respectively. 58.53% farmers practiced full hand milking, 39.02% knuckling and 2.43% striping. Milking practices and percentage farmers adopting each practice were, cleaning standing area (15.78%), cleaning cow (15.78%), washing udder (100%), introducing calf (94.73%) and milking (100%). No farmer practiced concentrate feeding, strip cup test, teat dipping and cleaning of utensils, but were willing to adopt cleaning the cow, strip cup test and teat dipping. Time taken for cleaning standing area, cow, udder, introducing calf, milking of cow and transferring milk to buckets were, 288.07 ± 101.6 sec, 195.47 ± 35.9 sec, 29.86 ± 19.3 sec, 107.46 ± 38.3 sec, 341.24 ± 106.7 sec, and 37.01 ± 19.6 sec, respectively. Milk yield was related ($P < 0.05$) to milking duration ($r = 0.3978$), heart girth ($r = 0.4334$), body weight ($r = 0.4368$) and height at withers ($r = 0.4717$). Milking for > 10 minutes did not increase milk yield, while heavier and tall cows produced more milk. The results suggest that, in Embilipitiya area, time taken for milking and associated practices exceed recommendations. Farmers do not practice hygienic milking, but willing to clean the cow, strip cup test and teat dipping. Focusing on those aspects in future farmer training programs will be beneficial.

Keywords: Pre- and post- milking practices, Body parameters, Milk yield, Buffalo

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Effect of Different Additives on Fermentation Characteristics of Fodder Sorghum (*Sorghum bicolor* (L.) Moench) Compared to CO-3 (*Pennisetum purpureum* X *Pennisetum americanum*)

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This study was carried out to evaluate the fermentation characteristics and nutritive value of fodder Sorghum (*Sorghum bicolor* (L.) Moench) compared to CO-3 (*Pennisetum purpureum* X *Pennisetum americanum*) with different additives. Fodder Sorghum and CO-3 were ensiled alone, with 1% molasses, with 1% inoculum or with 1% inoculum and 1% molasses on small laboratory silos for 60 days. Five laboratory silos containing 2kg of silage were prepared from each mixture. Proximate analysis was done for initial samples. After 60 days, physical parameters and fermentation characteristics such as pH, Lactic acid (LA), Water Soluble Carbohydrate (WSC), Ammonia Nitrogen (NH₃-N) and Dry Matter (DM) and Crude Protein (CP) contents were analyzed. Data were statistically analyzed using SAS computer software and mean comparisons were done using Duncan's Multiple Range Test. All the silos were free from molds and had a pleasant fruity aroma. Color of fodder Sorghum silage was greenish brown compared to the color of CO-3 silage which was light brown. Texture of the silage was good. The lowest ($P<0.05$) pH (4.30-4.47) and the highest ($P<0.05$) LA (7.42-12.75%) contents were recorded in fodder Sorghum silage compared to CO-3 silage. Addition of inoculum significantly lowered ($P<0.05$) the pH of silage compared to other treatments. The lowest ($P<0.05$) NH₃-N content (2.6%) was observed in control Sorghum silage compared to CO-3 (8.06%) control silage. Water Soluble Carbohydrate content was significantly higher ($P<0.05$) in fodder Sorghum compared to CO-3 and has increased with addition of 1% molasses and 1% inoculum. In conclusion, addition of 1% molasses and 1% inoculum has improved the fermentation qualities of fodder Sorghum and CO-3 compared to the control.

Keywords: Fodder Sorghum, Hybrid Napier, Additives, Fermentation characteristics

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Effect of Different Cooling Treatments on Performance of Rabbits

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A study was conducted to assess the degree of heat stress, effect of different cooling treatments on performance, and identify an effective cooling treatment for rabbits. Data on ambient temperature (AT) and relative humidity (RH) were recorded inside and outside the rabbitary at hourly intervals from 9.00 a.m. to 5.00 p.m. Fifteen non-pregnant does aged 2.9 ± 0.34 years, weighing 3 ± 0.01 kg were randomly allocated to three groups ($n=5/\text{group}$) balanced by age and body weight. From 8.00 a.m. to 5.00 p.m. every day, one group received fanned air through wetted gunnies, while 2 iced water bottles (3 kg ice) was placed inside each pen of another group. Third group received no cooling treatment. At 8.30 a.m. daily, 150 g commercial pelleted feed was given to every doe, while water was provided *ad libitum*. Data on hourly AT, and RH inside the cages and outside the rabbitary, ear pinnae temperature, pellet intake, body weight, days to conception and gestation length of does, litter size, birth weight and mortality rate of kits were recorded. Data were analyzed using Analysis of Variance and General Linear Model procedures. Temperature humidity index (THI) inside the rabbitary exceeded upper limits of thermal comfort zone for does from 11.00 a.m. till 2.00 p.m. Cooling treatments reduced ($P<0.05$) THI inside rabbit cages, increased ($P<0.05$) pellet intake and weight gain of does, with no significant effect on body temperature. Does which received fanned air through wetted gunnies had highest ($P<0.05$) weight gain. Iced water bottle group conceived earliest ($P<0.05$), and delivered heaviest kits ($P<0.05$). Litter size was not different, but mortality rate was lower ($P<0.05$) in fanning through wetted gunnies group. These results suggest that day time thermal conditions are stressful to rabbits, cooling reduces heat stress and improve performance, and fanning through wetted gunnies is more effective cooling treatment than iced water bottles.

Keywords: Heat stress, Fanning through wetted gunnies, Iced water bottles, Rabbit performance

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Rain Water Harvesting on Tea Land

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Camellia sinensis is an important crop in Sri Lanka. The yield of tea is highly depend on water. It is very difficult to survive tea lands at dry and water scarcity period. It is very difficult to find an irrigation method for tea lands due to topography. This study was carried out to consider the present situation of water on tea lands. Rainwater harvesting is low cost water source for irrigating tea cultivation in dry season. In rain water harvesting method, the catchment area of rain water harvesting for the study was created by using Google earth software. Average runoff coefficient was calculated by using rainfall and runoff data. The rainfall data was collected by using a rain gauge. The runoff data was calculated using a bucket which known as 'volume'. Direct runoff volume was calculated using the rain fall amount in ten year recurrence period (1984-2013). Required pond size is 705.18m^3 . Evaporation loss was calculated using last few years evaporation in Deniyaya area. The gross water storage of pond was calculated at the end of the season. The crop water requirement of the tea land was also calculated. Catchment area of the research conducted was 6659 m^2 . Average runoff coefficient of the catchment area was 0.052. Direct runoff volume for ten year recurrence period was 705.18 m^3 . Capacity of the ponds was 705.18 m^3 . Evaporation loss of the maha season was 115.09 m^3 . Gross water storage at end of the season was 590.1 m^3 . Crop water requirement for dry spell was 76 mm. Gross water requirement was 566.04 m^3 in the dry spell. When consider the gross water storage and the gross water requirement, there is a possibility to success rain water harvesting to irrigate the tea lands in the study area.

This research was funded by Tea Research Institute, Low Country Station, Rathnapura

Keywords: *Camellia sinensis*, Crop water requirement, Direct runoff volume, Runoff coefficient

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Development of an Effective Rooting and Acclimatization Procedure for *in vitro* Regenerated *Aegle marmelos* (L.) Correa Shoots

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Effect of growing medium (Murashige and Skoog (MS), compost: sand=1:1, sand only) and Indole-3-butyric acid (IBA) on rooting and acclimatization of *in vitro* generated *Aegle marmelos* (L.) Correa; a medicinal tree, under *in vitro* and *ex vitro* conditions was investigated. Shoots grown under *in vitro* conditions on MS medium supplemented with 1 mg/L IBA (T1) was used as the control. Shoots were treated with 500 mg/L IBA for 10 minutes before culturing either on MS medium (T2), sterilized compost: sand=1:1 (T3 and T5) or sand (T4 and T6) and incubated under control environmental conditions (T2, T3 and T4) inside the laboratory or under ambient conditions within single propagators (T5 and T6). The results showed that the medium containing compost: sand=1:1 was not suitable for rooting and all the plants died within two weeks. Shortest time duration for root initiation (25 ± 4.35 days), highest percentage of rooted plants (20%), longest roots (2.22 ± 1.3 cm), highest number of roots per shoot and the highest survival percentage (96.67%) was observed when shoots were established either on MS medium or sand giving 10 minutes pulse treatment of 500 mg/L IBA under *in vitro* condition. Even though shoots cultured on MS medium with 500 mg/L IBA pulse treatment had similar performances as the sand medium during rooting stage, the highest survival percentage (83.33%), during acclimatization was observed only in shoots rooted on sand medium. Therefore it can be concluded that sand is the most suitable medium for rooting and acclimatization of Bael, by considering both cost and time required to produce a rooted Bael plants.

Keywords: Acclimatization, *Aegle marmelos*, IBA, Rooting, Rutaceae

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Distribution, Propagation and Management of *Gyrinops walla* (Walla patta)

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Gyrinops walla Gaertner of the family Thymelaeaceae is a fragrant, resinous agarwood producing tree species. Despite the importance of *G. walla* as a high value resinous species, no research has been conducted on its natural distribution, status of illegal trade, effective funguses that induce agarwood production, vegetative and seed propagation techniques. Thus, this study was conducted to investigate the natural distribution, illegal trade, funguses that induce agarwood production and seed and vegetative propagation methods of *G. walla*. Based on the information of herbarium records, Divisional and Regional Forest Officers, the species is distributed wet and intermediate Zone of Sri Lanka. Based on the Sri Lanka Customs records, illegal trade of *G. walla* is in increasing trend and worth of Rs.12 million and the amount was 55 kg in year 2013. However, this information probably highly underestimated as only detected cases are recorded. Maturity stages of cuttings (softwood, semi hardwood, hard wood), planting media (sand, soil) and different concentration of rooting hormone (500 mg/L, 1000 mg/L, 2000 mg/L of Indole-3-Butric Acid) were consider as factors of vegetative propagation of *G. walla*. The experiment was conducted sequentially in mass propagator, single propagator and pots, respectively. The experiment was designed as three factor factorial in completely randomized design. Evaluate the germination ability of seeds, using sand as the planting media, three types of seed treatment; control, Gibberellic acid (500 mg/L) and HNO₃ (1%) were used. Results of cuttings with different IBA concentrations were negative without emerging of callus or shoot throughout the study period. Seed germination also revealed the poor germination (0.6%) of seeds, may be due to storage of seeds for more than 5 months. Implications of these findings for future research of *G. walla* are discussed.

Keywords: Cuttings, Gibberellic acid, Indole-3-Butric acid, Nitric acid, Vegetative propagation

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Development of Technology for Sustainable Rice Production in Wet Zone of Sri Lanka

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Paddy is the single most important subsistence agricultural product which occupies 34 percent of the total cultivated area in Sri Lanka. Although the demand for rice is increasing, cultivated paddy lands are diminishing at a rapid pace. The most crucial and deciding factor in this concern is found to be the high cost of paddy cultivation. Therefore, it is necessary to develop a good technological package to reduce the cost and mitigate other negative impacts while maintaining the environmental stability of paddy cultivation. The field experiment was carried out to develop a productive and sustainable rice package of paddy cultivation technology for the wet zone. Four treatment combinations that include a traditional variety (*Suwandel*) under improved management (T1 IM), an improved variety, BG 359 under improved management (T2 IM), *Suwandel* under conventional management (T1 CO), BG 359 under conventional management (T2 CO) were employed in a randomized complete block design with four replicates. There was a significant treatment effects on growth parameters (at $P < 0.05$) where the highest SPAD meter reading (43.9), the highest leaf area per plant (165.14 cm^2), the higher tiller number per plant (10 tiller per plant), minimum weed growth and minimum pest and disease problem was observed in both BG 359 and *Suwandel* under improved management (T2 IM) while plant height (45.74cm) and plant density (20 plant/ $50 \times 50 \text{ cm}^2$) were in the optimum range in BG 359 under improved management practices. According to the analysis of nitrogen, phosphorous, potassium content in plant stem/leaves and roots, more absorption take place in *Suwandel* variety in first five wk than BG 350 variety, despite its relatively low growth performance (compared to BG 350 variety). According to the overall condition best productive and sustainable package is *Suwandel* under the improved management practices.

Keywords: Productive, Package, Paddy, Sustainable

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Risk Assessment of Tree Failure Hazard of Trees Grown in the University Park, University of Peradeniya

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Wide range of trees both of indigenous and exotic origin have used to increase the aesthetic value of University Park of University of Peradeniya. However there were occurrences of tree failure in the University Park causing damage to property. Therefore identification of structural defects and evaluation of hazard condition is very important for conservation and management of trees and also considering the safety of large number of people visiting University Park. The objective of this research was to evaluate the hazard condition of *Samanea saman*, *Delonix regia* and *Peltophorum pterocarpum* trees growing in the University Park. 30 trees from each species were selected for the study. Height (H), Slenderness index (SL), Canopy imbalance index (CII), Percentage of pest and diseases (PD), Percentage of vine and epiphyte (VE), Intensity of cavity (CI), Canopy asymmetric index (CAI), Angle of tree (TA) and Weight on the cavity (WC), were the variables used to evaluate the tree hazard level by estimating Tree Stability Index (TSI). Trees were evaluated against those nine variables. The most related variables out of nine were selected using the stepwise multiple regression procedure. Considering selected variables mathematical models were developed for those three species using multiple regression procedure. TSI values for three species were calculated using these mathematical models. Of the *Samanea saman* trees evaluated 3.4% are at high risk level, 53.4% are at medium level and 43.2% are at low risk level. With *Delonix regia* 10% at high risk level, 46.6% at medium risk level and 43.4% at low risk level. *Peltophorum pterocarpum* had 30% low risk level and 70% medium risk level and did not had trees of high risk of failure. Research shows that of the 90 trees evaluated 5 (5.5%) are at high risk of failure and 51 (56.6%) are at medium risk. Hence TSI index can be used effectively to evaluate the stability of single trees.

This work was funded by the Department of Crop Science, Faculty of Agriculture, University of Peradeniya

Key words: Tree hazard evaluation, Tree stability index

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Allometric Relationships and Shading Patterns of Common Shade Tree Species Used in Landscaping and Perception of People about Shade Trees

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Landscaping is an emerging industry in Sri Lanka, which has a long history. However, yet people cannot reach their real expectations through landscaping. Therefore, landscape designers should understand the customer expectation to do a design successfully. Knowledge on tree parameters and their performances are very important to reduce the gap between expectation and real situation. In the present study, a survey was conducted to evaluate the perception of people about landscaping and shade trees. This study discusses six tree species namely, *Amherstia nobilis*, *Mesua ferrea*, *Tabebuia rosea*, *Filicium decipiens*, *Jacaranda mimosifolia* and *Mangifera zeylanica*. Measured tree parameters were tree height (TH), canopy width (mean crown radius - MCR) and the diameter at breast height (DBH). Thereafter, the relationships between tree parameters were investigated, such as tree height vs. canopy width and tree height vs. DBH. Light amount under the canopy was measured and analyzed the relationship with tree parameters and compared across species. According to the survey, there were no any significance differences between gender, educational level and age class for selection of landscape type for a home garden. Most people, who had a liking towards landscaping, liked the shade trees for their garden (58.1%). Tree canopies and their tree parameters can play a significant role in a landscaping design. Tree canopies can reduce the solar radiation that comes to the ground surface. According to the study, tree parameters were analyzed for identify the relationships among these parameters from species to species. These species show species-specific linear, logarithmic and exponential relationships among tree parameters. Moreover, the study compares the ratios such as MCR/DBH, DBH/TH and MCR/TH. In the DBH/TH ratio, there was no significant difference among the tree species except *A. nobilis* and *M. ferrea* ($P < 0.05$). Light and tree height relationship shows a logarithmic pattern except for *T. rosea*. With the increase of canopy width, light amount under the canopy become reduce in a logarithmic pattern. *M. ferrea* maintain a low light amount under the canopy (90% shade) than other species. Therefore understory vegetation cannot be maintained under *M. ferrea* canopy. According to the relationships and other data in this study, people can decide the trees compatible with the environment conditions such as wind, sunlight, space, near structure and people expectations such as shade, canopy cover.

Keywords: Landscape, DBH, MCR, Shade, Canopy width

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Time Series Analysis for Annual Production of Major Plantation Crops in Sri Lanka

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Plantation sector plays a significant role in Sri Lankan economy. This study mainly focus on modeling and analyzing of annual national productions of tea, rubber, coconut and annual tea productions in major three tea growing areas; high, medium and low grown. Annual national production data of tea, rubber and coconut in Sri Lanka from 1964 to 2013 and annual production data of tea in high grown, medium grown and low grown from 1970 to 2013 were collected from central bank reports of Sri Lanka. Time series models were fitted by the Box and Jenkins approach. Series were tested for stationary using the unit root test (Augmented Dickey–Fuller test). Differencing technique was applied to transform non-stationary series to stationary series. Model diagnostics were done by Ljung Box test, Box Pierce test and residual analysis. ARIMA (3,2,1) model was selected as the well fitted model for annual national production of tea, annual tea production in medium grown areas and annual tea production in low grown areas in Sri Lanka. ARIMA (2,1,1) model was well fitted for annual tea production in high grown areas in Sri Lanka. ARIMA (2,2,1) model was well fitted for annual rubber production and ARIMA (2,1,4) model was well fitted for annual coconut production in Sri Lanka. These time series models are useful for prediction of future production of major plantation crops in Sri Lanka and therefore useful for policy making.

Keywords: ARIMA, Differencing, Modeling, Time series, Unit root test

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Input Use, Productivity and Management of Organic and Conventional Homegardens Practiced in Wadduwa Area, Kalutara District

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Wadduwa area is located in the Low Country Wet Zone specifically in the agro-ecological region WL2b. Homegardens (HG) are a common agriculture practice in the area like other parts of Sri Lanka. Availability of resources, cropping patterns, crop management and problems and constraints were evaluated during the study. Field investigations were carried out during September-December, 2014 in the Wadduwa area in Kalutara District to characterize the HG practice. It is found that some of the gardens are managed only using organic inputs. Hence 20 HGs from both Conventionally Managed Homegardens (CMHGs) and Organically Managed Homegardens (OMHGs) were selected randomly for detailed study. HG layouts were sketched and a detailed study was conducted to characterize the cropping system. Questionnaire survey was conducted to evaluate the socio-economic status of people practicing HGs. Results revealed that there was no significant ($P=0.05$) difference between occurrence of vegetable species between OMHG and CMHG. Also no significant ($P=0.05$) differences were observed between two types of gardens in relation to the productivity of vegetables. Similar trend was observed with productivity leafy vegetables. It is found that vegetables produce of OMHG are used purely for home consumption. No specific Cropping season was observed in Wadduwa area in relation to vegetable cultivation in HGs. Most CMHG are using integrated methods in crop management. CMHG apply inorganic fertilizers. 70% of OMHG practice bin compost method. It is found that 85% of CMHGs adopt Integrated Pest Management (IPM) methods for pest and disease control. OMHG practiced traditional methods such as application of wood ash and natural extracts, traps, kem and other traditional methods. Flooding is the main constrain for homegardening as identified by the villagers. HG system is managed as a mixed cropping system. High crop diversity was observed in CMHG. Mukunawenna is the most dominant vegetable in both HG types, followed by Gotukola.

Keywords: Low country wet zone homegardens, Vegetable cultivation

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Validation of Integrated Dwarfing (gai) Gene in *Osbeckia octandra* using GUS assay and PCR method

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Osbeckia octandra (L.) Dc Prodr. (*Heen Bovitiya*) is a perennial endemic herb belongs to order Myrtales, family Melastomataceae with attractive phenotype characters which can be found in one of the 10 species in Sri Lanka and 50 species exists in the world. Attempts were made to produce transgenic *Osbeckia octandra* by integrating dwarfing (gai) gene in pJIT62 plasmid including the p35S promoter (CaMV promoter) and the GUS gene in the Department of Crop science, University of Peradeniya in 2013. The gai gene controls the height by inhibition suppression or reduction of plant growth as it antagonize Gibberallic acid (GA₃) production. Therefore, this study was conducted to detect and validate the gai gene integration in *O. octandra*. The leaf pieces of the plants which have been inserted with the gai gene through particle bombardment was evaluated through the GUS assay and Polymerase Chain Reaction (PCR) methods to detect the presence of the gene. The GUS assay is a histochemical assay where the GUS gene produces β -glucoronidase enzyme that breakdown X gluc solution into insoluble blue colour. If the blue colour appears on leaves that indicates that the GUS reporter gene is in the plant and theoretically the gai mutant gene is also should be there. The p35S promoter in the gene also can be used to detect the integration as it does not naturally occur in the plant. In PCR method p35S promoter is amplified by primers designed for the promoter. When promoter is detected it confirms the integration. GUS assay showed that there was no blue colour in the leaf pieces tested and also there was no any amplifications of the p35S promoter in Polymerase Chain Reaction. According to these observations it can be stated that the gai gene has not been integrated in to *Osbeckia octandra* plant tested in this study.

Keywords: gai gene, GUS assay, *Osbeckia octandra*, p35S Promoter, PCR.

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Suitability of CSUP Method for *in vitro* Establishment of *Dracaena sanderiana* L.

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This study was undertaken with the objective of evaluating the suitability of CSUP method for *in vitro* establishment of *Dracaena sanderiana* L. Sodium hypochlorite in 4 concentrations 5, 10, 15 and 20% v/v was used to rinse glassware and accessories before pouring the solid and liquid media for the varieties 'White', 'Victory' and 'Gold' of *Dracaena sanderiana* L. in *in vitro* establishment. Autoclaved culture media and culturing in a laminar air flow cabinet were used in the control. The highest contamination free cultures were obtained from 20% CSUP sterilized cultures ($P < 0.01$) with 60% in 'White', 65% in 'Victory', 95% in 'Gold' varieties in solid medium and 90% in 'White', 90% in 'Victory' and 95% in 'Gold' varieties in liquid medium. Highest shoot emergence was from the media sterilized with 5% CSUP solution ($P < 0.05$) with 100% in 'White', 86% in 'Victory' and 100% in 'Gold' varieties in solid medium and 47% in 'White', 100% in 'Victory' and 94% in 'Gold' varieties in liquid medium. Higher shoot lengths were achieved in solid medium than in liquid medium ($P < 0.01$). Highest shoot length was obtained from variety 'Gold' with a mean shoot length of 36.64 mm in solid medium and followed by varieties 'Victory' and 'White' 27.04 mm, 20.24 mm respectively. Highest shoot length was obtained from variety 'Gold' with a mean shoot length of 6.68 mm in liquid medium and followed by varieties 'Victory' and 'White' 6.2 mm, 2.52 mm, respectively. There was no significant difference among the control and CSUP treated cultures for shoot length ($P > 0.05$). There was also no significant difference among the control and the CSUP treated cultures for shoot quality ($P > 0.05$). Therefore, CSUP method can be used to establish *Dracaena sanderiana* L. *in vitro* as a low cost alternative to conventional sterilization method.

Keywords: CSUP, Low cost micro propagation, Sodium hypochlorite

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Relationship between Available Soil Nutrients and Effect of Cherrelle Wilt for Pod Development of Cocoa (*Theobroma cocoa* L.)

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Cherrelle wilt is a one major disease that affect for the pod development of cocoa (*Theobroma cacao* L.). There are two main reasons for the incidence of cherrelle wilt in cocoa. They are physiological disorders and soil nutrients. This study was carried out to determine the effect of the soil macro and micro nutrients to the cherrelle wilt incidence of cocoa. Therefore two different cocoa fields were selected and analyzed the soil macro/micro nutrient content (N, P, K, Ca, Mg, Zn and B). Then wilted pod count and healthy pod count were recorded every three weeks. The results showed that there is no significant relationship between soil macro/micro nutrients and incidence of cherrelle wilt ($P>0.05$). Field no.01 is rich with nutrients than field no.02. According to the yield of cocoa, field no.01 was higher than field no.02. However the cherrelle wilt incidence was also high in field no.01 than field no.02. The high yielding cocoa trees have high amount of cherrelle wilt and low yielding cocoa trees have low amount of cherrelle wilt. That concludes cherrelle wilt happening as thinning process of cocoa pods. According to results, the pod husk of cocoa can be used as K fertilizer to cocoa fields, because pod husks are very rich from K. According to results any stages of cocoa pod husks can be used as K fertilizer.

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Keywords: Cherrelle wilt, cocoa, micro and macro nutrients, physiological disorder, pod husk

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Effect of the Age of Stock Plant of *Averrhoa carambola* (Carambola) in Grafting

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Averrhoa carambola is an underutilized fruit in Sri Lanka. This study was conducted to find the effect of age of the rootstocks (2, 3 and 4 months) on grafting success of 2 Carambola varieties Arkin and Honey sweet. The experiment was conducted as two factor factorial designed as factorial experiment in completely randomized design with 3 replicates. Each replicate consisted of 12 plants. Success of grafting (%), growth parameters, microscopic observations of cross section of the graft union, sugar content and chlorophyll content of the leaves were measured. Success percentage, time taken to bud break, first shoot length, number of shoots, leaves, chlorophyll content were not significantly different between varieties but age of the root stock had significant effect. Highest grafting success (97.2%) was observed in scions grafted to four month old root stocks while lowest success (50%) was observed for two month aged rootstock irrespective of the variety. However, shortest time duration (9 Days) to bud break of survived plants was observed in scions grafted to 2 months old rootstock while longest duration (20 Days) was observed in four month aged rootstock in both varieties. Growth performance of plants grafted to 4 months old root stocks were significantly high compared to the 3 and 2 months old root stocks in both varieties. Highest mean number of shoots (2.97 ± 0.17 , 2.85 ± 0.16 Arkin and Honey Sweet respectively), mean number of leaves (47.31 ± 2.88 , 36.17 ± 2.85 Arkin and Honey Sweet respectively), total chlorophyll content (0.99 ± 0.02 mg/g, 0.87 ± 0.01 mg/g Arkin and Honey Sweet respectively), and sugar content (17.11 ± 0.11 mg/g, 16.18 ± 0.03 mg/g Arkin and Honey Sweet, respectively) were observed in plants grafted to 4 month old root stocks. Variety Arkin has significantly higher sugar content (17.11 ± 0.11 mg/g) than Honey sweet (16.18 ± 0.03 mg/g). Increase of both chlorophyll and sugar content was observed in grafted plants with maturity of the root stock. In contrast, longest shoots (7.87 ± 0.39 cm and 6.92 ± 0.60 cm Arkin and Honey Sweet respectively) and fast healing of cut surfaces as observed through microscope was observed in survived scions which are grafted to 2 months old root stock than four month age rootstock grafted in both varieties. The results of this study revealed that 4 months age root stocks are the best for the production of grafted Carambola plants.

Keywords: Age of rootstock, Carambola, Graft union, Success of grafting, Variety

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Dynamics of Proteoid Roots of Silver Oak (*Grevillea robusta* L.) under Field Conditions and Altered Root Environmental Conditions

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Silver oak (*Grevillea robusta* L.) produces special root structures with morphological and physiological significance called 'proteoid' or 'cluster' roots. The development of cluster roots occurs especially with deficiency of phosphorus and high soil organic carbon content. A field survey was conducted in two tea estates in two agro-ecological regions (WM1a, WM3b) where *G. robusta* L. was grown as a shade tree. Another experiment was conducted using a hydroponic system with optimum and low phosphorus treatments. As the third experiment, changes of cluster root development were studied with some selected soil properties. The results showed that the formation of cluster roots have a strong, significant and positive correlation with the availability of phosphorous and organic carbon under field and glass house conditions. The soil phosphorus content in the two agro-ecological regions were not significantly different ($P < 0.05$), which contained optimum amounts of available phosphorus for plant growth. With increasing number of cluster roots available phosphorus content was significantly increased ($P < 0.05$) in both regions. The cluster root increment coincided with the decrease in pH, possibly indicating secretion of organic acids. The availability of phosphorous had a significant effect on growth and development of cluster roots in the hydroponic medium. Cluster root development was also significantly higher ($P < 0.05$) with organic matter availability irrespective of the depth and other soil properties. The study shows that, in mid country soils of Sri Lanka, available soil phosphorous content increases with the growth and development of cluster roots, which is also highly dependent on the soil organic matter.

Keywords: Cluster roots/proteoid roots, *Grevillea robusta* L., Phosphorus, Organic carbon content, Hydroponic, Soil properties

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Selection of Appropriate Fertilizer Composition for Growth and Development of Orchid

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Strong market demand in recent years for potted *Dendrobium* plants has resulted in increased awareness and interest in commercial *Dendrobium* production and marketing. However, the major limitation of 2 years of lengthy vegetative phase has hindered its use as a potted plant. In order to overcome this barrier, it is required to enhance the vegetative growth through managing nutrients supplied to plants. Therefore, this study was conducted to find the most effective fertilizer combination for vegetative growth of cv 'Dendrobium Supenbury White × Doreen'. In this experiment, six liquid fertilizer combinations, T₁ -Boron+ Micronutrients + 20:20:20 NPK, T₂- Calcium + Micronutrients+ 20:20:20 NPK, T₃- Phosphorus + Micronutrients + 20:20:20 NPK, T₄ Potassium + Micronutrients+ 20:20:20 NPK, T₅ - Micronutrients + 6:30:30 NPK, T₆. micronutrients +20:20:20 NPK - (control) were compared on the vegetative growth performances. Well acclimatized micro propagated *Dendrobium* cv 'Denrobium Supenbury White× Doreen' (*Dendrobium phalaenopsis*-type white) plants were used in this experiment. Fifteen plants were allocated to each treatment. Coconut husk and charcoal were used as the growing medium. Number of shoots, number of leaves per pot, leaf length, shoots length, fresh weight and dry weight were measured at the end of the experiment. Fertilizer combinations significantly affected on vegetative growth performances of *Dendrobium* cultivar studied. The Boron + Micronutrients+ 20:20:20 NPK (T₁) treatment showed the highest dry (1.48 g) and fresh (15.28 g) weights and the highest shoot length (5.7 cm). However, the highest leaf length (6.94 cm) was recorded in the control. Number of shoots and number of leaves per pot were not significantly different among treatments. According to the result of the experiment it can be concluded that the fertilizer mixture of Boron + Micronutrients + 20:20:20 NPK (Robon™) is the most effective fertilizer for vegetative growth of *Dendrobium* cv 'Denrobium Supenbury White× Doreen'.

Keywords: Denrobium Supenbury White× Doreen, Fertilizer combinations

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Impact of Pre-harvest Factors and Post-harvest Treatments on Extending the Vase Life of Cut Foliage *Calathea zebrina* var. 'Humilior'

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Calathea zebrina is popular cut foliage exported from Sri Lanka. Wilting, yellowing and rolling are the problems to reduce vase life of *Calathea*. Experiment 1 was conducted to find, suitable time to be harvested among 6.00, 8.00, and 10.00 a.m., 2.00, 4.00 and 6.00 p.m. dipping in distilled water. Temperature was 20 °C air conditioned room, $15\mu\text{mol m}^{-2} \text{s}^{-1}$ of continuous light intensity. Vase life was measured. Six treatments were arranged in a Complete Randomized Design with five replicates. It revealed best harvesting times were 6.00 a.m. and 6.00 p.m. with no significant difference ($P < 0.05$) as 14 days. Based on the results of experiment 1, experiment 2 was conducted to investigate the best petiole length among 1.5, 10 and 15 cm by following the same procedure in experiment 2. It indicated 10 and 15cm performed vase life of 15 days. Experiment 3 was conducted according to the results obtained from experiments 1 and 2 to select the best post-harvest treatments among 40%, 50%, and 60% coconut water with 5% NaOCl, 5% Glucose + 5% NaOCl (Standard) and 0.1 mM GA₃ + 0.1mM BAP while distilled water as the control along with Direct dip, 3hr. pulsing and cotton plug and their combinations. The results showed that 3hr pulsing with 0.1 mM GA₃ + 0.1mM BAP, 50% and 60% Coconut water with 5% NaOCl were the best chemical treatments on leaves harvested at 6 a.m. And 6 p.m. with 10-15cm petiole length recording vase life of 31, 23 and 21 days. Average solution uptake among these treatments, was significantly different from the control and the standard in solution uptake. Therefore, the treatments of 0.1 mM GA₃ + 0.1mM BAP, 50%, and 60% coconut water containing 5% NaOCl have a potential to use as a preservative for *C. zebrina* harvested at 6 a.m. or 6 p.m.

Keywords: *C. zebrina* var. 'Humilior' cut foliage, Petiole length, Harvesting time, Coconut water, BAP

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Effect of Cytokinins for *ex vitro* Rapid Multiplication of Gerbera

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Gerbera hybrid is a perennial flowering plant and can be propagated through seeds, clumps, division of suckers and micropropagation. Plants propagated through division of suckers and clumps produce true to type plants and the easiest methods for propagating gerbera. However, natural multiplication rate is low and therefore, this method is not commercially viable. Thus, present study was conducted to evaluate the effects of BAP (6 Benzyl amino purine) on *ex vitro* rapid multiplication of *Gerbera hybrida*. Two and half month old Gerbera plants were treated with 100 µL four different concentrations of BAP (0, 500, 1000, 2000 mg/L) at six weeks, eight weeks and ten weeks after transplanting. Seedlings were transplanted in poly bags containing a mixture of top soil: paddy husk: coir dust at a 5:3:2 ratios. Six weeks after the final treatment (16 weeks after transplanting), newly produced suckers were separated from mother plants, treated with 500 ppm IBA for 10 minutes and repotted again in 14 inches diameter polythene bags containing a same potting medium. Plants treated with 1000 mg/L concentration of BAP is the best treatment which resulted early sucker initiation (13.75 ± 2.5 days), higher number of suckers per plant (5.2 ± 3.0) and high number of leaves per sucker (2.63 ± 1.1). There was no significant effect of BAP on flowering of gerbera plants. Good quality transplantable suckers could be obtained within one and half month after application of BAP treatments. All newly produced suckers (100%) grew successfully after re-potting on to same medium. The results of this study suggest that BAP can be used for *ex vitro* rapid multiplication of *Gerbera hybrida*.

Keywords: *Gerbera hybrid*, Cytokinin (BAP)

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Development of Hydroponic Protocol for Aromatic Herbs, Basil (*Ocimum basilicum* L.) and Mint (*Mentha* spp.) under Greenhouse Conditions in the Mid Country Wet Zone

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This study was conducted to aid the existing knowledge based on hydroponics basil (*Ocimum basilicum* L.) and mint (*Mentha* spp.) cultivation in Sri Lanka with the ultimate goal of meeting the local market demand for aromatic herbs, basil and mint. The experiment was conducted as two separate greenhouse trials for both basil and mint simultaneously. Those herbs were grown in soil; grow bags/aggregate culture and troughs/liquid culture. Vegetative growth of above two aromatics herbs grown in above hydroponic methods were compared with soil grown herbs (control) under mid country wet zone greenhouse conditions to identify the best protocol of hydroponics for each aromatic herb. The mean values obtained for the plant height of basil and mint grown in trough culture after six weeks were 47.297 cm and 22.547 cm, respectively while the same for number of leaves were 80 and 179, respectively. Similarly significantly ($P<0.05$) higher number of shoots (14 and 24), higher leaf area (824.7 cm^2 and 742.91 cm^2), higher shoot dry matter (1.19 g and 1.12 g) and higher leaf dry matter (2.35 g and 1.64 g) were found for basil and mint (respectively) in trough culture, compared to grow bag culture and conventional soil culture. As root parameters, root dry weight of both basil and mint were significantly ($P<0.05$) higher in both hydroponics methods than the soil. There was no significant difference ($P<0.05$) of root length in mint among cultivation methods but grow bag culture of basil resulted higher root length of 171.42 m. According to the results, both herbs grown in hydroponics showed better vegetative growth performances than herbs grown in the soil under mid country wet zone greenhouse conditions. Based on overall results, the best growth performance could be found in trough/liquid culture for both basil and mint, compared to grow bag/aggregate culture.

Keywords: Basil, Mint, Hydroponics, Grow bags, Troughs

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Testing New Propagation Techniques, Chip Budding and Stenting for Selected Rose Cultivars in the Mid Country Intermediate Zone

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The main objective of this experiment was testing the applicability of Chip budding and Stenting propagation techniques for Black magic, Grand Gala and White Success rose cultivars under tropical weather. The technique of propagation was significant on growth of roses ($P \leq 0.05$), except for leaf area, time taken to first flower bud initiation, length of flower bud and diameter of flower bud. Stenting gave the highest number of leaves (14.3 ± 0.58), rate of stem elongation ($5 \pm 2.5 \text{ cm week}^{-1}$), plant height ($23.33 \pm 7.37 \text{ cm}$) and vigour of the new growth (7 ± 1) at $P \leq 0.05$ significant level. And stenting technique reported the shortest time taken to succeed budding ($13.6 \pm 3.3 \text{ days}$) and to flower bud formation at $P \leq 0.05$ significant level. Also, there were significant differences among cultivars. The cultivar Black Magic reported higher number of leaves (14.3 ± 0.58), plant height ($23.33 \pm 7.37 \text{ cm}$) and growth rate ($5 \pm 2.5 \text{ cm wk}^{-1}$) at $P \leq 0.05$ significant level. Also it reported a shorter time to succeed the budding and to flower bud formation compared to other two cultivars. According to results, stenting technique was found to be the most suitable propagation technique for cut rose production, especially for rose cultivar, Black Magic, in the mid country intermediate zone. Further studies may be needed to reveal the conditions required for stenting technique to be adaptable in other climatic regions in Sri Lanka

Keywords: Chip budding, Cut flower, Propagation technique, Stenting

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Effect of Exogenous Application of Gibberellins and Silicon Supplementation for Floricultural Quality Traits of Cut Gerbera

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Gerbera hybrida belongs to family Asteraceae. It is a perennial flowering plant which produces flowers throughout the year. This study was conducted to identify the effect of exogenous application of gibberellins and silicon supplementation for floricultural quality traits of cut Gerbera. Two months old 144 Gerbera plants which were potted in quarter litter poly bags containing Top soil: Burnt paddy husk: Coir dust at a 5:3:2 ratios were used as experimental units. There were six treatments. (T1 is the control one, T2 only GA₃(Gibberellins) application once, T3 only Na₂SiO₃ weekly application, T4 GA₃ once+ weekly Na₂SiO₃ application, T5 GA₃ twice+ weekly Na₂SiO₃ application, T6 GA₃ thrice + weekly Na₂SiO₃ application). GA₃ was applied as a 1000 ppm solution, 10 µL drop per plant, in two weeks interval. Na₂SiO₃ was applied as a 50 ppm solution, as a foliar spray, in one week interval. Highest vegetative growth observed at T6. The length of the longest leaf was recorded as 27.96±1.3 cm in 6th treatment and there were not significant differences in number of leaves per plant among treatments. When consider about the flowering, first flowers initiated at T4 (35.66±2.08 days after transplanting). The highest cumulative flower number (14) observed in T4 at eleventh week after transplanting. When consider about the flower quality the best quality flowers could be observed at T4. The highest flower diameter (10.1±0.65 cm), longest peduncle length (52±2 cm), highest ray floret length (4.53±0.25 cm), highest ray floret width (1.03±0.15 cm), highest basal peduncle diameter (0.65±0.01 cm), highest epical peduncle diameter (0.48±0.03 cm) and highest vase life (16.66±1.52) also were observed in T4. Floricultural quality traits (flower diameter, peduncle length, basal and apical peduncle diameter, ray floret length and width, vase life) of *Gerbera hybrida* can be improved by foliar application of 1000 ppm GA₃ once at 2 weeks after transplanting (10 µL drop per plant) and 50 ppm Sodium Silicate (Na₂SiO₃) Foliar spray at weekly intervals.

Keywords: *Gerbera hybrida*, Gibberellins (GA₃), Sodium silicate (Na₂SiO₃)

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Combined Effects of Water and Heat Stresses on Growth and Physiology of Rice Varieties of Different Age Classes

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Drought and heat stress are two important abiotic stresses affecting crops, especially in view of future climate change. The objective of this study was to determine the combined effects of water and heat stresses on growth and physiology of three rice varieties (Bg250, Bg300, Bg352) representing three age classes. Plants were grown in aerated nutrient solutions, in controlled environmental growth chambers, under two temperature regimes, maintained at daily mean temperatures (T_a) of 32°C (Day/Night-36/28°C) and 28°C (30/26°C), with a 12-hour photoperiod. Within each temperature regime, water stress was imposed 49 days after transplanting (DAT) by adding 10% of polyethylene glycol, creating an osmotic potential of -0.355 MPa. All plants were harvested within vegetative stage at 56 DAT. There were no significant ($P < 0.05$) three-way or two-way interaction effects on any growth measurement. Increasing T_a from 28°C to 32°C reduced total biomass, leaf area and root length in all three varieties. However, heat stress did not affect biomass partitioning. Water stress reduced dry weights and leaf area in Bg250 only. Heat stress decreased the total absorption of nitrogen, phosphorus and potassium in all three varieties. However, water stress reduced only N and K absorption in Bg250 and P and K absorption in Bg352. Heat stress did not have a consistent effect on nutrient absorption efficiency (total absorption per unit root length). Water stress did not affect nutrient absorption efficiencies. Nutrient use efficiencies (biomass produced per unit of nutrient absorbed) showed significant ($P < 0.05$) heat x water stress interactions. Net photosynthetic rate (P_n) increased with increasing temperature in Bg300 and Bg352 while P_n of Bg250 was unaffected. Based on percentage changes in measured characters in response to heat and water stress, Bg352 were identified as least susceptible to both stresses. Bg300 and Bg250 were the most susceptible to heat and water stress, respectively.

Keywords: Rice, Heat stress, Water stress, Nutrient absorption efficiency, Nutrient use efficiency

Rooting and Acclimatization of *Exacum trinervium* (Binara)

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To develop low cost protocol for rooting and acclimatization of *in vitro* regenerated *E. trinervium*, *in vitro* rooted plantlets on MS medium supplemented with 2 mg/L IBA were transferred to medium consisted of coir, sand and top soil as layers (1:1:1) and grown under *ex vitro* and *in vitro* conditions. All the plants acclimatized (100%) under *in vitro* condition survived while 81.81% survived under *ex vitro* condition. No significant differences in plant height, leaf area, plant fresh and dry weights, newly emerged number of leaves, mean root number was observed in both conditions suggesting, acclimatization of *in vitro* rooted plantlets under *ex vitro* condition is possible to reduce the cost of production. Possibility of simultaneous rooting and acclimatization of micro shoots were investigated in soil based media (sand, sand: red soil: 1:1, red soil, top soil 1:1 and top soil: sand 1:1) and MS media after pulse treatment with IBA (500 mg/L). MS medium incorporated with IBA (2 mg/L) and MS media were used as the controls. Rooting performance of shoots was better in soil based media than MS based media. It was observed highest mean root length and total root length top soil: Sand mixture (1:1) (T5: 4.0 cm), top soil and red soil (T6: 4.15 cm) and red soil (T2: 4.1 cm) while higher mean number of roots in both sand (T3; 40) and top: sand mixture (T5: 40) four weeks after establishment. There was 100% survival except in top soil (T6: 90%) and no significant effect of rooting media on the plant height, plant fresh and dry weights, leaf area, cumulative number of newly produced leaves, and leaf chlorophyll content, suggesting, top soil: sand mixture as the most suitable medium for simultaneous rooting and acclimatization of *E. trinervium*.

Keywords: Acclimatization, *Exacum trinervium*, Low cost, Rooting

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Effects of Macro and Micro Nutrient on Vegetative Growth of Anthurium (*Anthurium andreanum* Lind.) Cultivar 'Tropical Red'

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Anthurium (*Anthurium andraeanum* L.) 'Tropical Red' is one of the most important cut flowers among tropical plants. Knowledge on effective fertilizer mixtures is important to commercial growers as plant growth and flowering are enhanced by them. Therefore, this research was conducted with the objective of determining the most suitable fertilizer combination for the vegetative growth performance of Anthurium cultivar 'Tropical Red'. Six fertilizer treatments, T1- NPK 20:20:20 fertilizer (Recommended level of NPK fertilizer by the Department of Agriculture), T2- NPK 20:20:20 fertilizer+ granular micro nutrients (Granular crop), T3- NPK 20:20:20 fertilizer+ micro liquid fertilizer (Micromax), T4- only micro granular fertilizer, T5- only micro liquid fertilizer, T6- without any fertilizer were compared in this study. All plants were arranged randomly under uniform shade condition (70%). Plants were established in 9cm*11.5cm (height * diameter) pots and 15 were included in each treatment. Experiment was arranged in a completely randomized design with five replicates. Plant height, number of leaves, leaf area, petiole length, leaf length, leaf width, plant fresh weight and plant dry weight were evaluated. The results showed that fertilizer treatment of balance NPK fertilizer with micro nutrient liquid fertilizer treatment (T3) had a significant increased ($P < 0.05$) in leaf number (8.86), shoot height (13.08 cm), root dry weight (1.11 g) and shoot fresh weight (16.41g). Shoot dry weight and leaf length was not significantly different in (T1) NPK fertilizer treatment, (T2) NPK with granular micro nutrient treatment and (T3) NPK with liquid fertilizer treatment. Leaf area, leaf width, root fresh weight did not show any significant differences for fertilizer treatments. But highest mean values were recorded by the (T3) NPK balance macro fertilizer with micro nutrient liquid fertilizer treatment. The plants which did not receive any fertilizer treatment (T6) showed the lowest increase in the leaf area, leaf length and height of plants. The results revealed that, the use of NPK balance fertilizer with liquid micro nutrient has a significant impact in increasing vegetative growth of Anthurium cultivar 'Tropical Red'.

Key words: *Anthurium andreanum*, Balance fertilizer, Micro nutrients

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Variation of Key Shoot and Root Characters in Selected Medium- and Long-Duration Rice Varieties Representing Different Periods of the Varietal Improvement Programme in Sri Lanka

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Continuous yield improvement in rice is essential to ensure future food security in Sri Lanka. For this purpose, new rice varieties with greater yield potential need to be developed. This study was conducted to identify the variation of shoot and root characters of a selected set of medium- and long-duration rice varieties introduced during different periods of the rice varietal improvement programme in Sri Lanka. Ten rice varieties representing different varietal groups (Traditional - Pachchaperumal, Old Improved - H10, New Improved - Bg379-2, Bg400-1, Bg450, Bg380, Bg352, Bg358, Bg407H, Bg366) and periods of release from 1950 to 2010 were grown under optimum conditions in a rain sheltered plant house. The majority of growth characters showed significant ($P < 0.05$) variation among the varieties tested. Tiller number, leaf area and leaf dry weight showed decreasing trends with time during varietal improvement. In contrast, specific leaf weight showed an increasing trend. Highly significant ($P < 0.0001$) varietal variation was shown for net photosynthetic rate (P_n), stomatal conductance (g_s), transpiration rate (E_t) and transpiration efficiency (T_E). P_n and g_s increased in varieties released from 1970s to 1990s before decreasing thereafter. Bg366, released after 2000, had a substantially lower P_n and a higher g_s than the rest, thus having a higher E_t and a lower T_E . A decreasing trend was shown for T_E from 1970s onwards. Significant ($P < 0.05$) varietal variation was shown for total root length (TRL), but not for mean root diameter or total root surface area. Fine roots (< 0.5 mm in diameter) contributed to 73 – 91% of the TRL in all varieties. Significant ($P < 0.05$) varietal variation was shown for nitrogen-, phosphorus- and potassium use efficiencies (biomass per unit nutrient absorbed), and their absorption efficiencies. The above findings could be useful in providing guidelines in future rice varietal improvement.

Keywords: Rice, Varietal improvement, Nutrient absorption, Nutrient use efficiency, Root length

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Comparison of Growth and Yield Performance of Tissue cultured and Mini Tuber plants of Two Potato Varieties in an Aeroponic System

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Even though there are number of seed potato production systems in Sri Lanka to meet the seed potato demand, lack of high yielding planting materials is a main reason for the inefficiency of such systems. The objective of this study was to compare the growth and yield performance of tissue cultured and mini tuber plants of two potato varieties in an aeroponic system. This research was conducted at the agricultural research station, Sita Eliya using two commercial potato varieties (Granola and Golden star) and two types of planting materials (tissue cultured and mini tuber plants) of each variety. Plant growth and plant yield parameters were measured. Results revealed that interaction between planting materials and varieties was highly significant ($P < 0.005$) for plant height, stolon length, root length, root dry weight, leaves dry weight, shoot dry weight, number of tubers per plant ($P < 0.0001$) and fresh tuber weight per plant. The interaction effects was not significant ($P < 0.05$) for number of leaves and number of stolons. When considering the fresh tuber weight per plant, in tissue cultured plants, Golden Star had the highest value when comparing with the Granola. But in mini tuber plants there was no significant difference ($P < 0.005$) between two varieties. Therefore, there was a significant influence of tissue cultured plants on productivity of the aeroponic system and tissue cultured plants of variety Golden Star were more productive. The response of tissue cultured plants under aeroponics conditions is cultivar dependent.

Key words: Aeroponic, Tissue culture, Mini tubers, Seed potato

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Phenotypic Plastic Responses in Morphological Traits of *Gerbera jamesonii* in Response Different Shade Levels

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Gerbera jamesonii is known as a cut flower in world floriculture industry. It is naturally inhabited in South Africa. This study was undertaken to test whether variation of leaf and flower morphological characters alter in response to light heterogeneity to test their adaptability to different microclimatic conditions and to identify the interrelationships among leaf and flower parameters. Leaf and flower parameters were taken from ten different farmer fields in two different districts, each location including 10-15 plants. Number of leaves, leaf length, leaf width, petiole length, and leaf area and leaf color grade were taken as the leaf parameters, whereas number of flowers, flower diameter, length of ray florets, center diameter, angle between flower and pedicel and flower color grade were measured as flower parameters. The light level inside and outside of the net house was taken at each location in bright sunny day to obtain the shade level received by plants. The results revealed that the shading has a significant effect on some of the leaf and flower parameters of *Gerbera*. Leaf length, leaf width and leaf area showed moderate relationships with shade heterogeneity ($P < 0.05$, $r^2 \sim 0.13-0.67$) with fitting to quadratic model and, petiole length did not show a correlation with shade heterogeneity ($P > 0.05$). Flower diameter and pedicel length were showed significant correlations with shade ($P < 0.05$, $r^2 \sim 0.3-0.6$). Those parameters also showed moderate relationships with fitting to quadratic model. Leaf length, leaf width, leaf area and petiole length which is leaf size determining parameters showed significant ($P < 0.05$, $r^2 \sim 0.22-0.64$) interactions with each other. Leaf parameters showed interrelationships with fitting to linear model. As well-known, leaf area is increased with increasing shade level to capture more light for photosynthesis. And flower parameters in *gerbera* were interrelated each other to maintain quality flower characters under different environment conditions. *Gerbera* showed better performance around 45-53% shade range. The optimum shade is $\sim 49\%$ to maintain high quality flower production. This indicates that *Gerbera* shows a lower performance under low and high light levels, thus *Gerbera* can be recognized as moderately plastic in morphological characters in response to shade heterogeneity.

Key words: *Gerbera jamesonii*, Phenotypic plasticity, Shade tolerance

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Evaluation of Root Distribution Pattern of Selected Coconut Cultivars at Early Bearing Stage under Different Climatic and Soil Conditions

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Human inhabitation and climatic changes are the main contributory factors for reduction of extent of coconut growing lands in traditional areas, consequently, moving the cultivating areas to nontraditional areas. The limitations in soil, climate and water create great challenge for coconut cultivation in those areas. Strong well distributed root system is extremely important to withstand in those marginal areas. This experiment was conducted to identify the root distribution pattern and active root zone of 4 improved coconut cultivars (CRIC 60, CRIC 65, CRISL 98 and *Kapruwana*) at early bearing stage. Experiment was conducted with above cultivars under 3 climatic zones with 2 land suitability classes (LSC) on S1/S2 and S3/S4. Soil core samples were collected from 4 different distances from the base of each palm at 5 different depths in 2 opposite direction. Roots were separated by washed soil core method. Number of roots, dry weight and root length were measured for primary and other roots separately. All tested cultivars showed significantly ($P < 0.05$) lower root distribution in S3/S4 LSC. All cultivars showed significantly ($P < 0.05$) higher root distribution in Intermediate Zone while the lowest was observed in Wet Zone. More than 90% of the roots out of the total roots, presents within the first 150 cm from the base of palm in dry zone. More than 85% of the total roots present within the first 100 cm distance from the base of palm in Wet Zone. This would indicate the need of adjusting the manure circle according to the active root zone in different regions and LSC. Among four improved cultivars *Kapruwana* cultivar was showed significantly higher ($P < 0.05$) root distribution in Dry Zone. CRIC60 cultivar showed significantly higher root distribution in marginal soil classes (S3/S4)

Keywords: Coconut, CRIC 60, *Kapruwana*, Root system

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Effect of Application of Benzylaminopurine and Gibberellic Acid on Lateral Shoot Induction of Decapitated *Philodendron erubescens* cv 'Gold'.

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Philodendron erubescens (K. Koch & Augustin) cv 'Gold' is an important potted plant species which is used as a cut foliage in the local and export markets. Unavailability of planting material is the major problem and due to high capital and running cost *in vitro* propagation is also not feasible. Therefore, this experiment was conducted to investigate the effective hormone combinations to increase lateral shoot induction under *in vivo* condition. In this experiment, cuttings of *Philodendron erubescens* cv 'Gold' were established in the polythene bags. Rooted cuttings were decapitated after one month and the plants were treated with eight combinations which comprised with two different concentrations (250 ppm, 500 ppm) of BAP and four different concentrations of (125 ppm, 250 ppm, 375 ppm, 500 ppm) of GA3 twice in weekly intervals. The plants in the control were not treated with any hormone application. Number of lateral shoots, number of new leaves, length of lateral shoots, length of apical shoot and leaf length on the shoots had been measured for six weeks. There was a significant variation ($P < 0.05$) between the control and other treatments on lateral shoot formation and lateral shoot elongation in *Philodendron erubescens* cv 'Gold'. Plants treated with 500 ppm BAP in combination with 500 ppm GA3 showed the highest number of lateral shoots (2.6). Highest length of lateral shoots (1.4 cm) was recorded in plants treated with 500 ppm BAP in combination with 375 ppm GA3. Since there was no significant difference among treatment it is economically viable to use 250 ppm BAP in combination with 250 ppm GA3 as the most effective hormone combination that increased number of lateral shoot from decapitated *Philodendron erubescens* cv 'Gold'.

Keywords: Benzylaminopurine, Gibberellic acid, Hormone combinations, *Philodendron erubescens* cv 'Gold'

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Validation of a DNA Probe to Detect Chilli Leaf Curl Virus in Alternative Host Plant Tissues

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Chilli (*Capsicum annuum* L.) is an economically important cash crop and a major condiment in Sri Lanka. Cultivation of chilli in Sri Lanka is limited primarily due to chilli leaf curl virus, (CLCV) a begomovirus transmitted by whitefly (*Bemisia tabaci*). Preventive measures are more efficient in the management of plant virus diseases due to lack of therapeutic measures. Weed plants are behaving as alternative hosts of insect vectors transmitting plant viruses. Identifying alternative host plants harboring CLCV would be useful to design effective management programmes of virus diseases of chilli. Due to latent infections, mixed infections and complexity of field symptoms, identification of host plants bearing viruses through symptoms is not reliable. In the present study, an already developed DNA probe specific for CLCV was validated to detect the CLCV in alternative host plants. Eleven weed species showing virus-like symptoms were collected from fields having virus-infected chilli plants. DNA was extracted from the weed samples using Doyle and Doyle method. Genomic DNA was subjected to dot-blot hybridization with the already prepared DNA probe and signal detection was done through colourimetric method. Hybridization results given by the DNA probe were confirmed by PCR using CLCV specific primers. Among the weed species *Borreria* spp. (gatakola), *Tagetes patula* (marigold), *Amaranthus* spp. (koorathampala), *Emilia sonchifolia* (kadu pahara) and *Ludwigia hyssopifolia* gave positive signals with the DNA probe.

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Keywords: Begomovirus, Dot-blot hybridization, Weed hosts, Probe, Hybridization

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Identification of Causal Agents Associated with Chilli Plants Showing Virus-like Symptoms

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Chilli (*Capsicum annuum* L.) is one of major cash crops grown in Sri Lanka which belongs to family Solanaceae. Chilli crop, cultivated in Sri Lanka, experiences heavy yield losses due to virus diseases. Many virus diseases of chilli show similar symptoms, hence, identification of virus diseases based on symptoms is not reliable. Moreover, phytoplasma infections also cause virus-like symptoms in chilli plants. The objective of the present study was to identify the causal agents associated with chilli plants showing virus-like symptoms with a special reference to DNA and RNA viruses and phytoplasma using PCR techniques. Chilli plants showing virus-like symptoms were collected from different fields of Kandy district. CTAB method was used to extract DNA from chilli leaf samples. The protocol based on Cheng and Seemann method was successful in extracting RNA from chilli leaves. PCR was performed using begomovirus specific primers namely, Bega Cp F/R and Begomovirus F/R and phytoplasma specific primers (WL-F and WL-R). The PCR product with the expected size of 771 bp was detected in samples infected with begomovirus and a PCR product of 1250 bp was expected in samples infected with phytoplasma. In the present study, 61.5% of the samples showing virus-like symptoms were infected with begomovirus and the virus was identified as chilli leaf curl virus through DNA sequencing and subsequent homology search. However, phytoplasma was not detected in the used samples. Even though, some of the samples showing virus-like symptoms were positive to cucumber mosaic virus through immunoassays (e.g. ELISA), CMV could not be detected by RT-PCR.

Financial assistance by HETC/PGIA/QIG3 is acknowledged.

Keywords: Chilli leaf curl complex (CLCC), Begomovirus, Phytoplasma, Cucumber Mosaic Virus (CMV), Polymerase Chain Reaction (PCR)

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Evaluation of Performance *Trichogrammatoidea bactrae* Nagaraja under Field Conditions for Controlling of Rice Leaf Folder (*Cnaphalocrocis medinalis* (Guenee))

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Rice leaf folder (*Cnaphalocrocis medinalis*) is one of the major insect pests in rice, causing defoliation by larvae. Farmers tend to use insecticides heavily to control the larvae, and it leads to destroy the natural enemy population in rice ecosystem. Therefore, use of egg parasitoids is suggested to use as augmentation and release. Field experiments were carried out at Batalagoda and Galagedara to evaluate the performance of *Trichogrammatoidea bactrae* as a bio control agent against rice leaf folder. *T. bactrae* was mass reared on *Corcyra cephalonica* eggs and they were released in three different rates at 6, 10 and 20 adults/m² in one square meter research plots. Research plots were continuously monitored by sampling the RLF eggs, insect pests and natural enemies. Meteorological data during the study period was recorded. A total of 211 and 456 insect pests were collected from Batalagoda and Galagedara respectively. The pest populations were not significantly varied ($X^2=1.550$ df= 3 $P>0.05$) within the each locations. Higher number of natural enemy population was recorded in Galagedara (478) compared to the Batalagoda (422). Gall midge and short horn grass hoppers were the prominent pest species in Batalagoda and Galagedara respectively. Bottle neck beetle was the dominated natural enemy in both locations. Parasitism percentage of *T. bactrae* was not significantly varied among treatments at Batalagoda ($X^2=1.149$ df= 3 $P>0.05$) or at Galagedara ($X^2=5.886$ df= 3 $P>0.05$). However when the parasitoid was released at the rate of 20 adults/m², the parasitism percentages were 68% at Batalagoda and 62% at Galagedara. Parasitism percentage of *T. bactrae* was positively correlated with rainfall (CV=0.856) and negatively correlated with temperature (CV=-0.826). These results revealed that *T. bactrae* could be mass reared and released in field in order to control the rice leaf folder effectively.

Keywords: *Cnaphalocrocis medinalis*, *Trichogrammatoidea bactrae*, Natural enemies

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Diversity of Egg Parasitoids in Vegetable ecosystems in the Mid-country Region of Sri Lanka

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Application of insecticide is the most common strategy for managing insect pests in vegetables. This strategy creates many environmental consequences and health problems among consumers; hence, it is important to have an alternative strategy. Biocontrol of insect pests has been suggested as an alternative within integrated pest management. Use of egg parasitoid is more promising in biocontrol programme considering its mode of action. However, egg parasitoid fauna in Sri Lanka has been poorly studied; therefore, objective of this study was to assess the diversity of egg parasitoids in vegetable ecosystem in the mid-country region. Weekly samples of eggs of vegetable pests: Paddle leg bug (*Leptoglossus australis*), Pentatomid bug (*Nezara viridula*), Blue bean butterfly (*Lampides boeticus*) and Leaf eating caterpillars were collected in home gardens. Field collected eggs were individually reared in plastic vials in the laboratory until the emergence of host larvae or parasitoid adults. The emerged adult parasitoids were preserved in 70% ethanol. The parasitoid adults were dissected and slide mounted for microscopic examination. Morphological structures of antennae, wings and genitalia were used for the identification as per the taxonomic keys and published literature. Parasitoid adults were identified upto species and genus level. *Trichogrammatoidea prabhakeri* and *Telenomus* species were found as egg parasitoids of blue been butterfly in long bean and cowpea. The parasitism percentages were 29.4% and 6.6% respectively. Two species of *Trissolcus* were also identified as egg parasitoids of pentatomid and paddle leg bug eggs in brinjal. Parasitism percentages were 92.9% and 19.6% respectively. Abundance of *Trichogrammatoidea* parasitoids did not significantly varied ($P>0.05$) among different sampling sites. Relative abundance of parasitoids of *Trichogrammatoidea* and *Telenomus* did not vary with the crops.

Keywords: Diversity, Insecticide, Parasitoid, Vegetable ecosystem

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Detection of Causal Viruses in Cucumber and Tomato Showing Mosaic Symptoms by PCR

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Tomato (*Solanum lycopersicum* L.) and Cucumber (*Cucumis sativus* L.) are important vegetable crops grown in Sri Lanka. Cucumber mosaic virus (CMV) causes severe yield and quality losses of tomato and cucumber. Moreover, involvement of begomovirus with cucumber plants showing mosaic symptoms has been speculated. However, symptom-based identification of virus is not reliable due to latent infections and mixed infections. PCR and Reverse Transcription Polymerase Chain Reaction (RT-PCR) can be used as effective molecular-based diagnostic methods to identify viruses having DNA and RNA genomes, respectively. Extraction of RNA from plant tissues is difficult due to presence of high amounts of polysaccharides, polyphenols and RNase in plant tissues. Objectives of the present study were to optimize RNA extraction protocols for tomato and cucumber and PCR conditions to detect CMV and begomovirus in tomato and cucumber plants showing mosaic symptoms. RNA extraction from tomato and cucumber leaf tissues was done by TRIzol reagent method described by Hsin-Mei WANG *et al.* (2009) and CTAB method described by Yang *et al.* (2008), respectively. Complementary DNA (cDNA) was prepared using Go-script reverse transcription system. A gradient RT-PCR was done to optimize PCR conditions using CMV3 and CMV5 primer pair to detect CMV. DNA extraction of cucumber leaf tissues was done using Doyle and Doyle method (1990) to detect begomovirus associations in cucumber. A modified method of CTAB method developed by the present study was the best to extract high quality RNA from tomato and cucumber. However, the optimization of PCR conditions to detect CMV was not successful and the possible reasons have been discussed. PCR revealed that no involvement of begomovirus in cucumber plants showing mosaic symptoms.

Financial assistance by HETC/PGIA/QIG3 is acknowledged.

Keywords: Begomovirus, Cucumber mosaic virus, RT-PCR

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Genome wide Genetic Diversity Analysis of *Suduru samba* Rice (*Oryza sativa* L.) based on SSR Polymorphism

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Molecular characterization of genotypes gives precise information about the extent of genetic diversity. Assessing the genetic diversity of the traditional rice variety '*Suduru samba*' which has 11 accessions as replicates at the PGRC is a timely requirement. Main objective of this study was to select a set of closely related accessions of using molecular analysis. Total 13 accessions [11 *Suduru samba*, one *Kaluheenati* (traditional) and one Bg360 (new improved)] were evaluated by 31 SSR markers distributed widely over the rice genome. DNA was extracted from tender leaves of 14 days old seedlings using modified CTAB method and PCR amplicons were separated using 8% polyacrylamide gel electrophoresis. Average linkage clustering, Principle component analysis (PCA) and Polymorphic information content (PIC) analysis were performed to assess the genetic diversity. A significant degree of genetic diversity was found among the accessions. A total of 184 alleles were detected by 31 markers, all of which were (100%) polymorphic. Allele richness ranged from 3 to 9 per locus. The first two principal components cumulatively explained about 39.89% of the total variation among the 13 accessions. Polymorphic information content values varied from 0.8758 to 0.4230. Seed morphology analysis was done using 7 seed characters to compare the results. The first three principal components cumulatively explained over 85% of the variation and first two principal components explained about 74.79% of the variations. Molecular and seed morphology clusters delineated the 11 accessions effectively and highly related accessions 2202, 3333, 3594, 5402 and 3671 were selected as the representative set of *Suduru samba*. These results will pave way for establishing a reliable seed certification scheme for *Suduru Samba*.

Financial assistance by Plant Genetic Resource Centre, Gannoruwa, is acknowledged.

Keywords: Accessions, Genetic diversity, Polymorphism, SSR, *Suduru samba*

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Assessment of Feeding Potential of *Coccinella transversalis*, *Coccinella sexmaculata* and *Illeis cincta* on Black Bean Aphids

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Pest management is an important practice in crop cultivation to reduce the crop loss, and to ensure enhanced economic benefits for the farmers. Crop protection is mainly done by applying synthetic insecticides; however, there are many negative impacts on insecticide use such as environmental pollution, effect on non-target organisms, health hazard on human and accumulation of insecticide residues in food chain. Biological control has been suggested as an alternative. The main objective of this study was to generate required data to implement a biocontrol project through augmentation and release. These experiments were conducted to assess feeding potential of *Coccinella transversalis*, *Coccinella sexmaculata* and *Illeis cincta* (Coccinellid Beetles) on black bean aphids. In addition, a field survey was conducted to assess the diversity and abundance of Coccinellid beetles on Leguminosae, Solanaceae and Cucurbitaceae crops at Gannoruwa. Their abundance was reported on weekly basis and there was a significant difference ($P < 0.05$) in coccinellid species abundance among the selected three crops. According to the field study, eleven coccinellid species: *Anegleis cardoni*, *Coccinella sexmaculata*, *Coccinella transversalis*, *Coccinella octomaculata*, *Illeis cincta*, *Micraspis discolor*, *Crptolaemus montrouzieri*, *Propylea dissecta*, *Brumoides suturalis*, *Axinoscymnus puttarduri*, *Axiniseymnus spp.*, were found in all crops. Ten coccinellids species were found in legumes, five species were found in Solanaceae, and six species were found in Cucurbitaceae crops. Three species: *Coccinella transversalis*, *Coccinella sexmaculata* and *Illeis cincta* were selected for further on feeding rate on black bean aphids. Feeding rate of each beetle species was calculated on daily basis. Feeding potential of *Coccinella transversalis* was 46.2 ± 6.2 aphids. It was 45.5 ± 6 for *Coccinella sexmaculata*, and 27.6 ± 5 for *Illeis cincta*. *C. transversalis* larvae consumed 55.6 ± 6.2 aphids per day. According to the results, above three species can be considered as potential candidates in controlling black bean aphids.

Keywords: Biological control; *Coccinella transversalis*; *Coccinella sexmaculata*; *Illeis cincta*; Feeding potential

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Evaluation of (*Cryptolaemus montrouzieri* Mulsant), a Coccinellid Predator, as a Potential Biocontrol Agent to Control Papaya Mealybug (*Paracoccus marginatus* Williams and Granara de Willink)

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Pest management is an important aspect in crop production mainly due to high crop loss associated with pest injuries. At present, the most popular method of pest control is pesticide application. In chemical control, there are many negative impacts: therefore, Integrated Pest Management (IPM) has been suggested to reduce the use of chemicals in crop fields. Biological control is an important component in IPM programmes. The main objective of this research was to generate required data to initiate a biocontrol programme to manage papaya mealybug. In order to achieve this objective, a field survey was conducted in the Agricultural Park, Gannoruwa, Peradeniya to assess the diversity of coccinellid predators on Legumes, Solanaceae and Cucurbitaceae crops. In this survey, eight coccinellid species: *Illeis cincta*, *Anegleis cardoni*, *Coccinella transversalis*, *Coccinella sexmaculata*, *Micraspis discolor*, *Cryptolaemus montrouzieri*, *Axinoscymnus* spp. and *Propylea dissecta* were found. Survey data indicated that the abundance of the coccinellid species was significantly ($P < 0.05$) different among the three crops. Number of beetle species found in leguminous, solanaceae and cucurbitaceae crops were 8, 4 and 5 species respectively. Of these species, *C. montrouzieri* was selected for further studies to promote as a biocontrol agent of papaya mealybug. In order to confirm the identity of the beetle, adults were dissected to examine the genitalia and it was slide mounted for further microscopic examination. Morphological structures of antennae and genitalia were compared with taxonomic illustrations and taxonomic keys and published literature were also used for identification. Experiments were conducted on the feeding potential of *C. montrouzieri* on papaya mealybug. Experiment results indicated that the Adult beetle consumed 108.17 ± 21.15 1st instar nymphs, 7.6 ± 4 adults of the mealybug while larvae of *C. montrouzieri* consumed 152.69 ± 25.57 1st instar nymphs, 1.74 ± 1.31 adults of the mealybug per day under laboratory conditions. As per the feeding rate, *C. montrouzieri* can be suggested as a candidate predatory species to use in biocontrol of papaya mealybug.

Keywords: Biological control, *Cryptolaemus montrouzieri*, Feeding potential, Integrated Pest Management, *Paracoccus marginatus*

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Molecular Characterization of *Colletotrichum* and *Fusarium* Isolates Associated with Leaf Twister Disease of Red onion in Jaffna District

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Leaf Twister disease (LTD) is a major disease of red onion cultivated in Sri Lanka. The objective of the present study was to identify *Colletotrichum* and *Fusarium* species associated with LTD of red onion grown in Jaffna district of Sri Lanka using molecular methods. Ten morphologically-different isolates of *Colletotrichum* and eight *Fusarium* isolates were used in this study, which were the stock cultures and already isolated from LTD-infected onions, collected from 30 locations of Jaffna district. Genomic DNA was extracted from each fungal isolate using a modified CTAB method. PCR amplification was done with ITS1 and ITS4 primers to amplify the 5.8S-ITS subunit of the *Colletotrichum* isolates. The ITS2-rDNA subunit of *Fusarium* isolates was amplified by ITS-Fulf and ITS-Fulr primers. As expected, 590 bp and 466 bp PCR products were resulted in by all *Colletotrichum* and *Fusarium* isolates, respectively. Resulted in PCR products were subjected to DNA sequencing and compared with available databases using Basic BLAST search option of NCBI. Four *Colletotrichum* isolates, showed more than 95% similarity with *Colletotrichum gloeosporioides* (Accession no. KM203611.1) and the other six samples of the *Colletotrichum* showed more than 88% similarity with *Colletotrichum dematium* (Accession no. JN998107.1, JN998109.1). All the *Fusarium* isolates, showed more than 97% similarity with *Fusarium solani* (Accession no. EU 326470.1, EF560607.1 and KM260354.1). Based on the results, *Colletotrichum* isolates used in the present study were identified as *Colletotrichum gloeosporioides* and *Colletotrichum dematium* and all the *Fusarium* spp. were identified as *Fusarium solani*. Therefore, *Colletotrichum gloeosporioides*, *Colletotrichum dematium* and *Fusarium solani* have been identified as the causal agents of LTD of red onion.

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Keywords: ITS region, Species delineation, PCR, DNA homology search

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Evaluation of Non-Synthetic Pesticidal Compounds as Effective Seed Treatments of Tomato and Mungbean

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Tomato (*Solanum lycopersicum* L.) and Mungbean (*Vigna radiata*) are widely grown vegetable and pulse crops, respectively in Sri Lanka. Seed borne pathogens cause considerable yield losses to the above crops. Crop losses due to seed-borne pathogens can be eliminated through effective seed treatments. The objective of the present study was to identify non-synthetic pesticidal seed treatments to eliminate seed borne pathogens. Clorox (Na hypochlorite) and Bougainvillea (*Bougainvillea spectabilis*) leaf extraction were tested as non-synthetic pesticidal seed treatments in the present study. Efficiency of the two types of seed treatment and the effective concentrations and soaking times of each treatment were determined based on seed germination percentage, no. of days taken to germinate and total counts of fungal and bacterial colonies developed from seeds under *in vitro* conditions. Growth performances of plants were determined by growing the treated seeds in an insect-proof cage. As fungal pathogens of tomato seeds, *Aspergillus niger* (14.67%), *A. flavus* (5.33%), *Penicillium spp* (15%), *Rhizopus spp* (11.67%), *Colletotrichum acutatum* (3.33%), *Phoma spp* (1.67%) and *Aspergillus spp* (1.33%) were identified. *Aspergillus niger* (4%), *Rhizopus spp* (14.67%), *Fusarium spp* (35.33%) were identified as fungal pathogens on mungbean seeds. Soaking of the seeds for 24 hours in 20% and 5% concentrations of the Bougainvillea leaf extract were effective seed treatments for tomato and mungbean, respectively. With respect to Clorox treatment, soaking of the seeds for 30 min. in 1% and 5% solutions, respectively were effective for tomato and mungbean. Growth performances of tomato and the germination percentage were significantly higher in plants treated with Bougainvillea leaf extract.

Keywords: Bougainvillea leaf extract, Germination percentage, Na hypochlorite solution, Plant growth performance

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The Species Diversity of Bee Pollinators (Hymenoptera: Apoidea) in Vegetable Agro-ecosystems in Batticaloa District, Sri Lanka

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Pollinators provide a valuable free service to increase both the size and quality of harvests. As the intensive agriculture continues, it threatens the wild pollinators. Maintaining these pollination services requires the conservation of pollinators and management of sufficient resources for wild pollinators within agricultural landscapes. There is paucity of data on pollinator diversity in agro-ecosystems locally. Therefore, this study was conducted with the objective of investigating the diversity of bee pollinators and their abundance in vegetable cropping systems of Batticaloa district of Sri Lanka. Pollinators were surveyed in vegetable agro-ecosystems, in Koddaikallar, Onthachimadam, Kaluwanchikudy, Kalluthavallai and Periyakallar in Batticaloa during September to November, 2014. A total of 91 bee specimens were collected and identified. They were belonging to three families: Apidae, Halictidae, and Megachilidae and to 13 genera. Family Apidae included the largest number of collected bees (51). Most of them were belonging to the genera *Apis* and *Amegilla* followed by genus *Ceylalictus*, and *Megachile*. The highest bee species diversity ($H' = 2.017$, $P > 0.05$) and Evenness ($E = 0.712$) were recorded from Koddaikallar agro-ecosystem and it was followed by Kalluthavallai ($H' = 1.937$, $E = 0.647$). The abundance of bee species was not significantly varied among the locations. *Apis florea* was the leading bee pollinator (35%) in all locations; however, there was a considerable proportion of bee fauna represented by wild bee species. The findings of this study are useful in correct use of cultural practices to promote, enhance and protect the existing pollinators within the vegetable based agro-ecosystems.

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Keywords: Agro-ecosystem, Batticaloa, Bee pollinators, Species diversity, Sri Lanka

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Effects of Organic Additives on the Callus Initiation of *Anthurium* Varieties: *Anthurium andreanum*, *Anthurium andreanum* (Lady Jane) and *Anthurium hookeri*

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Anthurium, (Araceae) is one of the most popular cut flowers in the tropical cut flower industry grown at commercial level. Continual demand of the export market requires propagation of thousands of plants each day. Propagation via seeds is inefficient as it takes years to develop an elite clone. Therefore vegetative propagation is the perfect method to produce plants which are similar to the mother plant. *Anthurium* leaf is highly amenable in regeneration, and hence micro propagation is the most effective method of regenerating new plants. It is proved that many cut flowers have performed well with the existence of organic additives as a supplement to the culture media. It takes at least 3-5 months for the initiation of callus from *Anthurium* explants. This study was carried out to investigate the impact of adding organic additives to the media on the time taken for the callus initiation. Three varieties of *Anthurium* leaf explants were used with three types of organic additives. Immature leaf parts were established in two types of media, containing organic additives together with hormones (2,4-D 2 mg/L and kinetin 0.5 mg/L) and organic additives alone. Both treatments were supplemented with 50 g/L and 100 g/L of tomato pulp, carrot pulp and 50 mL/L and 100 mL/L of king coconut water to evaluate the efficiency of callus initiation. A complete randomized design (CRD) was used with 10 replicates. Time taken for the callus formation was recorded and the statistical analysis was carried out using Kruskal Wallis test by Minitab 14 version. Effects of media additives on callus induction showed a significant difference at $P \leq 0.005$ level. The highest average rank among the explants (125.5) was scored by the medium with 50 g/L of king coconut water in *Anthurium hookeri*. The explants with tomato pulp and carrot pulp media did not give a significant difference.

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Keywords: *Anthurium*, Callus initiation, Micropropagation, Organic additives

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Effects of Applying Sodium Bicarbonate, Salicylic Acid and *Bacillus megaterium*-Based Biopesticide on Population Dynamics of Phyllosphere Microorganisms

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The present study was conducted to determine the population dynamics of phyllosphere microbial communities due to the application of alternatives to synthetic pesticides. It was also determined the effect of selected alternative compounds on reducing the powdery mildew incidence and severity on tomato. Foliage of tomato (var. Thilina) and chilli (var. MI 2) were sprayed with sodium bicarbonate (0.1%), salicylic acid (400 μ M) and *Bacillus megaterium*-based biopesticide (10^8 CFU/mL) one week after transplanting. Leaf samples were detached at different time intervals to isolate culturable microorganisms on leaf surfaces. Total colony counts of fungi, bacteria and yeasts were quantified and identification of the microbes was done using colony and spore morphology, biochemical assays and selective media. Bacterial and fungal populations on tomato increased with the time and showed significantly higher densities (CFU/cm²) at the third week after application at every treatment combination. On chilli phyllosphere, a similar trend was observed except for fungal population density under three treatment applications. Population density of fungi and bacteria varied significantly due to the interaction effect of crop and type of application ($P=0.05$). Application of salicylic acid to tomato and chilli phyllospheres significantly reduced bacterial population densities. In contrast, biopesticide application to the phyllospheres of the two crops significantly reduced the bacterial population but not the fungal populations. Application of NaHCO₃ has no significant effect on reducing the bacterial or fungal populations on tomato phyllosphere though it reduced the bacterial population significantly in chilli phyllosphere. Application of salicylic acid and the biopesticide significantly reduced the incidence and severity of powdery mildew of tomato. Application of salicylic acid and water are equally effective in reducing the incidence and severity of powdery mildew while biopesticide is more effective than the treatment of water and the salicylic acid in reducing the powdery mildew development.

Financial assistance by HETC/PGIA/QIG3 is acknowledged.

Keywords: Culturable microorganisms, Microbial density, Microbial diversity, Powdery mildew

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Optimizing DNA Extraction Methods and PCR Conditions for Insect Vectors of Plant Viruses to Determine Their Genetic Variability

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Thorough understanding of genomic variability within the populations of virus vectors is important in designing effective management strategies for plant virus diseases. Polymerase Chain Reaction- Restriction Fragment Length Polymorphism (PCR-RFLP) is one of the molecular techniques to determine genomic variability of within insect populations. Crucial steps of determining genetic variability are optimizing the extraction of high quality DNA from individual insects with adequate quantity and optimizing PCR conditions to amplify specific regions of the genome. Five different protocols with modifications were employed to optimize a DNA extraction method for individual whiteflies (*Bemisia tabaci*) and three different protocols with modifications were employed to optimize a DNA extraction method for individual aphids (*Aphis fabae*). PCR conditions were optimized to amplify mitochondrial cytochrome oxidase 1 (*COI*) gene of *B. tabaci* using the primer pair, LCO 1490 and HCO 2198. Optimization of PCR conditions to amplify Internal Transcribed Spacer 1 (ITS 1) of ribosomal DNA of aphids (*A. fabae*) was done using the primer pair, TW81 and *B. tabaci* 5.8R. Out of five different protocols used to extract DNA from individual whiteflies and three different protocols used to extract DNA from individual aphids, the protocol described by Mansoor *et al.*, (1999) with some modifications was selected as the best protocol to be used for subsequent PCR. Amplification of *CO I* region for whiteflies and ITS 1 region for aphids was successful through PCR.

Financial assistance by HETC/PGIA/QIG3 is acknowledged.

Keywords: Aphid, *COI* region, DNA, ITS 1 region, PCR, Whitefly

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Testing and Evaluation of Particle Motion in a Multi-pass Vibro-fluidized Bed Tea Dryer

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Drying is an important unit operation of black tea manufacture and it consumes a large amount of both thermal (81720 kJ/kg of made tea) and electrical energy (2700 kJ/kg of made tea), which is accounted for about 40% of the total processing cost. Multi-pass vibro-fluidized bed dryer is a novel energy saving design concept which involved a drying chamber with three sloping decks fixed vertically in a zigzag path as a single unit and sloped in opposite directions to facilitate uniform particle motion. Each deck measured 3.6 m x 0.78 m and consisted of perforated sheets having 13 holes per square centimeter where each perforation diameter was 1.5 mm. The three decks unit was horizontally vibrated at 3 mm amplitude using an eccentric shaft driven by a 5 kW electric motor. A centrifugal fan (5 kW) with the capacity of 2.83 m³/s (6000 cfm) was used for supplying air for fluidization. The scope of this study was limited to optimize the vibration frequency and slope of the deck to obtain the expected particle moving speed of 6 mm/s at different moisture contents. Orthodox rolled tea dhools at three levels of moisture (10%, 35% and 55%) were used for testing at different vibration frequencies and slope of the deck at the fixed amplitude and air flow rate. Three moisture contents represented the expected mean moisture contents in three decks. Results revealed that the moisture content (MC) influenced the particle motion speed on the bed. Decrease in the moisture increased the particle speed at a given bed slope and frequency. The 38 Hz (504 rpm) frequency was found to be the best for expected particle speed for all three moisture levels. The optimum bed slopes were determined as 3%, 4% and 5% for 10%, 30% and 55% MC (wet basis), respectively, at 38Hz (504 rpm).

This work was funded by the National Science Foundation, Sri Lanka (Technology Grant N: TG/2013/Tech-D/01) and Pirekma Pvt. Ltd., Industrial Park, Galigamuwa.

Keywords: Multi-pass vibro-fluidized bed, Tea drying, Bed slope, Vibration frequency, Dhool, Particle speed

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Use of Ground Penetrating Radar (GPR) to Investigate Sub-surface Contamination and Stratified Dump Sites under Controlled Conditions

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Developing countries including Sri Lanka mostly practice open dump sites to dispose Municipal Solid Waste (MSW). The leachate generated from these dump sites contains both inorganic and organic pollutants which can easily contaminate surface and ground water resources. Monitoring of these dump sites and leachate migration is essential, but found to be tedious and expensive task, which requires advance technology and/or modeling approaches. Geophysical methods have found to produce promising results of which Ground Penetrating Radar (GPR) can be used to map dump site features and polluted areas without disturbing in-situ structure. This study was done on two lysimeters (4.0 m x 1.0 m x 1.5 m) at the Meewathura research farm, University of Peradeniya. A Pulse EKKO-Pro GPR system with 500 MHz transducers together with 0.25 m antenna separation and 0.02 m step size was used. The lysimeter-1 had been filled with sand and the lysimeter 2 was filled with decomposed MSW and fresh MSW in two separate layers. Amplitudes of GPR reflected waves from two metal bars (known sub-surface reflectors) and the water table were studied under different salt concentrations injected to water table in the lysimeter-1. The waste stratification was studied using the same GPR system in the lysimeter-2. The collected GPR data were processed using EKKO-View Deluxe and EKKO-View software. Results revealed that the GPR method can be used to detect the areas of inorganic pollutants in sub-surface if the strength of the contaminants is high enough to attenuate GPR signals. 2D GPR profile images under wet condition in the lysimeter-2 showed stratification of the waste layers and thickness of it. But under dry condition, it was difficult to resolve the waste layers in this controlled experiment and can be recorded as one of the limitations under complex field conditions.

Keywords: Ground penetrating radar, Leachate, Lysimeter, Municipal solid waste, Reflected waves

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Development and Evaluation of an Integrated Charcoal Filter-Constructed Wetland (ICFiWet) System for Grey Water Treatment

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Management of household grey water is an important environmental concern in urban and sub-urban areas of the Sri Lanka and only very few effective systems are available in the country. In this study, three parallel pilot-scale integrated charcoal filter constructed wetland (ICFiWet) systems were established in order to study the treatment capacity of variably loaded BOD and COD and nutrient concentrations in synthetic greywater. Each reactor had 200 L volume separated into three compartments; anaerobic chamber, charcoal filter bed and constructed wetland. The reactor was assembled in a 200 L empty plastic barrel. Two reactors were planted with *Typha angustifolia* on the top at wetland compartment whereas the third reactor tested without vegetation. The first planted reactor commenced operation 120 days prior to others. Three reactors were continuously fed at hydraulic and BOD loading rates of 106 ± 4 L/m²/d and 18 ± 1 g/m²/d, respectively. The planted systems clearly outperformed the unplanted systems in all measured parameters. The common maintenance problems such as clogging, unsteady hydraulic flows and fluctuation of treatment efficiency were not observed during the start-up (60 d) and steady (120 d) operation period. The BOD and COD removal were >98% in planted systems as opposed to 96% in unplanted systems. The planted system reduced the nitrate (2.5 ± 1.3 mg/L) and ammonium (4.5 ± 4.3 mg/L) concentrations by 78% and 85%, respectively. It was also revealed that the system decomposes the phosphorous complexes in influent leaving 10 folds increase in effluent phosphate, demonstrating that charcoal substrate and plants have limited capacity to fix phosphate. Thus, it can be concluded that ICFiWet treated grey water can be used in irrigation and home gardening as it contains high amount of soluble phosphorous; however, a mechanism to remove phosphorus should be incorporated into the ICFiWet system if treated water to be discharged into natural waters.

Key words: Grey water, Charcoal, Constructed wetland, ICFiWet, *Typha angustifolia*

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Wastewater Treatment using Adsorbents cum Constructed Wetland for Textile Industry

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Textile dyeing process produces large amount of wastewater with residual dyes which are toxic and carcinogenic. These dyes are not easily biodegradable and to be removed with chemical treatment before discharge into the environment. Using biosorbent would be a better option to remove the dyes compared to chemical treatment. This study is focused on the adsorption potential of dyes on three adsorbent materials, charcoal, brick pieces and clay (Kaolinite), as those are abundant, environmental friendly and cost effective. It was combined with a constructed wetland for further improvement of water quality for the purpose of reuse. Adsorbents were saturated with wastewater collected from a textile industry-Biyagama and colour was measured after 24 h using Spectrophotometer at 436 (Yellow), 525 (Red) and 620 (Blue) nm wavelengths. Clay showed a higher performance on colour removal compared to charcoal and brick pieces. Batch sorption trials of dyes were performed to investigate the effect of different forms of clay (raw balls, burned balls and solubilized clay), pH (1-12), adsorbent dosage (4-40 g/L), initial dye concentration (20-80 mg/L) and contact time (1-60 min). Solubilized clay has given 92% colour removal. The adsorption was pH dependent and optimum adsorption was observed between pH 2-4. The dye was effectively adsorbed at initial concentration of 50 mg/L, 10 min mixing at 300 rpm and the optimum dosage of 12 g of clay per L of wastewater. Langmuir and Freundlich isotherm models were fitted and found that Freundlich was the best fitted model for clay adsorption with $R^2 > 0.9$ for all 3 wavelengths, describes heterogeneous multilayer adsorption where desorption and reuse is possible. Removing of solubilized clay from wastewater after adsorption was possible with 0.02 g of Alum per 1 g of clay or constructed subsurface wetland. Alum treatment and constructed wetland have given over 92% and 95% removal efficiencies, respectively. 16% of cost effectiveness has calculated from adsorption cum constructed wetland comparatively to coagulation/flocculation method along with other environmental benefits.

Key words: Adsorbent, Clay, Constructed wetlands, Isotherm, Textile dyes

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Design and Development of Abrasion Peeling Machine for Pieces of De-shelled Coconuts in Desiccated Coconut Industry

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About 2% of de-shelled coconuts break in to pieces and discarded from production of desiccated coconut (DC) due to practical problems in peeling (paring) testa from those pieces. It reduces total volume of DC. Therefore, an abrasive peeling machine was built to pare those pieces. A 10 cm wide conveyer was built by inserting 6 mm diameter stainless steel (SS) rods at 5 cm spacing between two V belts. It moved over a horizontal bed. Five, 15 cm diameter SS wire brushes mounted on swinging arms, at different locations along the conveyer to cover the total width were powered using chains and sprockets from a common shaft, which was driven by a 1 hp, 3-phase motor and a speed controller. Holding arms helped to press the pieces down while brushing. Even after several modifications, the machine did not perform well. Therefore, a new machine was built using a 10 cm diameter nylon sphere mounted on a 2.5 cm diameter rod. SS pins to protrude 4 mm from the surface were fixed around the sphere to hold the pieces of coconut during peeling. A 7.5 cm diameter nylon roller rotating in the opposite direction was fixed to press pieces against pins. A set of 15 cm diameter SS wire brushes were mounted on a separate 2.5 cm diameter rod and its mid region was ground to a concave shape. Both shafts were mounted on a frame 50 cm long, 30 cm wide and 75 cm high. During testing, sphere rotated at 7.5 rpm while brushes turned at 600 rpm using suitable belt and pulley system from a 1 hp, 3-phase motor and a speed controller. The machine performed satisfactorily. Throughput was 720 pieces per hour with 10% weight loss and 90–100% peeling efficiency.

This work was funded by Baduwatta DC mill, Katana.

Keywords: Abrasion peeling, Desiccated coconut, Paring, Stainless steel, Testa

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Development of a Water Availability Index for Deduru Oya Basin

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Water availability is a critical factor for the performance of different water use sectors. Objective of this study was to develop a Water Availability Index (WAI) for Deduru Oya river basin considering Divisional Secretariat (DS) Division as the basic spatial unit. Spatial data such as rainfall, drainage density, surface water resources, agro well density, pipe borne water coverage, water quality (Fluoride, hardness and salinity), land use (Paddy) and population density were considered as the parameters that affect on water availability in the basin. These data were compiled into DS divisions using GIS. Each parameter was categorized and scores were given for each category out of 20. To identify the relative importance of each parameter, expert knowledge was sought. Finally, these parameters were compiled into two WAIs which are based on general water availability (WAIg) and consumption related water availability (WAIc). The temporal variation of the two indices was assessed for Yala and Maha seasons. Results revealed that there is a considerable spatial variation of each parameter within the basin. The two developed indices also show spatial and temporal variations indicating low water availability in some DS divisions. Water availability varies in Yala and Maha seasons and Yala shows low water availability in many DS divisions highlighting the need for management interventions. This study identified the usefulness of GIS to successfully map spatial and temporal variability of water availability in Deduru Oya basin. Field verification of these indices will help to refine them further. Selection of a small spatial unit for mapping (GN division) will further enhance the results by improving the ability to represent spatial variability more effectively.

Keywords: Water availability index, GIS, Deduru Oya basin, Spatial variation, Temporal variation

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Design and Development of Abrasion Peeling Machine for Coconut in Desiccated Coconut Industry

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To overcome the shortage of skilled labour for coconut peeling and to reduce losses of manual peeling in Desiccated Coconut industry, an abrasion-peeling machine was designed using dimensions of coconuts collected from Baduwatta mill, Katana. The brown skin (testa) was removed by 150 mm diameter stainless steel wire brushes, mounted in an alternate pattern, on two shafts turning inwards. The gap between brushes on each shaft was 2.4 cm. Those gaps were covered by a set of fingers attached to the frame to prevent cracking of coconuts. These shafts were rotated by a 3 hp, 3-phase motor turning at 1440 rpm. Two plates were fixed parallel to the shafts, at an angle from vertical to keep coconuts above brush rollers. A belt conveyor with stainless steel plates was mounted above the brush rollers to convey coconuts lengthwise. A draining system was attached below the rollers to collect peeled testa and water. The abrasion-peeling machine performed satisfactorily when brush rollers rotated at 1000 rpm and conveyer speed set at 0.18 m/s. The capacity of the machine was 300 nuts/h.

Keywords: Abrasion peeling, Desiccated coconut, Stainless steel, *Testa*

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Impact of Agro-Wells in Reducing the Risk of Crop Failure in the Command Area of *Hakwatuna Oya* Irrigation Scheme

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Hakwatuna Oya is one of major irrigation scheme in *Deduru-Oya* basin and face water shortages especially during *Yala* season. This has prompted some farmers to construct agro-wells within the irrigation command. In this context, a study was conducted to find whether the presence of agro wells could reduce the risk of crop failure due to water scarcity. A total of 10 farmers, 5 with agro-wells and 5 without agro-wells, from *Anicut-ela* farmer organization of *Hakwatuna Oya* command area were selected for the study. A questionnaire survey was conducted to gather information on land extent, crop yield, water abstraction from agro-wells etc during both 2013/2014 *Maha* and 2014 *Yala* seasons. Seasonal rainfall and irrigation water issues from the reservoirs were obtained from the Office of the Residential Project Manager at *Hakwatunawa* and Divisional Irrigation Engineer's office at *Hiriyala*. The results showed that all the selected farmers without agro-wells has lost the crop during the 2014 *Yala* season even though the irrigation system issued about 75% of the water requirement of the crop. According to the farmers, there were no water issues after the milking stage of the paddy crop which led to the total crop failure. In contrast, those with agro-wells were able to obtain 25% to 80% of the potential yield due to supplementary irrigation from agro-wells during the latter part of the season. During 2013/2014 *Maha* season, all 10 farmers used only the irrigation water issued from the reservoir in addition to the rainfall and, hence, no noticeable difference between the average yields of paddy between both groups was observed. It could be concluded that the presence of agro-wells has reduce the risk of crop failure during the *Yala* season due to supplementary irrigation when there was no irrigation water available from the irrigation scheme.

Key words: Agro well, Crop failure, Irrigation scheme, Supplementary irrigation, Water scarcity

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Development of an Area-Capacity Curve and Effect of Tank Water for Groundwater Availability of Command Area of the *Badabeddegama* Minor Irrigation Tank

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Minor tanks are unique water conservation structures created by ancient irrigation system in Sri Lanka and have an identity in shape and capacity due to topographical variability and drainage pattern in the area. The area-capacity relationships in water storage structures are commonly used for sustainable water management practices. Today issue is the insufficient tank water availability for crop cultivation in command area and Use of groundwater has also immersed as a solution to compensate this issue. This research was conducted; (i) to develop depth-area and depth-capacity curves for a selected minor irrigation tank in *Awlegama* area of the *Kurunegela* district and (ii) to assess the groundwater availability in the command area. Topographic survey was carried out to obtain depth-area relationship and then to calculate the depth-capacity relationship. Three piezometers were installed in the command area from tank bund towards the natural stream with 100m intervals and weekly readings of depth to the water table were collected. The daily rainfall data were collected for October and November period of year 2014. Regression analyses were carried out to analyze different relationships. Depth-area and depth-capacity curves showed significant strong nonlinear relationships ($P < 0.0001$) with higher coefficient of determination values ($R^2 > 0.98$). There was a significant relationship ($P = 0.001$) between the depth to the water table in the command area and height of tank water level at the range of 1.05m to 1.50m from sluiceway level and showed a high strength relationship at closely located piezometer reading. The relationship of groundwater table with respect to weekly rainfall depth was not significant ($P = 0.47$). Effect of direct rainfall on groundwater recharge through infiltration could have been negligible compared to the recharge occurred from tank water seepage and groundwater availability in the command area mainly is determined by the tank water availability than direct rainfall.

Key words: Area-capacity, Groundwater, Irrigation, Minor tanks, Water conservation

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Production of Biochar from Pruned Tea (*Camellia sinensis* L.) Bushes for *In Situ* Application

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Prevention of soil nutrient losses and organic matter depletion are considered important management strategies in tea plantations of Sri Lanka, especially in highly weathered soils in central highlands. Many studies have shown that biochar is a useful resource to improve the quality of soil, and application of biochar to soils might be a practical method to aid in the long-term maintenance of the soil's organic carbon contents and soil fertility. This study evaluates the feasibility of biochar production from pruned tea bushes in a simple two stage pyrolyser for *in situ* application in tea fields. The study was conducted in collaboration with Watawala Plantations PLC, at Henfold Estate, Lindula. The two-stage pyrolyser was fabricated from steel barrels. Pyrolyser had the capacity to produce 6 kg of biochar during a 40 min long single batch processing. The average pruned tea harvest was 5.2 ± 1.2 kg/m² with 23% water content. During the entire operation period, the pyrolyser produced biochar at a rate of 6240 ± 140 kg/ha with 30% mass conversion efficiency. The estimated pruned tea biochar production rate was 626 g/m² for a single pruning cycle. The estimated *in situ* biochar manufacturing cost was Rs 53 per 1 kg of biochar which can be reduced by 20% if mobile chopping machine is introduced to the process since the manual material handing cost accounted for the single highest cost element. In comparison with previous studies conducted in highly weathered tropical soils, the amount of biochar produced from tea pruning is not adequate to fulfil the biochar application rate of 5% in soil. However, based on these results, it can be concluded that in-situ conversion of pruned tea to biochar in a single two-stage pyrolyser is a feasible option to partially fulfil the biochar demand in tea plantations.

This research was partially funded by Watawala Plantations PLC, Henfold Estate, Lindula, Talawakelle.

Key words: Biochar, Pruned tea, Pyrolyser

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Pretreatment of Distillery Spent Wash for Developing *Azotobacter vinelandii* based Bio-Fertilizer

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Distillery spent wash is the residual wastewater discharged from alcohol distillation process which is characterized by high organic content and low pH below 4. High solid content, acidic nature and refractory organics present in spent wash makes it one of the most difficult wastewater to be treated with conventional biological wastewater treatment methods. Thus, this study aims at pre-treating spent wash prior to inoculate *Azotobacter vinelandii* which is commonly used as a bio-fertilizer. First, series of diluted distillery spent wash was pretreated by soaking in softwood charcoal, mixing with alum, adding lime and filtering through mixture of charcoal, alum and lime. Secondly, bakery yeast was cultured on pretreated spent wash to examine the growth of microorganisms and reduction of brix value was used as the index of growth. Bakery yeast grown in charcoal pretreated 75% spent wash solution showed a significant drop in brix value from 9 to 7.5% in 120 h incubation period. Thereafter, *Azotobacter vinelandii* cultures obtained from soil in sugar cane fields in Palwatte were grown on charcoal treated spent wash. Though yeast and *Azotobacter vinelandii* failed to growth in raw spent wash, all concentrations of charcoal treated spent wash facilitated the growth of microbes observed by continuous reduction in brix value over the incubation period. A distinct pattern of brix reduction was observed in samples inoculated with *Azotobacter vinelandii* where brix value increased by 0.5 % during the first 24 h, possibly due to degradation of melanoidin in spent wash. *Azotobacter vinelandii* showed similar pattern of bakery yeast where the highest reduction in Brix value observed in charcoal treated 75% spent wash samples. In conclusion, treatment of 75% spent wash by charcoal creates favorable environment for yeast and *Azotobacter vinelandii* growth.

Keywords: *Azotobacter vinelandii*, Bio-fertilizer, Distillery spent wash

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Development and Performance Evaluation of the Leachate Treatment System at Gohagoda Municipal Solid Waste Disposal Site

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Leachate emanating from Gohagoda dumpsite is polluting the River Mahaweli. Therefore, a low cost leachate treatment system (*LTS*) which was developed based on the clay-polythene-clay biofilter liner was established during the rehabilitation efforts. *LTS* is consisting of two leachate collecting systems, a leachate treatment bioreactor (*LTB*) followed by an algae pond (*AP*), a floating wetland (*FW*), two sub-surface constructed wetlands (*SCWs*), two charcoal filter-beds (*CFBs*). *LTS_{outlet}* is being discharged into the natural stream (*NS*) which flows adjacent to the *LTS*. In this research, the existing *LTS* was improved and the performances were evaluated. To determine the surface water quality of surrounding area and performance of the *LTS*, samples were obtained from 13 pre-defined points on weekly basis for two months, analyzed for 14 quality parameters and calculated removal efficiencies. Average pH, DO, chemical oxygen demand (COD) and biochemical oxygen demand (BOD) of leachate were $7.7.4 \pm 0.35$, 0.46 ± 0.5 mg/L, $24,552 \pm 2,612$ mg/L and $4,125 \pm 965$ mg/L respectively. *LTS_{outlet}* of pH (7.16 ± 0.23) was within the CEA discharge water quality standards. Average salinity, EC, DO, TDS, TSS, TS, VS, VSS, BOD, COD, PO_4^{3-} , NO_3^- and NH_4^+ of *LTS_{outlet}* were $0.84 \pm 0.25\%$, 1.71 ± 0.52 mS, 0.63 ± 0.6 mg/L, 852 ± 261 mg/L, $1,058 \pm 199$ mg/L, $1,303 \pm 772$ mg/L, 406 ± 220 mg/L, 609 ± 111 mg/L, 217 ± 177 mg/L, $780 \pm 1,049$ mg/L, 2.33 ± 3.29 mg/L, $0.97-0.27$ mg/L, 4.38 ± 1.59 mg/L, respectively. Average pH, TDS, BOD, PO_4^{3-} and NO_3^- and NH_4^+ of *NS_{outlet}* were 7.69 ± 0.39 , $1,457 \pm 930$ mg/L, $1,382 \pm 784$ mg/L, 5.04 ± 6.36 mg/L, 1.58 ± 1.26 mg/L, 4.3 ± 2.02 mg/L, respectively. The removal efficiency of BOD varied from 91.9% to 97.64%. The *LTS* was stabilizing and attaining the required standards even without high growth in *SCWs*, until heavy rainfall occurred. The system cannot cope with total rainfall going through it, thus drastic reduction of retention time. Therefore, it is essential to install sub-surface interceptor drains and connect to the leachate treatment system. It will require a proper dumpsite cover system to reduce infiltration and thus promote runoff. It is imperative to monitor and evaluate frequently the system and improve it with an aerated biological indicator pond.

Keywords: Dumpsite, Rehabilitation, Leachate treatment

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Effect of Irrigation Transformation on Groundwater Pollution in Kalpitiya Peninsula, Sri Lanka

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Irrigation practice in Kalpitiya peninsula has undergone a rapid transformation from drag hose irrigation to sprinkler irrigation during the recent past. Therefore, soil column studies were conducted in the laboratory to assess the effect of this transformation on groundwater pollution. Soil collected from Navalkadu, in Kalpitiya peninsula was air dried and passed through 2 mm sieve and packed in three columns of 50 cm each to its field bulk density of 1.3 g/cm³. Two irrigation treatments namely drag hose and sprinkler in combination with the fertilizer applications as practiced by the farmers were tested. Drag hose irrigation was simulated by giving an instant application of 15 mm/day while sprinkler irrigation was simulated by applying 10 mm/day over a period of 20 minutes. The theoretical requirement of 5 mm/day was given as the control. Fifty kilograms per hectare of granular urea was soil incorporated as basal dressing, and 70 kg/ha and 140 kg/ha of urea were applied subsequently at 10 day intervals. The columns were irrigated daily and leachates were collected from the bottom of the columns at regular intervals and analyzed for nitrate concentrations. Breakthrough curves were established for a continued period of 30 days. Nitrate concentrations in the leachate samples collected from all three columns showed gradual increase, and after reaching the peak decreased rapidly. However, it did not reach zero even at the time of next fertilizer application. The pattern of nitrate leaching and the peak varied with the rate of water application. Drag hose irrigation has shown the highest leaching of nitrate while the control showed the least. This could be due to the piston flow of water in drag hose irrigation while the flows in the sprinkler applications were unsaturated. The effect was prominent with increased rates of fertilizer applications. The lowest loss of nitrate nitrogen was observed in 5 mm sprinkler irrigation at 50 kg/ha fertilizer application and the highest was in 15 mm drag hose irrigation at 140 kg/ha fertilizer application. The effect of irrigation treatments on nitrate leaching and the interaction with fertilizer applications were statistically significant ($P < 0.05$). Therefore, appropriate combination of irrigation and fertilizer application can reduce the leaching losses and prevent groundwater pollution in Kalpitiya.

Keywords: Kalpitiya peninsula, Groundwater pollution, Irrigation transformation, Drag hose irrigation, Sprinkler irrigation

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Evaluation of a Commercially Available Hydroponic System

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This study was conducted at the Meewathura farm in University of Peradeniya to evaluate the effectiveness of the sample mini-hydroponics system proposed by Hayley's Agriculture Holdings Ltd. Spatial and temporal consistency of the physical and chemical parameters in the nutrient solution were evaluated with lettuce (*Lactuca sativa*) as the indicator crop. Its rapid growth pattern and short life time are preferred in hydroponic culture. Two weeks old lettuce plants were planted in the proposed hydroponic system and in soil plot for comparison. Nutrient solution was added as liquid fertilizer (Albert solution) at the rate of 2.1 g/L. The solution was circulated twice daily and the water parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solid (TDS), water temperature and Dissolved Oxygen (DO) were monitored at three locations along the unit. Circulation period was adjusted until the water parameters became constant at optimum levels. Volume flow rate was measured weekly. Number of leaves and crown height of all the plants were measured in both media on weekly basis until harvesting. After harvesting, average fresh crown weight and root weight were measured in both media. Finally, economic analysis was performed to assess the cost of production. Time taken to achieve constant volume flow rate increased gradually from 31 to 71 minute with root growth and maturity. Water parameters showed approximately the same readings and less variation less along the system with daily circulation. Therefore, to keep the temporal and spatial variation of water parameters at preferred levels, the circulation periods should be increase and maintained at required levels. Overall growth performance of hydroponically grown lettuce plants in terms of quality and quantity was higher than plants grown in soil. Labor cost and production cost were less than the income from the harvest.

Keywords: Hydroponic, Lettuce, EC, pH, TDS, DO

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Development of a Wave Length Control System for Electric Far Infrared Radiation Emitters

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An algorithm and hardware for feedback control system with pulse width modulation (PWM) to control the surface temperature of infrared emitters was developed. Infrared (IR) radiation heating is extensively used in the food process industry. The present major constrain in applying IR heating efficiently is the difficulty of controlling the wavelength. A variable (i) used in the nested loop of the algorithm, which uses 50 cycles of the processor (runs at 4 MHz) was changed from 1 to 250 to achieve the duty cycles with selected 1 second period. The surface temperature of the IR emitters for wavelength control by feedback PWM of supply voltage to the IR emitters was successfully with an accuracy of $\pm 5^{\circ}\text{C}$. The 1 second period was capable of switching the IR emitters effectively without making an audible noise from heaters while minimizing the temperature fluctuations within ON and OFF cycles. The wave length of IR changed from $9.59\text{ }\mu\text{m}$ to $4.22\text{ }\mu\text{m}$ (surface temperatures of the IR emitters were from 28°C to 413°C) by changing the duty cycle from 0.09% to 24.90%. Therefore, the feedback control system with PWM could be effectively applied in controlling the power of the IR emitters to achieve the required IR wavelength.

Keywords: Control system, Infrared radiation, Pulse width modulation

Development of a method to measure CO₂ evolution from MSW compost

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Assessment of maturity is an important index of compost quality control, in addition to conventional nutrient and heavy metal analysis. Microbial activities are often estimated by respiration activity and toxicity induced by phytotoxins and pathogens are usually evaluated by seed germination tests. This study evaluated the respiration rates and germination rates of marketable municipal solid waste (MSW) derived compost and compost feedstock undergoing different stages of maturation (10th to 13th week). Compost samples collected from medium scale MSW composting facilities analyzed for physical (moisture, total dissolved solids, volatile solid and total carbon) and chemical properties (pH, EC, salinity, dissolved NH₄⁺, NO₃⁻ and PO₄²⁻). The germination test was carried out by germinating lettuce seeds on filter papers wetted with compost extracts and distilled water used as the control. The CO₂ evolution was measured by incubating 500 g of wet (55% MC) compost sample in a sealed apparatus connected to gas collection. Carbon dioxide in collected gas was dissolved in a NaOH solution and CO₂ concentration was measured by acid titration. The basic physical and chemical parameters of marketable compost samples were not significantly different ($P < 0.01$) among samples. The respiration rate measured by CO₂ evolution rate varied between 800 to 1600 mg/ kg of volatile solids for mature compost samples which was similar to reported respiration rates of mature compost. Germination of lettuce seeds on compost extract varied from 40 to 50 % whereas control showed 65% germination on 28th day. of the test showed that germination on com was sensitive indicator of compost quality. Compost feedstock sample taken from last stage of processing prior to complete maturation 10th week) showed rapid respiration activity of 4, 500 mg/ kg of volatile solids for 12d incubation at 37 °C. The measured cumulative CO₂ evolution was well described by first order kinetic equation ($R^2 > 0.86$). Thus, it was concluded that MSW composting requires at least 10 weeks period in active phase prior to marketing and respiration activity can be used as an important parameter in developing a maturity index for MSW compost.

Keywords: Compost maturity, CO₂ evolution, Germination test, Municipal solid waste

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Estimation of Methane Generation Potential of Organic Wastes Used in Anaerobic Digesters

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The biomethane potential of organic feedstock used in anaerobic digesters (Biogas) is a major design parameter which has not been widely studied in Sri Lanka. This study estimated the methane generation potential of vegetable wastes in a newly fabricated laboratory scale reactor according to the standard Biochemical Methane Potential (BMP) test. The reactor was fabricated by an Acrylic pipe with 55 mm diameter and 250 mm length. The reactor also equipped with gas outlet piping, sampling ports, and gas trap attached to a volumetric container. Biomethane potential of vegetable waste was estimated in two scenarios; estimation on pulverized raw waste and cooked waste after pulverizing. A culture of methanogenic bacteria was prepared by incubating methanogenic sludge in an incubator. The tests were conducted by incubating 150 g of inoculated samples for 20 days at 37 °C in an incubator. Total Solids (TS), Volatile Solids (VS), pH, EC, DO and Salinity of reactor solution were measured daily in a small sample (20 mL) drawn from the reactor. Further, the generated gas was collected and measured daily. The results showed that pH variation of reactors followed the typical phase changes and achieved a favorable pH range (6 to 8) for methanogenic bacteria after 7th day. The observed data was used to derive Gompertz growth model parameters using non-linear regression in MS Excel. The cumulative gas production potential of 7.1 L/g of VS was estimated for cooked samples which was higher than the potential of raw waste (5.0 L/g of VS). Further the model estimated that raw waste undergoes a 28 days of lag phase before the rapid gas production in contrast to 17 days in cooked waste which could be attributed to toxic/inhibitory nature of raw waste. In conclusion, the developed BMP test method can be used to predict the biomethane generation potential of different waste and can be used to compare characteristics of wastes during biomethane generation.

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Keywords: Anaerobic digestion, Biochemical methane potential test; Gompertz model, Vegetable waste

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Prediction of Leachate Generation in an Open Dumpsite Using HELP (Hydrologic Evaluation of Landfill Performance) Model

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One of the problems associated with municipal solid waste landfill design and long term care of landfill /dumpsite and its surroundings is managing the leachate. Quantification of leachate is very important although it is highly varies and difficult to predict. It depends on many factors such as waste composition, climate, site and surface specific condition. Several mathematical computer models have been used for prediction of leachate for controlled sanitary landfills. However, the prediction of leachate for an open dumpsite is rarely reported. The applicability of Hydrologic Evaluation of Landfill Performance (HELP) – DOS version 3.07) model based on water balance method was evaluated in this study for Udapalatha open dump site in the Central Province, Sri Lanka. Input weather data (rainfall, temperature, RH, wind velocity, solar radiation) and site specific data (area, depth, profile characteristics) were obtained nearby weather station and site investigation, respectively. Model generated leachate, surface runoff and evaporation. Leachate generation was validated (quasi) with changes in groundwater level in percussion bore holes which were installed at the dump site and monitored for a period of one year (May 2013-May 2014). The result shows that predicted annual leachate was 2739 mm when the rainfall was 3249 mm in 2013/14. Thus 80% of precipitation is contributed to leachate production annually. Monthly leachate generation is more than the rainfall in few months where heavy rain was recorded in the previous month. This may be due to the release of water stored in the waste layer in the previous month. HELP model simulation shows that there was no significant difference in leachate production for change in vegetation cover. HELP model satisfactorily produce the annual and monthly leachate depth in the open dump site tested.

Keywords: HELP model, Leachate generation, Open dumpsite, Precipitation

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Development of an Effective Organic Fertilizer through a Novel Approach of Biocatalyst Derived from Biochar

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This research was conducted to develop a biocatalyst char (BCC) activated with 1kg of market wastes and 25g of Eppawala rock phosphate (ERP) in aerobic and anaerobic reactors mixed in 2.5L of water and then applied to compost. Activation was achieved by adding small quantities of biochar to reach pH of 7. 4 samples were taken from each reactor twice a day on daily basis to analyze biochemical parameters. Afterwards, three each of 1kg shredded garden waste were used to produce composting piles. Aerobic and anaerobic biocatalysts were mixed intermittently while maintaining the required moisture (MC) in two composting piles. Third pile was the control with only water additions. Sampling was done daily and analyzed the decomposition process. Electron microscopic structure, total N, P and K of each catalyst and compost were analyzed. pH, total N, P, K content of used biochar were 8.25, 7,840 mg/kg, 2.56 mg/kg and 7,800 mg/kg respectively. Initial pH, salinity, EC, DO, TDS of the slurry were 4.5, 1.8%, 3.38 mS, 0.66 mg/L and 1,750 mg/L. Both aerobic and anaerobic reactors made available phosphorous content that increased from 55.24 mg/L to 2,196 mg/L and from 113.86 mg/L to 2,183 mg/L, respectively within 40 days. After 71 days NH_4^+ -N content was 77.28 mg/L and 49.28 mg/L, respectively; NO_3^- -N contents were 10.08mg/L and 13.44 mg/L and K contents were 3,000 mg/L and 2,940 mg/L, respectively. Microscopic observations showed smooth surfaces of catalyzed sample from aerobic reactor. Average MC content (w/b) of aerobic, anaerobic and control compost were $41.2 \pm 5.2\%$, $39.14 \pm 4.18\%$ and $37.56 \pm 9.3\%$ respectively during 41 days of operation. Similarly, average VS contents were $72.03 \pm 6.43\%$, $75.72 \pm 4.5\%$, $76.12 \pm 6.63\%$, total N contents were 10.64 mg/g, 11.2 mg/g, 11.48 mg/g and total P contents were 0.78 mg/g, 2.45 mg/g and 1.93 mg/g, respectively. The microscopic images of compost have jagged surfaces and more pronounced broken structures in aerobic biocatalyst. The aerobic condition seems to be the best and more research should be conducted to give conclusive evidence of the advantages.

Key words: Biochar, Biocatalyst, Eppawala rock phosphate, Compost

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Estimation and Comparison of Recharge of Agro-wells in the Highland and Irrigated Command areas of *Hakwatuna Oya* Irrigation Scheme

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Farmers tend to extract water from agro-wells when surface water is not adequate to fulfill the crop water requirement. This may affect the ground water resources, and in worst cases, leads to drying and abandonment of agro-wells. Over-exploitation of ground water can be avoided if abstraction is less than the recharge. Rate of recharge also varies with the location of agro-wells. Therefore, this research was conducted to estimate and compare the recharge of agro-wells in the catchment and the irrigated command of *Hakwatuna Oya* Irrigation Scheme. A total of 10 agro-wells, representing 5 from the catchment and 5 from the command area, were selected for the study. Information on ground water abstraction and well specifications were obtained from respective farmers. Daily rainfall and Evapotranspiration for during 2013/14 *Maha* and 2014 *Yala* seasons were collected from the Divisional Irrigation Engineering Office, Hiriya and Natural Resources Management Centre, respectively. Field observations were made to get data on canal width and wetted perimeter to estimate canal seepage. Runoff was calculated using the USDA Curve Number method. Finally, the estimated the recharge from the theoretical water balance was compared with farmer observations. The results, according to the farmer's observations, showed that the average agro-well recharge in 2013/14 *Maha* and 2014 *Yala* seasons in catchment and in command areas was 460.88 mm (33% of rainfall) and 563.45 mm (41% of rainfall) respectively. The recharge was over estimated by the theoretical water balance method compared to farmer's observation by 135% and 218% for the catchment and the command area respectively. This over estimation may be due to the non inclusion of the drainage outflow from the area in to the water balance equation. Therefore, it is recommended to include the drainage outflow also into the water balance equation when calculating the recharge.

Key words: Agro-well, Catchment area, Command area, Over-exploitation, Recharge

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Effect of Soil Moisture Deficit on Productivity of Paddy in Hakwatuna Oya Irrigation Scheme

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The productivity of paddy is generally linked to the amount of rainfall and supplementary irrigation. However, in certain cases, this relationship is not very clear. Therefore, this study was conducted to find whether the soil moisture deficit is a better indicator to predict the yield of a paddy crop. *Hakwatuna Oya* major irrigation scheme, located in Agro Ecological Region IL3 was selected for the study. Daily rainfall, irrigation water issues and evaporation data were collected from 2004 to 2011. The yield obtained in *Yala* and *Maha* seasons during the above period was also obtained. Soil parameters were acquired from available literature. Using the above data, daily soil water balance was conducted to estimate the Soil Moisture Deficit (SMD). The Maximum Allowable Soil Moisture Deficit (MASMD) was also calculated using crop and soil parameters. Using this information, the total soil moisture deficit during each season and the total number of days during which SMD exceeded the MASMD was estimated. The number of days during which SMD exceeded the MASMD during different growing seasons were also calculated. These values were then compared with the observed yield using a regression analysis. The results showed that the strongest relationship with R^2 value of 0.76 exists between the paddy yield and the total SMD during the *Yala* season. This relationship is very poor ($R^2 = 0.02$) during the *Maha* season. Presence of rainfall during the *Maha* season may have reduced the accuracy of estimating the SMD. The observed relationships between number of days during which SMD exceeded MASMD and different growth stages also did not show a strong relationship. Therefore, it could be concluded that the total SMD during the *Yala* season is a better indicator to predict the yield of paddy crop when compared to total rainfall and irrigation.

Keywords: Growing seasons, Paddy productivity, Soil moisture deficit, Supplementary irrigation, Yield variation

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Potential Use of Anaerobic Digester Slurry as an Organic Fertilizer

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Anaerobic digestion of organic fraction of solid waste for methane gas production is an in-situ resource recovery option in waste management. The useful products from anaerobic digestion are combustible methane gas which can be used for burners and digested slurry which can be used as a fertilizer in agriculture. This study was conducted to evaluate the nutrient content of digester slurry from three small scale digesters and to evaluate the plant growth response to slurry application. Samples of digester slurry was analysed for physical (total solids, volatile solid and total carbon) and chemical properties (pH, EC, salinity, dissolved NH_4^+ , NO_3^- and PO_4^{2-}). The field trials were conducted with two crops; tomato (*Solanum lycopersicum*) and chilli (*Capsicum annuum*) at the Meewatura research farm. The crops were grown in an open field with three treatments for each crop; control without fertilizer, with recommended inorganic fertilizer and slurry application at a rate of 1 L/ plant/ application. Each treatment had three replicates in a randomized block design. The soil nutrient analysis showed that the field soils were slightly acidic with pH value of 5.1 prior to treatment whereas soil available nitrogen, phosphorus and potassium levels were 1540, 4, and 44 ppm, respectively. Addition of slurry marginally increased three nutrient contents of soil; however the inorganic fertilizer addition outperformed the control and slurry application. The crop growth was estimated by increase in plant height, plant diameter and number of leaves. There was a significant ($P<0.05$) effect from inorganic fertilizer addition on plant growth. Although there was no observed difference between the control and slurry addition on chilli plant growth, the difference was significant ($P<0.05$) for tomato plant growth. Thus, it was concluded that anaerobic digester slurry application has varying effect on crop growth, depending on the type of crop, and tomato plant growth is promoted by addition of slurry compared to unfertilized condition.

This work was partially funded by the Janathakshan (GTE) Ltd.

Keywords: Anaerobic digester slurry, Crop growth, Fertilizer

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Effect of Different Crop Establishment Techniques on Root Development, Morphological Parameters and Yield Parameters in Aerobic Rice Cultivation

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Lowland rice is the largest consumer of irrigation water in Sri Lanka. Alternatively, aerobic rice is an emerging concept of cultivating rice in well drained, non-puddled and non-saturated soil with supplementary irrigation. Water productivity is effectively increased by minimizing water losses through percolation, seepage and evaporation. In this research, five crop establishment techniques namely direct dry seeding, direct wet seeding, parachute method, transplanting after 1 week and transplanting after 2 weeks were tested with a 2 1/2 month rice variety (BG250) to choose an appropriate crop establishment technique for aerobic rice cultivation. The combination of direct wet seeding and flood irrigation was used as the control. Morphological parameters and yield parameters were monitored and compared among the treatments. It was clear that the method of establishment affected both, morphological and yield parameters significantly ($P < 0.05$). Performance of control (lowland rice) was better than all the aerobic treatments. Establishment methods did not affect the number of panicles per plant in aerobic rice cultivation. The number of grains per panicle in crops transplanted after 1 week was significantly higher ($P < 0.05$) than that of direct dry seeding. However, crop transplanted after 1 week showed no significantly higher ($P < 0.05$) number of grains per panicle when compared with the other three aerobic treatments. Therefore, direct wet seeding can be recommended as an alternative to direct dry seeding in aerobic rice cultivation. However, this experiment has to be repeated with different rice varieties to confirm the findings.

Key words: Water scarcity, Aerobic rice, Establishment techniques, Morphological parameters, Yield parameters.

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Assessment of the Applicability of Electromagnetic Survey (GEM-2) in Monitoring of Open Dumpsite for Municipal Solid Waste in Sri Lanka

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Open dumping of municipal solid waste creates series of environmental and social problems. Monitoring of dumpsites is important in deciding the mitigation measures to reduce the risk. Direct and continuous monitoring of dumpsite is difficult and required time, money and labour for both sample collection and laboratory analysis. Geophysical methods such as electromagnetic (EM) technique can be used for subsurface investigation rapidly without in-situ drilling and sampling. GEM-2 is a Multi-frequency, handheld, EM sensor. This sensor produce EM waves at pre-set multi frequencies and receives secondary EM waves from eddy current of substrate, depending on the apparent electrical conductivity (EC_a) thus EC_a of the underneath substrate can be mapped. An open dumpsite in Udapaltha Pradeshiya Sabha, Central province, Sri Lanka was surveyed using GEM-2 and validated with field measurement to assess applicability of EM survey. The dumpsite has two sections: Old and New with the age of 7 and 5 years, respectively. EM survey was carried out at 5 different days in the month of November and December 2014. EC_a variations were mapped in horizontal plane at 5 frequency levels. Waste samples were collected at 15 and 30 cm depths and electrical conductivity (EC) was measured at the laboratory. Waste distribution and delineation are clearly depicted in EM survey maps. Maximum reported EC_a in Old Bottom and New Top were 88 mS/m and 180 mS/m, respectively. Measured EC and EM surveyed EC_a were correlated with simple linear regression. Best correlations were obtained at Old Bottom (88%) with 93 kHz wave length and New Top shows (99%) with 85 kHz. Higher the frequency of EM wave, the penetration is shallow. Leachate plume and migration have been identified using inversion maps produced by turning all frequency GEM-2 data into resistivity of different waste layers. It can be concluded that EM survey is a powerful technique for dumpsite monitoring with careful interpretation.

Keywords: Apparent electrical conductivity, Electromagnetic survey, Municipal solid waste, Open dumpsite

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Development of an Anaerobic Baffled Reactor to Treat Pineapple Waste

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Pineapple waste is characterized by high amounts of nutrients, organic acids and potential microbial growth inhibitors and is considered as a waste that is difficult to treat biologically without pre-treatment. In this study, an experimental reactor was designed to treat pineapple waste anaerobically producing anaerobic products such as acids and biogas. The digester was fabricated as a lab scale anaerobic baffled reactor that treats pineapple waste by Acrylic sheets and Aluminium reinforce. The reactor consisted with six chambers that are separated by permeable charcoal filled baffles. Five different particle sizes of charcoal as 15 mm, 10 mm, 7.14 mm, 4.38 mm and 3 mm were filled into five baffles. A single reactor chamber was having 675 mL of active volume and 400 mL of air space. The baffled reactor consisted of feeding, sludge removal, gas collection, pressure reading and sample drawing mechanisms. During the operation, reactor was operated as a batch digester inoculated with methanogenic culture. The process started up by co-digestion of pulverized pineapple waste with pulverized food and vegetable waste. The reactor operated at room temperature (32 ± 5 °C) and each trial was carried out for 20 days of detention time. The result of the principal study showed that the optimum acidogenesis phase was reached at the 10th day from the start-up where physical compartmentalization showed a profile variation of the pH from the 1st to 6th chamber. Furthermore, batch experiments were carried out to find the suitable combination of pineapple waste and culture media and results showed that 10% (v/v) of pineapple is the most suitable combination to start-up the anaerobic digester. In perspective, the developed anaerobic baffled reactor can be used to separate the different phases of anaerobic digestion and can be fed with 10% pineapple waste during the start-up operation.

Keywords: Anaerobic digestion, Charcoal baffles, Pineapple waste, Baffled reactor

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Integrating Remote Sensing and Spatial Analysis Tools for Detecting and Monitoring Solid Waste Open Dump Sites

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This study investigated the possibility of using satellite remote sensing technology as a novel approach in assessment and management of solid waste open dump sites. The overall objective of the study was to determine whether the remote sensing derived information based on environmental/spatial variables and spectral response patterns could be used for evaluation and management of waste dump sites. Three open dump sites (Gohagoda, Karadiyana and Bloumendhal) and one sanitary landfill site (Moon Plains in Nuwara Eliya) were selected for the study. Medium resolution multi-temporal Landsat satellite images were used as the primary data. Surface vegetation, surface moisture, built-up characteristics and land surface temperature of the selected dump sites were analyzed using satellite image derived NDVI, NDWI, NDBI indices representing vegetation biomass, moisture and built up/ artificial surfaces respectively. Land surface temperature was derived using thermal bands of the Landsat images and heat islands were identified. According to the results, NDVI is a useful index to assess the variation of vegetation characteristics from the active dump site to the surrounding and also to monitor vegetation regeneration in abandoned dump sites. According to the NDBI index and land surface temperature, dump sites show similar characteristics with heavy built up areas. Heat islands were identified in core area of the dump sites and the highly urbanized areas. Hence, it was difficult to develop a unique index to identify the open dump sites. Satellite images of high spatial resolution will help to study and map the spatial variability within the dump sites and remote sensing technology can be used to establish and update an information management system in waste management.

Keywords: Remote sensing, Open-air waste dumps, Spectral reflectance, Surface vegetation, Heat Islands

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Heating and Roasting Characteristics of Dried Chilli (*Capsicum annuum* L.) Exposed to Far-Infrared Radiation

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The heating and roasting characteristics of dried chilli (*Capsicum annuum* L.) exposed to far-infrared radiation (FIR) were investigated in this study. Chilli is widely consumed as a food additive throughout the world. Infrared radiation is utilized in industrial scale because of its efficient and fast heating characteristics. Therefore, the moisture content, temperature and the color variation of chili pods, pedicels, seeds and placenta were measured exposing to FIR wavelengths; 7.76 μm (100 °C), 6.12 μm (200 °C), 5.06 μm (300 °C) and 4.30 μm (400 °C). The pericarp and seeds account for 48.44% and 41.82% of weight from the whole pod. The initial moisture removal rate was low, because it required some time period to increase the pod temperature. The moisture content of whole pod reached zero percent after 10 and 1 min at 6.12 μm (200 °C) and at 5.06 μm (300 °C) wave lengths respectively. The highest moisture removal rate was from placenta and the highest moisture percentage after drying was in the pedicel. The lightness of chili pods and pedicel was reduced with exposure time. There was no significant difference in color of the seeds and the placenta. The wave lengths lower than 6.12 μm (200 °C) for drying chilli was difficult to control due to rapid moisture removal.

Keywords: Chili, Drying, Heat transfer, Infrared radiation, Roasting

Evaluation and Applicability of Colorimetric Organic Matter Determination and its Relationship with Total Soil Nitrogen for Sri Lankan Soils

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Volumetric determination of organic matter using Walkey and Black method is a very common, more laborious, time and chemical consuming method. Colorimetric determination of soil organic matter is simple and less time consuming method which has not been tested for the Sri Lankan soils yet. Relationship between soil Nitrogen level and colorimetric soil organic matter content is also useful to predict soil Nitrogen level. The objectives of this present study to investigate the applicability of colorimetric determination of soil organic matter to Sri Lankan soils and to investigate the relationship between soil Nitrogen and soil organic matter. Fourteen soils varying in C content were collected from agricultural fields at 0-30cm depth differing in physico-chemical and other characteristics. In colorimetric method 1 g soil samples were placed in 100 mL volumetric flasks followed by the addition of 10 mL of 1/6 N $K_2Cr_2O_7$ and 20 mL of concentrated H_2SO_4 . The samples were mixed by swirling the flask and allow standing on a pad for 30 minutes (in a fume cupboard). After bring-to a volume of 100 mL the mixture was filtered and analyzed for light absorption at 600 nm using spectrophotometer. Colorimetric organic matter values showed strong correlation with organic matter determined by volumetric method ($r = 0.95$). Determined organic matter from both methods showed no significant difference ($P < 0.05$). Colorimetric method organic matter values showed strong correlation with total Nitrogen ($r = 0.75$). It is confirmed that colorimetric method can be used effectively and reliably to determine soil organic matter in Sri Lankan soils and total Nitrogen in soil can also be predicted.

Keywords: Colorimetric method, Organic matter, Soil nitrogen, Volumetric method

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Estimation of Soil Surface Moisture Content of a Yellow Latosol using the Chopra Model

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The knowledge on the moisture content of surface soils is important for the efficient planning of water resources in crop production. In this study, a simple hydrological model called Chopra model was assessed to estimate the soil moisture content of a Yellow Latosol at the Regional Agricultural Research and Development Centre, Kilinochchi. The input parameters required for the Chopra model are initial soil moisture and surface boundary flux conditions along with few easily measured soil physical parameters. To investigate the functioning of the model, input data were obtained from three different sources namely, literature based, laboratory analysis and from pedo-transfer functions. Soil water content of the surface soil (0-15 cm) was measured daily at three plots for twenty days. The model predictions of soil moisture contents at different depth intervals and at different time intervals were obtained. Measured and predicted soil moisture contents of the surface were compared by using the root mean square error (RMSE) and residual error (RE) values. Results indicated that the RMSE of the predicted moisture contents were within the range of 0.02 to 0.08 and the RE values ranged from 2-8%. When using input data from three different sources, the model predicted the moisture contents maintaining a residual error less than 10% and which is reported as an acceptable level of prediction accuracy. The model produced most accurate predictions when using the values of input parameters from laboratory analysis. This study revealed that the Chopra model can be used to generate the profile soil moisture data with an acceptable accuracy.

Keywords: Chopra model, Moisture, Pedo-transfer functions, Yellow Latosols

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Assessment of Soil Salinity Using DUALEM-1S Proximal Soil Sensor

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Soil Salinity is a significant problem affecting agriculture worldwide and is predicted to aggravate in the coming decades endangering the food security. In Sri Lanka, soil salinity occurs in major irrigated inland areas of the dry zone and coastal areas. Information on spatial variability of soil salinity is important to adopt reclamation measures and also to select suitable crop varieties. This study focuses on the potential of DUALEM-1S, an electromagnetic induction-based proximal soil sensor to explore the spatial variability of soil salinity and subsequent delineation of potential salinity hazard zones. Apparent electrical conductivity (EC_a) survey was performed using the DUALEM-1S sensor in a paddy field (2.5 ha) in Mahailuppallama. Top (0-30cm) and subsoil (30-60 cm) samples were collected at 35 sample locations those identified using the Latin Hypercube sampling technique based on EC_a . Soils were analyzed for pH, EC (1:5 Soil:Water), EC of saturated paste (EC_e), texture, organic matter (OM), available Na, Ca, Mg, and CEC. The EC_a survey resulted in 6318 measurements of horizontal (EC_{aHCP} , subsoil sensitive) and perpendicular (EC_{aPRP} , top soil sensitive) coplanar coil orientations. Both measurements were highly correlated ($r = 0.95$). The EC_{aPRP} and EC_{aHCP} measurements showed strong correlations with topsoil EC_e ($r=0.90$) and ($r=0.89$), respectively. Two potential salinity hazard zones were delineated using the Fuzzy k -means classification based on the interpolated map of EC_{aPRP} . One zone having comparatively low EC_a (0.1- 155 mS/m) and the other having higher EC_a (155- 309.9 mS/m). Soils were obtained from each zone for further analysis. Soil analyses revealed that the zone having high EC_a as sodic zone ($ESP > 90.1\%$) and zone having lower EC_a as non-saline zone. A pot experiment was conducted using soils of potential salinity hazard zones revealed a zero germination of Bg 352 and At 354 rice varieties in the sodic zone and the nonsaline zone did not affect on the germination of both varieties. This study confirmed a strong potential of using DUALEM -1S proximal sensor for mapping the salinity of paddy soils in Sri Lanka.

Keywords: Apparent electrical conductivity, DUALEM-1S proximal soil sensor, Salinity hazard zones, Soil salinity, Sodicity.

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Exploring the Short Scale Spatial Variability of Soil Properties in a Calcic Red Latosol Soilscape

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The information on the spatial variability of soil properties is vital for the better soil management and to increase the crop productivity. This study was conducted to explore the short-scale spatial variability of selected chemical and physical soil properties in a Calcic Red Latosol soilscape in the Alaveddi area in the Jaffna district. The study area consisted of 2.5 ha and samples were collected within the plough depth (0-30 cm) by using stratified random sampling scheme. The soil clay content, silt content, sand content, organic matter (OM), pH, electrical conductivity (EC) were determined for all the samples (n=40) and available phosphorous, exchangeable potassium were measured for selected samples (n=9). The variability these properties were investigated by means of classical and geostatistical analysis techniques. The coefficient of variation of properties ranged from 4% (pH) to 32% (clay content). The experimental variograms calculated for soil properties were best fitted with spherical model. According to the relative nugget effect (RNE -ratio of nugget to the sill) of variograms, the clay content, sand content, silt content, electrical conductivity and organic matter exhibited a highly spatially structured variability (RNE < 25%), whereas a medium structured variability was observed for soil pH (RNE 25-75%). The observed spatial dependencies of soil properties indicated that sampling space for future studies can be ranged from 20 m (pH) to 43 m (clay). The maps of texture, OM further illustrated a strong short-scale spatial variability indicating the potential of site-specific soil management in the study area.

Keywords: Calcic Red Latosol, Semi-variogram, Short-scale spatial variability, Site-specific soil management

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Diversity of Bacteria as an Indicator of Soil Quality in two Intensively Cultivated Vegetable Cropping Systems of the Central Province

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Soil bacterial communities are known to be affected by intensive agricultural practices such as high usage of chemical fertilizer, manure and pesticides. This study was conducted to assess the diversity of soil bacterial communities in two intensive vegetable cropping systems in Marassana on reddish brown latosolic soils and in Nuwaraeliya on red yellow podzolic soils using soils collected from six fields in each location with three replicates. The total culturable bacteria population was assessed by the spread plate technique using a minimal medium. The percentage of cadmium and antibiotic resistant bacteria and glyphosate consuming bacteria were assessed by amending the same medium with 2 mM Cd, 0.1g of amoxicillin and 50 mg of glyphosate per liter, respectively. Soils were analyzed for pH, organic matter and total Cd. Soil pH in Marassana and Nuwaraeliya soils varied from 4.3 to 7.5 and 4.8 to 6.7, respectively. The mean organic matter contents and total Cd contents were $0.95\% \pm 0.13$ and 0.048 ± 0.002 mg/kg in Marassana soils and $2.07 \pm 0.3\%$ and 0.27 ± 0.025 mg/kg in Nuwaraeliya soils. The total culturable bacteria in Marassana and Nuwaraeliya soils varied from 1.5 to 4.5×10^7 cfu/g dry soil and 3.6 to 6.8×10^6 cfu/g dry soil, respectively. The Cd-resistant bacteria in communities ranged from 0.0026% to 0.24% in Marassana and from 0.0062% to 0.21 % in Nuwaraeliya. The glyphosate consuming bacteria population varied from 0.0012% to 0.29% in Marassana soil and 0.0031% to 0.11% in Nuwaraeliya soil. The percentage of antibiotic resistant bacteria population was significantly higher in Nuwaraeliya (51% to 100%) than in Marassana soils (<1%) partly due to continuous application of manure. Results of this study provide evidence that selected three bacterial populations are good indicators to assess the soil quality of intensively cultivated two soil types. As indicated by these parameters, cultivated soils in Marassana are better in quality than those of Nuwaraeliya in terms of pollution.

Keywords: Antibiotics, Cd, Glyphosate, Intensive cultivation, Resistant bacteria

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Occurrence of Antimicrobial Resistance in Bacteria Isolated From Poultry Manure and Agricultural Soils in Kandy District, Sri Lanka

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Nature of antibiotic resistance of bacteria in soil and animal manure have ecological implications. A study was conducted to isolate and characterize antibiotic resistant bacteria (ARB) from poultry manure and agricultural soils. Five piles of poultry manure, thirteen crop fields, and two uncultivated sites were selected from WM3 agro ecological region in Kandy district, Sri Lanka. Soil collected from 0-10 cm depth and manure samples were analyzed for pH, electrical conductivity, respiration, potential N mineralization, active C and total culturable bacteria. Bacteria were enumerated using 0.3% TSB agar supplemented with tetracycline or enrofloxacin each at 0, 1, 5 and 10 ppm in spread plate technique. Nine isolates were selected and characterized for minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) for tetracycline. Multiple antimicrobial resistances of isolates towards tetracycline, enrofloxacin and neomycin were evaluated by antibiotic susceptibility test using disk diffusion technique. Isolates were tested for gram staining, P solubilization, cellulose decomposition, N₂ fixation, and resistance towards Cu (5 mmol) and Cd (5 mmol). Culturable bacteria populations were in the range of 6.18 to 7.71 log₁₀ CFU/g in cultivated soils and values were comparable to those of uncultivated soils and manure. Bacteria resistant to tetracycline and enrofloxacin were present in all samples. Abundance of ARB populations in soils and manure declined with increasing antibiotic concentration in the growth medium ($r = -0.63$). The MIC and MBC of the isolates ranged from 16-128 mg/L and 512-1024 mg/L, respectively. Six isolates were resistant to only tetracycline and one isolate was resistant to all three antibiotics. All the isolates could decompose cellulose and 56% and 44% of the isolates had the potential to fix N₂ and solubilize P, respectively. Poultry manure and soils in the study area harbor tetracycline and/or enrofloxacin resistant bacteria having the potential to perform important ecological functions. Variability in tetracycline and/or enrofloxacin resistance characters is suggestive of high diversity among ARB.

Keywords: Antibiotic resistance, Enrofloxacin, Poultry manure, Soil bacteria, Tetracycline

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Inhibitory Effect of Six Leaf Extracts on N₂O Emission from Soil: An Incubation Study

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Emission of nitrous oxide (N₂O) from agricultural soils reduces nitrogen fertilizer use efficiency by the crop and contributes to global warming. Therefore, compounds that inhibit nitrification and denitrification, which are the two major biochemical pathways of emitting N₂O, are being used in agricultural soils worldwide. In this study, inhibitory effects of six leaf extracts were tested on the emission of N₂O and the activity of NH₄⁺ and NO₂⁻ oxidizing bacteria. Leaves were (T1, T2, T3, T4, T5 and T6) extracted into water using a blender and amended at 1% and 2% rates alone and as combinations to a soil collected from a paddy field in Peradeniya. Soils were incubated in plastic bottles under unsaturated and saturated conditions for two and three weeks, respectively. Head space gas was collected periodically after sealing the bottles for 2h and assessed for N₂O using gas chromatograph. Inhibitory effects of leaf extractants on NH₄⁺ and NO₂⁻ oxidizing bacteria *in vitro* were assessed by quantifying the formation and consumption of NO₂⁻, respectively by amending their growth media. Under saturated condition, significant reductions in N₂O emission was observed for leaf extract treatments T1 (3496 pmol/cm³) and T2 (5172 pmol/cm³) in comparison to unamended control (7482 pmol/cm³) up to 10 days. Thereafter, emission increased. Under unsaturated condition, treatment 0.5% T1 + 0.5% T2 showed significantly lower emission (3555 pmol/cm³) than control (13327 pmol/cm³) and lower values were kept up for 15 days. The inhibitory effects of T1 and T2 treatments were observed on NH₄⁺ and NO₂⁻ oxidizing bacteria *in vitro*. The concentration of NO₂⁻ in NH₄⁺ oxidizing bacteria medium amended with T1 (0.0007 mg/L) and T2 were (0.0012 mg/L) significantly lower than the control (0.0038 mg/L). Results of this study suggest that leaf extractants T1 and T2 are effective inhibitors on emission of N₂O under controlled conditions for a short period. Further investigations are necessary for long-term inhibition under field conditions.

Keywords: Inhibition, Leaf extraction, N₂O emission, Saturated soil

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Effect of Different Coco Pith Buffering Processes on Cation Availability and Growth of Tomato (*Solanum lycopersicum*) Plant

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Disproportionate contents in plant nutrients and high sodium content negatively affects plants grown in coir based soilless growth media. This study was conducted to determine cation availability in coir pith buffered with different chemicals and also to determine the growth and nutrient status of the tomato plant (*Solanum lycopersicum*) grown in such media. In a leaching column experiment, 0% and 100% of the recommended level of the Albert solution was applied in to coir buffered with either water, $\text{Ca}(\text{NO}_3)_2$, or MgSO_4 . Cation concentrations were determined in leachates collected at six times in 42 days. In a greenhouse pot experiment, four levels of the Albert solution (0%, 50%, 100%, and 120% of the recommended level) were applied in to tomato plants grown in the three buffered coir medium. Growth and leaf nutrient concentrations of the tomato plants were measured after 42 days. Available potassium contents were significantly high ($P < 0.001$) in water (278 $\mu\text{g/ml}$) and MgSO_4 (304 $\mu\text{g/ml}$) buffered coir compared to that in $\text{Ca}(\text{NO}_3)_2$ buffered coir (91 $\mu\text{g/mL}$). Magnesium content in coir buffered with MgSO_4 was significantly high ($P < 0.001$) compared to that in coir buffered with water and $\text{Ca}(\text{NO}_3)_2$. The most effective buffer for the removal of sodium from coir pith was $\text{Ca}(\text{NO}_3)_2$. Dry matter accumulation in plants grown in both $\text{Ca}(\text{NO}_3)_2$ and MgSO_4 buffered coir was not increased when the Albert solution was increased beyond 50% of the recommended level. But in plants grown in water buffered coir, application of 100% of Albert solution was required to record the highest growth. Multiple regression analysis revealed that the change in phosphorous (80%) and calcium (10%) status of the plant could be the possible reasons for the observed variations in plant growth. Coir could be used as a growth media efficiently by employing appropriate buffering methods and nutrient management strategies.

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Keywords: Albert solution, Buffered coir media, Cations, Plant nutrition

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Investigating the Capability of Selected Plant Proteins to Self Assemble in- to Nano-scale particles with Carrageenan

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Biopolymer particles at nano and micro-scales can be formed by controlled electrostatic interactions between proteins and ionic polysaccharides. The aim of this study was to fabricate biopolymer particles by interacting proteins extracted from three legume varieties, namely mung bean (*Vigna radiata* var. MI-6), cowpea (*Vigna unguiculata* var. MI-35) and black gram (*Vigna mungo* var. MI-1) electrostatically with carrageenan. Extraction and purification of proteins from legume seeds were carried out in-house and their molecular weight profile were obtained by sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE). Vicilins (48 kDa) was abundant in all three protein extracts, while proteins or peptides with molecular weight of 45 kDa and legumins (40 kDa) were only present in black gram. To initiate the self-assembly of proteins with carrageenan, 0.2% (w/v) protein solutions prepared from the extracts were mixed with 0.1% carrageenan at a volume ratio 1:1 pH of both biopolymers solutions were adjusted to pH 7.0 before mixing together. pH of the mixtures was then reduced to 6.0 and 6.5 to provide an adequate, yet not excessive electrostatic potential to form protein-polysaccharide particles. Scanning electron microscopy (SEM) revealed that they are roughly spheroid in shape, and the average diameter of the particles formed by interacting mung bean, cowpea, black gram protein extracts was ~120, 140 and 160 nm, respectively ($\eta=50$). The mixtures containing these nano-scale particles were heated above the thermal denaturation temperature of proteins (85°C). Heat treated biopolymer particles were stable to aggregation over a pH range from 4-7, as shown by turbidity measurements. However, SEM images illustrated that the size of the nanoparticles has increased after the thermal treatment up to 2-fold of their initial size. These nanoparticles can be potentially used for the encapsulation and delivery of bioactive compounds, or as a substitute for lipid droplets in food emulsions.

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Keywords: Carrageenan, Electrostatic interactions, Nanoparticles, Vicilins, Legumins

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A Comparative Study of Sri Lankan and Indonesian Areca nut (*Areca catechu* L.)

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Areca nut palm (*Areca catechu* L.) is cultivated primarily for its kernel, chewed in its tender, ripe or processed form. This study investigates the degree of compatibility of dried areca nut for export, comparative morphological characteristics, chemical compositions and physical properties between Sri Lankan dried areca nut (SA) and Indonesian dried areca nut (IA). Seed morphological characteristics revealed whiter core with unclear light brown color veins of SA and lesser white core with distinct dark color veins of IA. Physical properties of SA and IA were determined by considering kernel shape as ovate. IA had higher effective diameter, average volume, projected area and weight of one nut, roundness and sphericity values at normal-major axis compared to SA. SA had greater true density, bulk density and porosity values in comparison to IA. Higher coefficient of friction of SA was observed on wood and stainless steel surfaces. The results of the proximate analysis revealed that the IA was richer in crude fiber, ash, volatile oil and aqueous extract percentages than that of SA, while SA exhibiting greater amount of carbohydrate content. Gas chromatography (GC) revealed that myristic, palmitic, oleic, linoleic and linolenic acids are prominent in both SA and IA. SA contains significantly ($P < 0.05$) higher percentage of linoleic acid than that of IA. The phytochemical analysis suggested a quantitatively higher percentage of total phenolic, flavonoid and tannin content in IA than SA. Alkaloid and arecoline concentrations were observed in significantly ($P < 0.05$) higher amounts in IA extracts than SA. IA showed greater antioxidant properties in the DPPH assay followed by SA and ascorbic acid standard. As a rich source of phenolics and flavonoids, and high antioxidant activity, IA can be considered as a good source of antioxidants, but higher arecoline content in IA compared to SA may cause oral submucosis fibrosis and cholinergic muscarinic agonistic activity in human beings.

Key words: Arecanut, Sri Lankan dried areca nuts (SA), Indonesian dried areca nuts (IA), Antioxidant activity, Phytochemicals

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Detection of the Adulteration of Edible Oils Using Fourier Transform Infrared [FTIR] Spectroscopy

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Adulteration of expensive edible oils with cheap oils is a major issue in the edible oil industry. In the present study, the possibility of using Fourier Transform Infrared (FTIR) spectroscopy to detect the presence of palm oil in regular coconut oil (RCO), Virgin Coconut oil (VCO), Sunflower oil (SFO), Soybean oil (SBO) and Sesame oil (SeO) was investigated. The Authentic oil samples were prepared through solvent extraction and mechanical pressing of oil seeds. The fatty acid profile of the oils was determined using Gas Liquid Chromatography (GLC). Authentic samples, their mixtures with palm oil as well as the edible oil samples purchased from local market were analyzed using spectroscopy at mid infrared region ($4000\text{--}650\text{ cm}^{-1}$) using horizontal attenuated total reflectance. The infrared spectrum of pure palm oil showed a clear band at 3007 cm^{-1} which is absent in the spectrum of pure coconut oil. The band at 1111 cm^{-1} was found to be characteristic to coconut oil. Based on the calibration curve (absorbance versus percent palm oil added to coconut oil prepared), it was possible to determine the degree of adulteration of coconut oil with palm oil. A strong correlation ($R^2 > 0.95$) was observed in this study. Soybean oil and sunflower oil showed a characteristic band at 3009 cm^{-1} . Presence of palm oil shifted this band to lower frequencies due to reduction of unsaturation of those oils. The spectral patterns in the finger print region ($1500\text{ cm}^{-1}\text{--}700\text{ cm}^{-1}$) showed the difference between the spectra of pure sesame oil and palm oil. The data in this study demonstrated that FTIR spectroscopy proves to be a valuable tool to identify and quantify the adulteration of edible oils. According to gas chromatographic results, the highest amount of saturated fatty acids were reported in coconut oil while sunflower oil showed the highest percentage of unsaturated fatty acids.

Keywords: Adulteration, Fourier transforms infrared (FT-IR) spectroscopy, Finger print region, Vegetable oils

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The Thin Layer Drying Characteristics of Nutmeg: Comparison between Sun Drying and Mechanical Drying

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This study was performed to identify thin layer drying characteristics of nutmeg and most appropriate thin layer drying model for nutmeg. The thin layer drying tests were conducted under two major parts. They are sun drying and mechanical drying. Sun drying was conducted under natural atmospheric conditions. Mechanical drying tests were conducted at three different drying temperature levels of 40, 50 and 60 °C. Fresh nutmegs were used for the test which were having $79 \pm 1.03\%$ of initial moisture content. For the mechanical drying, 15.5 m/s air flow rate was used. During drying, the mass loss was measured continuously. Drying of nutmeg occurred in falling rate period where critical moisture content of nutmeg was observed at the moisture content (% d.b) in the range of 8-10%. Drying curves observed from the experimental data, fitted to five thin layer drying models and compared with four statistical parameters. Results indicated that the Page model gives better predictions for moisture transfer in sun dried nutmegs than other models. According to the results logarithmic model was adequately explained the mechanical drying characteristics of nutmeg at all three different temperature levels. These two models were fitted to the experimental data of sun dried and mechanically dried nutmegs with high statistical coefficient values. However 40 °C dried nutmeg shows highest oil content of $8.5 \pm 0.7\%$ and oleoresin content of $46.0 \pm 0.2\%$. But there is no significant difference ($P < 0.05$) of oil content between 40 °C and 50 °C and also there is no significant difference ($P < 0.05$) of oleoresin content among all the drying methods. Sun dried nutmegs showed inferior quality in microbial count. It was nearly about 75-150% higher microbial count than the mechanical dried nutmeg samples. According to the above results 50 °C dried nutmegs showed the best quality than sun dried, 40 °C and 60 °C samples.

Key Words: Drying, Nutmeg, Thin layer, Thin layer drying model, Quality

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Impact of Extraction Temperature upon the Quality of Sesame Oil, and a Survey-based Investigation of its Marketability in Sri Lanka

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Sesame (*Sesamum indicum* L.) oil is an underutilized oil with a high potential to compete with other vegetable oils. This study addresses two issues; impact of extraction temperature upon the quality of sesame oil; the factors affecting its marketability. Sesame seeds (MI-2), dried at 60°C (cross-flow air drier; 3.76±0.15% moisture content), were expelled in a screw-type expeller (DL-ZY-J02) operated at 38.98±0.47°C (SO40) and 60.66±3.21°C (SO60) as treatments in triplicate, and the two oil samples were subjected to physicochemical analyses. Refractive index (40°C), moisture content (% wb), water activity (24.94±0.12°C), saponification, and iodine values, unsaponifiable matter (%) and free fatty acid (oleic acid %) of SO60 samples were 1.46, 0.17±0.01, 0.86±0.01, 191.68±3.26, 104.56±0.51, 1.75±0.09, and 0.15±0.02 respectively, and the peroxide value was not detectable. SO40 samples were not significantly different ($P>0.05$) from SO60 samples in physicochemical properties, which are within the specifications of SL and Codex standards. Extraction at 60.66±3.21°C resulted in a significantly higher ($P<0.05$) oil yield (38.44±2.05%) than at 38.98±0.47°C (30.08±1.49%). Impact of extraction temperatures upon the sensory attributes of the oil tested by evaluating the overall acceptability (paired-preference test; 30 consumer panelists; boiled potato as the carrier) revealed that SO60 was significantly better ($P<0.05$) than SO40 showing 73.3 and 26.7% preferences respectively. A consumer survey conducted revealed that 86% out of 50 users of sesame oil buy the local products and 66% them was not satisfied with the quality. Informal interviews conducted with non-users (50) revealed high price, inaccessibility and displeasing odour as major constraints of sesame oil use. Market situation of edible oils analyzed by observing 12 randomly selected supermarkets (Kandy, Colombo and Kegalle districts) revealed that sesame oil was comparatively less popular than other oils. Extraction of sesame oil at 60°C can be recommended, even though 50°C is considered the maximum extraction temperature for cold pressed oil.

Keywords: Sesame oil extraction, Temperature, Quality

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Extraction of Cassava (*Manihot esculenta* Crantz) Linamarin for Incorporating into Candy as a Possible Cancer Preventive Functional Food

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Over 14,000 patients died of cancer in Sri Lanka in 2013. Several cancer patients have expressed their views with regard to curing cancer after consuming crude cassava extract (CCE). Linamarase present in cancer cells hydrolyzes linamarin in CCE to HCN, which kills cancer cells and is detoxified by rhodenase in healthy cells. The present study focuses on extraction of cassava linamarin for possible incorporation into candy. Proteins in the homogenized (acetate buffer, pH 5.5) MU51 tuber peels were precipitated (60%-(NH₄)₂SO₄), resolubilized (phosphate buffer, pH 6) and dialyzed (12-20 kDa) to obtain partially purified linamarase (PPLE). Diced tubers (MU51) were homogenized (dH₂O) and filtered (0.45 µm) to obtain CCE filtrate (CCEF). Presence of linamarin (proportional to HCN content) in CCEF was checked by comparing the absorbencies (alkaline picric paper method, 510 nm) of CCEF with and without PPLE, which were 0.167 and 0.082 respectively. The HCN contents in CCEF of *Suranimala*, MU51 and *Shani* were 34.45±1.81, 44.45±0.60 and 46.73±1.73 mg/kg respectively. MU51 was used for partially purifying linamarin (PPL) as it is the most available variety and HCN contents of MU51 and *Shani* were not significantly different (P<0.05). Percent reduction of linamarase activity of CCE extracted with water at varying temperatures (35, 40, 60 and 70 °C) was 4.5, 13.8, 17.0 and 25%, respectively. Diced MU51 tubers homogenized with dH₂O were left for 1h for starch deposition followed by filtration (0.45 µm). The filtrate was heated (70 °C, 3 min), dialyzed (kDa 12-20) and incorporated with citric acid to which cassava starch and sucrose were added to manufacture the candy. As interviews held with cassava consuming cancer patients revealed three distinct groups; cured while getting medical treatments (MT); cured without MT; cured after failing MT, the potential of the candy for preventing cancer needs to be explored after further developing the product.

Keywords: Cancer, Linamarin, Cassava, Functional food, CCE

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Effect of Physically Structured Water on Extractability of Caffeine, Curcumin and on Oil Emulsification

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Physically structured water (PSW) possesses reduced molecular cluster structure. The study researched into identifying the effect of PSW on caffeine and curcumin extractability and oil emulsification. PSW obtained using a column of nano-tourmaline impregnated ceramic balls was compared with non-structured water (NSW) based on physical properties. ORP, pH and NMR frequency of PSW and NSW were different ($P > 0.05$), and were -113 & $+97$ mV, 8.64 ± 0.08 & 6.83 ± 0.06 and 55 & 120 -Hz respectively. Caffeine was extracted from black tea, green tea, coffee and instant coffee at 24.5 ± 0.2 and $95 \pm 2^\circ\text{C}$ for 30 min in triplicate using PSW and NSW (2×2 factorial, CRD) and quantified by spectrophotometry (273 nm). PSW increased ($P < 0.05$) the extractability of caffeine at 95°C by 83.6% (black tea), 79.7% (coffee), 56.6% (green tea) and 3.6% (instant coffee). Caffeine contents from black tea (63.2 mg l^{-1}), coffee (60.2 mg/L) and instant coffee (135.0 mg/L) with PSW at $24.5 \pm 0.2^\circ\text{C}$ were not different ($P > 0.05$) from the contents extracted at $95 \pm 2^\circ\text{C}$ with NSW. Curcumin was extracted from turmeric powder (sieve size, 300μ) at 24.5 ± 0.2 and $95 \pm 2^\circ\text{C}$ for 20 min in triplicate using PSW and NSW (2×2 factorial, CRD), and the absorbencies (420 nm) of the extracts were compared. PSW increased ($P < 0.05$) the extractability of curcumin at $95 \pm 2^\circ\text{C}$ by 430% and at $24.5 \pm 0.2^\circ\text{C}$ by 282%. Virgin coconut (VCO), sunflower and olive oils were sonicated (50-Hz, 5min) in triplicate with PSW and NSW in a CRD, and the turbidity at 500nm were measured daily for 6 days. Turbidity of VCO was significantly higher ($P < 0.05$) by 1.1-, 1.2-, 1.2-, 1.2-, 1.2- and 1.5-fold on day 1, 2, 3, 4, 5 and 6 respectively when treated with PSW than with NSW. Similar pattern of turbidity was evident in other oils. PSW is more effective than NSW in extracting caffeine and curcumin and emulsifying oil.

Keywords: Physically structured water, Extractability, Emulsification

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*Agricultural Markets,
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A Study on Production and Marketing of Leafy Vegetables in a Peri-urban Area of Colombo, Sri Lanka

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Demand for leafy vegetables, has recently increased due to urbanization and diversity of diets. Highly perishable nature of products of this vegetable group has led to emerge peri-urban areas as major production areas. This has implications on agricultural land use patterns and sources of income for farmers. Studies to identify practices and profitability of production and marketing of leafy vegetables are important to design policy interventions. However, despite abundance of research on production and marketing of other vegetables, there is a paucity of studies in Sri Lanka on economics of leafy vegetable production and marketing. This study aimed to document production practices; calculate farm profitability; map market channels and calculate marketing margins for leafy vegetables in a peri-urban farm supply area. This research comprised of two parts, a farm level study and a study on marketing channels. The farm level component was conducted in two villages selected from *Bolgoda Lake Periphery* that is a major supply area of leafy vegetables to Colombo, the major urban market in the country. A sample of 32 farmers was selected randomly from farmer organization membership registers for this component. Data on farming and marketing practices, quantities of inputs and outputs and costs and revenues were collected using a structured survey schedule. 47 other market participants were identified using snowball sampling and data on their practices and prices were collected using semi-structured interviews for the market analysis. Farm budgets and marketing margins were computed. According to results, 70 percent of farms plant multiple crops. Average farm size is 0.5ha. *Kankun* (*Ipomea aquatica*); *Mukunuwenna* (*Alternanthera sessilis*) and *Gotukola* (*Centella asiatica*) accounted for 85 percent of the area under leafy vegetables. Eleven market channels were identified. Village collectors account for handling of 50 percent of quantity produced. Farm-retail price spread in the dominant channels is 70 percent.

Keywords: Marketing margins, Farm budgeting, Village collectors, Multiple cropping, Market middlemen

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Adoption of Parachute Method for Crop Establishment: A Study of Rice Farmers in Major Irrigation Areas in Kurunegala District

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Rice cultivation faces multiple challenges in continuation of production to feed the world. Parachute technology is expected to increase the yield and to lower labor costs. However, the continuation and the realization of expected benefits of this technology depend on farmers' adoption rate. Objectives of this study were to estimate the adoption rate, determine factors influencing adoption and estimating the benefits to farmers in a major rice growing district in Sri Lanka. Data were collected during 2014 using a structured survey schedule. 88 farmers were selected from 10 villages in *Ibbagamuwa* and *Nikaweratiya* DS areas through multi-stage random sampling. Data on history of adoption and costs and benefits of rice production for the last two seasons were collected. Binary logit regression was used to determine the factors influencing the adoption decision. Farm budgets were developed to compare benefits of different technologies. According to results, adoption rate of parachute technology in the study area is 30 percent. Number of extension contacts, education level, land ownership type, age, office in farmer organization and monthly income significantly affect the adoption decision. Farmers' beliefs on the benefits of the technology are consistent with the intended benefits by extension services. Specifically, farmers stated that convenience in weed management as the best advantage of the technique. Adopters reported highest average yield of 4.86 t/ha and 4.98 t/ha in *Yala* and *Maha* seasons respectively. Average yields reported by farmers using random transplanting and broadcast sowing are 4.63 t/ha and 4.29 t/ha respectively for *Maha* Season. Profits for adopters are the highest and significantly differ from that of conventional methods. Although the technology is proven beneficial, rate of farmer awareness on it is greater than the rate of adoption indicating the potential for awareness building through proactive extension services and field trials to get increased benefits to the society.

Keywords: Parachute transplanting, Yield advantage, Farm budgeting, Binary logit regression, Labor augmenting technology

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A Study on Competitiveness of Black Tea Exports from Sri Lanka in the Japanese Market

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Tea is the most important agricultural export from Sri Lanka accounting for 15 percent of total annual value of exports. Black tea is the leading segment of Sri Lankan tea industry accounting for 98.6 percent of the total export value. Japan is considered as the most sophisticated tea market in the world. It demands for tea products as green, black, instant, and oolong teas. As Japan is not a black tea producing country, its black tea market completely depends on imports from other countries. Japan is one of top five export destination of Sri Lanka for two black tea products, tea bags less than 4g and bulk tea of more than 10kg in weight. It is one of highest revenue earning market for Sri Lankan black tea. The country competes with other tea exporting countries in this market. Knowledge on determinants of competitiveness is important for understanding market dynamics and planning. In this analysis rival countries of Sri Lanka for black tea were identified using Export Similarity Index (ESI). Competitiveness was measured by Herschman-Herfindahl Index (HHI) and Revealed Comparative Advantage (RCA) Index. United Kingdom, France, Malaysia, Kenya and Indonesia are main rival countries of Sri Lanka. Japanese market is highly concentrated for black tea as it shows HHI value is 3,951. Sri Lanka accounts for the highest market share of 50 percent. The RCA index shows that Sri Lanka's competitive power is higher than Kenya and Indonesia for tea bags. It is higher than United Kingdom, France and Malaysia for bulk tea. Based on the econometric import demand model, export price of tea from Sri Lanka has a significant effect on import demands of United Kingdom, France and Malaysia for tea bags. For bulk tea Sri Lankan export price has a significant effect on France and Malaysian import demands.

Keywords: Herfindahl Index, Export similarity index, Revealed comparative advantage, Import demand model, Seemingly unrelated regression

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Consumption Patterns and Preferences of Yoghurt Products among Households: A Study in Anuradhapura District

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Milk and milk products are considered key components of healthy human diet. Promoting local milk production is a strategy by the Government of Sri Lanka to reduce dependency of the nation on imports. Yoghurt and curd industry primarily depends on local production of milk and involve a diverse set of industry participants. Understanding the current status of the market from consumer perspective is important to the government for planning for increasing local production of milk and to producers in design of market strategies. Objectives of this study were to investigate the factors affecting consumption patterns and brand preferences of yoghurt and curd by households in Anuradhapura District. Data were gathered using a structured survey schedule. Ninety households were randomly selected from 3 locations (*Kadiyangalla, Kurundankulama and Yasasiripura*) to represent rural, semi-urban and urban households. Consumption data were based on seven-day recall of food purchase and consumption. Data on socio-demographics and availability of brands in the locality were also collected. Data were analyzed using descriptive statistics to understand consumption patterns. Determinants of consumption quantity were identified using multiple regression analysis. Results reveal that 96 percent and 93 percent of households consume yoghurt and curd respectively. Nearby grocery is the most preferred place of buying yoghurt and large groceries and distributors are the most preferred place of buying curd. Regression model suggests that household size and per capita consumption of curd and ice-cream negatively affect the per-capita consumption of yoghurt, while presence of children less than ten years old and wellbeing index positively affect it. The effect of mother's education on yoghurt consumption is positive and significant. 98 percent of the households prefer national brands to local brands in yoghurt buying while only 45 percent of households prefer national brands of curd over local brands.

Keywords: Purchasing behaviour, Local brands, Multiple regression analysis, Local industries, Respondent recall methods

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Patterns and Determinants of Household Vegetable Consumption: A Case Study in Udapalatha Divisional Secretariat Area

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Adequate intake and diversity of vegetables is increasingly recognized important to reduce the incidence of non-communicable diseases. Understanding consumption patterns of various segments of the society and their determinants will help effectively target nutrition interventions. Objectives of this study were to identify the patterns and the effect of social and demographic characteristics on vegetable consumption in households in selected villages from Central Province of Sri Lanka. Data were collected using one week recall method using a structured survey schedule. 90 households were selected from 3 Grama Niladari divisions (*Sinhapitiya North, Godagama and Rathmalkaduwa*) in Udapalatha Divisional Secretariat Area through simple random sampling. Data on socio-economic and demographic factors and expenditure patterns of households were collected. Data were analyzed using descriptive statistics and linear regression. Linear regression analysis was used to explain relationships between the per-capita weekly vegetable expenditure and socio-economic and demographic characteristics of the households. Mean total household monthly expenditure is LKR.29, 342.22. Mean monthly food expenditure is LKR 18,341.11. Two-third of the households buys vegetables at least once in three days. Mean vegetable expenditure per week is LKR 640.89. Mean per-capita vegetable consumption is 111 g/day. 16 percent of weekly vegetable meals are generated from own home garden. Dietary diversity of traditional vegetables is higher than that of exotic vegetables. Education level of mother, Well Being Index, working status of mother and presence of elders in family has positive and significant influence on per-capita vegetable expenditure. Household size and per-capita expenditure on vegetable substitutes have negative influence on per-capita vegetable expenditure. Price, nutritional value and family preference of vegetable are factors that influenced the selection of vegetables. Results of this study would be useful for food producers and marketers to identify target consumer groups of vegetables.

Keywords: Market purchases, Home garden produce, Dietary diversity, Multiple regression analysis, Exotic and traditional vegetables

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**Motivational Goals Regarding English Language and Impact of English
Language on Academic Achievement:
The Case of Final Year Students of the Faculty of Agriculture, University
of Peradeniya**

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In Sri Lanka, knowledge of English offers advantages to undergraduates. Lack of English proficiency is identified as a major barrier to achieve academic success. Motivation to learn English has been shown to influence individuals' language proficiency. Achievement goal theory provides a useful framework to examine motivation. Achievement goals are mastery approach, mastery avoidance, performance approach, performance avoidance goals and motives, include positive self-motives, motives by others and negative self-motives. Those goals and motives guide the achievement behavior of students. The purpose of the present research was to finding the motivational patterns towards learning English language and to examine how achievement goals and motivational variables impact on English language performance and academic achievement. Final year undergraduates in Agricultural Technology and Management, Faculty of Agriculture, University of Peradeniya were selected as the sample. Fifty-five Sinhala speaking students were selected as participants. Data regarding achievement goals, and fear of failure towards learning English language were collected using existing measures. Motives were measured with a scale constructed for the purpose. English examination marks (ATM 6) were used to measure the performance of English language. Final year GPA was used to measure academic achievement. Descriptive analysis of identified that, mastery goals were highly endorsed relative to other goals, suggesting a healthy motivational pattern towards English. The motives show that students are highly motivated to learn English for their career development. However, achievement goals towards learning English language did not affect performance on the English test. Achievement goals towards English language and performance of English language influenced on academic achievement. The results indicate that motivation to learn English is high and that English influences academic achievement. Yet it seems that students' motivation is not clearly captured through performance as ELTU assessments. Future research should explore means through which English program can better capture students' motivation.

Keywords: Achievement goal, Fear of failure, Motivation, Academic achievement

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Effect of Adaptation to Climate Change on Yield Performance Based on Market versus Production Orientation: Case of Paddy Farmers in Ibbagamuwa Area

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Global climate change is increasing at an alarming rate. The impacts of climate change are most evident in the agriculture sector in Sri Lanka. The manners in which farmers respond to climate uncertainties affect their yield performance. Further, their orientation towards their crops may influence the nature of these responses. Therefore the main objective of this study is to identify the extent to which adaptation to climate change affect for yield of market versus production oriented farmers. The study was conducted in *Ibbagamuwa* Divisional Secretariat Division which is moderately vulnerable to drought and is in the Intermediate zone in Sri Lanka. Semi-structured questionnaire was used to collect primary data and by using stratified random selected 60 paddy farmers in *Ibbagamuwa*. Descriptive statistical was used to find out the degree of orientation of farmers and how they responses differ according to orientation. The regression analysis was used to identify factors that are affecting on climate change. Then predict the yield based on degree of orientation and climate change responses by using mediation analysis. The results indicate that, 26 farmers as market oriented and 34 farmers as production oriented. Market oriented farmers have higher positive responses towards climate change responses compare to production oriented farmers. Degree of orientation, age, land extent and cultivated variety of farmer were significantly affecting on climate change responses at $P < 0.05$ level. Market oriented farmers relative to production oriented farmers reported higher yield. This relationship was partially mediated by their climate change responses. These finding suggest that market oriented farmers respond more effectively to climate change and that these responses positively influence on their yield. However, they also indicate that market oriented farmers seem to use other strategies as well, which increase yield but which were not examined in this study.

Keywords: Climate change responses, Degree of orientation, Paddy farmers, Yield performance

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Consumer Preference and Perception Towards Wheat-based Products and Rice-based Products

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The rice production in Sri Lanka recorded an unexpected growth during last few decades, mainly due to technological improvements and expansion of irrigable lands. Conversion of a part of the supply to value added products is deemed to be most appropriate option given the narrow export potential for Sri Lankan rice. Therefore, understanding of consumer preferences and perceptions towards the rice-based products compared to that of wheat-based products is very important. In this background, this study examines the status of consumer preference towards wheat-based products and rice-based products, as well as characteristics of the consumers in outlets/restaurants that supply these products. Data for the study were collected through a structured questionnaire covering 100 consumers. The study used descriptive analysis to distinguish the demographic profile of the consumers and contingent analysis to investigate various interrelationships. A binary logistic regression model was used to understand the factors responsible for consumption of these two groups of products. The majority of the consumers had good awareness about the food and their health aspects. Food consumption pattern of the respondents has been changed recently by about 8% who live/work vicinity of rice-based products sales outlets. The consumers interviewed had a priority on price, convenience and source of food over the taste and nutrition. The study revealed that awareness on traditional food, health concerns and education had a significantly positive impact on moving towards rice-based products. Results of this study will be useful to policy makers as well as practitioners who want to promote rice-based products.

Keywords: Consumer preference, Logit analysis, Perceptions, Rice-based products, Wheat based-products

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An Assessment of Import Tax Evasion: Case of Food and Agricultural Trade between India and Sri Lanka

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Despite the efforts made by the government officials to charge taxes as per the tariff schedule of the government of jurisdiction, non-payment of taxes, i.e., tax evasion is widespread throughout the world. This paper assesses the extent of tax evasion of food and agricultural imports originated from India at the point of entry into Sri Lanka. Evasion gap was measured as the log difference between values and volumes of India's reported exports to Sri Lanka and Sri Lanka's reported imports from India. The effect of tax rates on tax evasion was econometrically estimated. Imports of products into Sri Lanka from India in year 2008 to 2012 and custom duties and para-tariff rates in 2011 and 2012 were used for the analysis. All the products listed in chapters 1-24 of the Harmonized System (HS) classification at level 4 were considered. The results reveal both underreporting of the unit values and taxable quantities and the latter has been the most common method adopted. There exist differences in tax evasions across various product categories. Vegetable product category is the highest tariff evaded food and agricultural product category during 2008 to 2011 and in 2012 this was replaced by the live animals; animal products category. Tax rates have positive and statistically significant effects on tax evasion through underreporting the unit value and underreporting of taxable quantities. The results of the estimation indicate a one-percentage-point increase in the tax rate causes 0.005 and 0.003 percent increase in evasion in year 2011 and 2012, respectively. These results indicate that the intended revenue generation effect of import tax policy on food and agriculture products had not been achieved and imposition of higher taxes might further worsened the situation.

Keywords: Import tariff, Tariff evasion, Agriculture, India, Sri Lanka

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Compliance with Food Safety Standards: An Assessment of Determinants and Profitability of Black Pepper Exports from Sri Lanka

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Pepper exports from Sri Lanka date back to the colonial period and occupy a special place in the world market due to their higher piperine content. The stringent food safety standards imposed by developed nations pose both challenges and opportunities to the industry. Currently over half of the exports of Sri Lanka pepper reaches South Asian destinations, such as Bangladesh, India, and Pakistan, which do not require high food safety standards. Accordingly, the prices received by the exporters are much lower than those of EU, Japan and USA. The objectives of this study are; (i) to assess financial feasibility of producing high quality pepper, and (ii) to investigate the factors that determine the decision of pepper exporters to comply with high food safety standards. Payback period, Benefit Cost ratio, Net Present Value and Internal Rate of Return were computed to assess the feasibility of investing on machinery, certification, testing, fumigation etc. Computations were performed under alternative scenarios; (a) exporters purchase raw-materials from farmers, wholesalers and processors and (b) exporters supply to high-end (EU, Japan and USA) and low-end (Bangladesh, India and Pakistan) markets. The results of cost-benefit analysis indicate that the production of high quality pepper to meet food safety standards expected by high-end markets is financially feasible even without any government incentives. The highest returns were recorded when value addition starts at farmer level. A binomial probit model was estimated to assess the extent to which various economic, cultural, political and legal characteristics affect the compliance decision using primary data collected from 57 pepper exporters. The results show that method of purchasing, competition from other country suppliers and political stability of the host country significantly affect compliance decision. It is recommended to create awareness and develop a conducive environment for connect exporters with high end markets.

Keywords: Black Pepper, Food safety, Compliance, Probit model, Cost-Benefit analysis

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Impact of Climate Change on Paddy Production in Sri Lanka: Ricardian Analysis with Time Series Data

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Global climate change can affect crop yields therefore understanding of impacts of weather parameters is vital in mainstreaming adaptations to climate change in policy formulation. In this context, the changes of climatic parameters and their impacts on rice yield was studied using a time series data for the period of 1979-2011. Data set included rice yields by seasons and by mode of irrigation in *Anuradapura*, *Hambantota* and *Kurunegala* districts. This study investigated trend of eight seasonal weather variables (minimum, maximum and average temperatures, average rainfall, wind velocity, pan evaporation, and morning and evening relative humidity) using Mann-kendall test. Also the study attempted to detect the change points of seasonal weather variables using cumulative sum charts. *Ricardian* approach was used to assess effect of climate on net revenue of paddy lands. Results revealed that many of seasonal weather parameters had significant ($P > 0.05$) changes over last 30 year of period. Seasonal rainfall of three districts did not exhibit any trend or change point during past 30 years. Annual seasonal temperatures showed an increasing trend in *Hambantota* district whereas that had decreasing trend in *Kurunegala* district. Ricardian analyses revealed that productivity of paddy land in three districts have different relationships with seasonal climate parameters. Major irrigated paddy lands of *Maha* season in *Anuradapura* district were more vulnerable to climate change compared to other paddy lands of district. The resulting expected benefits arising from climate change on *Maha* season paddy land of *Hambantota* district because the Ricardian analysis revealed that maximum temperature had a positive significant ($P > 0.05$) impact on net revenue. Paddy cultivation in *Yala* season in *Kurunegala* districts may lose in come as the minimum temperature has significant ($P > 0.05$) positive relationship coupled with a decreasing trend. The study generates meaningful implications related to the impacts of climate change on farm income.

Keywords: Paddy land productivity, Ricardian analysis, Trend analysis, Change point

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A Comparison of Dual and Single Manager Households' Business and Work-to-Family Conflict in Small and Medium Scale Enterprises (SMEs)

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SMEs make up a large part of Sri Lanka's economy, accounting for 80% of all businesses. It is an essential source of employment opportunities, contributing about 35% of all employment. For such businesses, work and family roles are more integrated than in large scale organizations. Therefore Work-Family-Conflict (WFC) becomes more relevant and single versus dual managing households and businesses provide an indication of this interface. Yet, much of the WFC research is done with employees working in large scale organizations. This study examines the nature of single/dual household's roles in affecting WFC and business success. Single/dual manager households were categorized based on who made business and household decisions, and business performance was conceptualized by the difference of the revenue gained from the year of start up to the present. WFC and household, business and demographic characteristics were also examined. The study population is the registered SMEs related to agribusinesses at the Chamber of Commerce/Kandy who commenced business between the years of 2000-2004. Thirty percent of the population was selected using simple random sampling methods. Eighty two business owners were interviewed using structured questionnaires. Descriptive and regression analyses were used to analyze data. Findings indicate single/dual manager households differed based on education level, but not gender and age. Regression analysis revealed that business success is significantly affected by single/dual manager household role and WFC. Dual manager households performed better than single manager households and WFC was negatively related to business performance. Finally single and dual manager household role is not significantly affected to the work and family conflict. The results are partially consistent with theory and suggest that having separate managers for households and businesses may benefit the business in the SMEs. It also suggests conflict with household responsibilities can be detrimental and separating home and work may be beneficial for business success.

Keywords: Single and dual manager households, Work to family conflict, Business success, SMEs

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Market Orientation of Small and Medium Scale Rural Farmers in Saga Prefecture, Japan

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After the sixth industrialization in Japan, the markets for agricultural products have become more competitive, compelling the small and medium scale rural farmers (SMRF) to compete with their large-scale counterparts. This situation has necessitated them to be more market-oriented in their farming operations. There is a dearth of research in Japan on the market orientation of SMRF. We conducted this study with the main objectives of studying (a) the types of marketing constraints faced by SMRF, and (b) the nature of market orientation of SMRF in terms of the types and the extent to which their production and selling strategies were market oriented. The population of sixty SMRF in *Karatsu* city, *Saga*, Japan, who sold their farm produce through farmers' markets was selected as the sample of this study. A questionnaire survey was conducted to collect data using a structured questionnaire that was prepared based on the reviewed literature. Data were analyzed using descriptive analysis techniques. Farmers were classified into two groups as those who showed a higher tendency to adopt market-oriented strategies (High Market Oriented Farmers-HMOF) and those who showed a lower tendency to adopt market-oriented strategies (Low Market Oriented Farmers-LMOF). Lack of market information was identified as the major constraint faced by these farmers and taking the membership of Japanese Agricultural Cooperatives (JA) has been adopted as the major strategy to overcome the said constraint. Findings revealed that farmers have focused more on specific methods of production and selling, selection of specific markets and buyers for selling their produce as main market-oriented strategies to overcome the constraints faced by them. Enhancing the flow of marketing information into farmers and educating them on various strategies available to adapt to the marketing environment were found to be major solutions to most of the marketing constraints faced by the farmers.

Keywords: Small scale and Medium scale rural farmers, Marketing constraints, Marketing strategies

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Socio-Economic Impact of Drought among Dry Zone Major Irrigation Farmers

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Sri Lanka is a tropical country and its climate has been changing. The past climatic data reveals increasing trend of annual temperature, decreasing trend of rain fall with increased drought incidence and severity in dry zone, which can affect the farming community. Last *Yala* (2014) experienced an unusual drought and affected the irrigation water allocation for dry zone farming. Taken this as a natural experimental case, this research aimed to investigate the impact of drought on returns to farming, poverty and investment capacity of dry zone farming community by using Ricardian, Logistic and SLR empirical model respectively. Primary data collected using pretested questionnaire from a stratified random sample of 90 households in D5 canal of *kandalama* right bank were used for analysis. Results revealed, Water availability, household labor, ownership of machinery and education has positive effect on Land rent (Return on farming). Land area under cultivation shows negative effect where water is a limiting factor for area under cultivation. Water is not a determinant of the level of poverty but results show decreasing trend of poverty depth and severity with increasing water availability. Water availability, access to formal credit and non-farm income, Informal credit, expected cultivated area and household labor are the determinants of reinvestment capacity of farmers. The value of water is estimated at Rs.38/m³ of water. The results show, that water availability is a key to improve socio economic status of farming community in dry zone and investigation of other means of irrigation methods is important, Education about crop water requirement and selection of crop variety can increase the return on farming. Increasing the opportunity for non farm income and credit access in drought season can also improve the socio-economic status of farmers in Dry Zone farmers.

Keywords: Climate, Water availability, Returns on farming, Poverty, Investment

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Economics of Adaptation to Climate Change

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Climate change poses significant threats to crop production in tropics and it is forecasted to decrease the crop yields by 30-46% before the end of the century even under the slowest climate warming scenario. Adaptation could be the best option to increase the capacity of a system to survive under external shocks of change in climate. Therefore, a study was carried out to investigate the economics of climate change adaptation based on Ricardian model by examining the changes in net revenue/acre of cultivated crops in the presence of climate change. These effects are measured separately for *Yala* and *Maha*, the major cultivation seasons in Sri Lanka. Farmers' choice of crops in order to maximize net revenue is captured using the Multinomial logit model. The study includes a sample of 150 farmers in 29 agro-ecological regions in Sri Lanka. The results show that limited temperature variation among different agro ecological regions accounts for major temperature effects on net revenue and greater range of precipitation distinguishes more complex precipitation affects. The impacts of rainfall increase are to be beneficial to the country as a whole, whereas temperature increase is harmful especially in *Maha* season having a reduction in net revenue/acre of LKR 157,785 (5% of total revenue) for each unit increase of temperature. Farmers' choice of crops gives an indication of adaptation to the climate change among different agro ecological regions. Age, education of the household, mean temperature during *Yala* appeared are seems to be important determinant of farm level adaptation strategies assuming that the farmers have access to alternative practices and technologies available in the region. Moreover, the analysis reveals that the climate change damages could be significant for Sri Lanka but highly dependent on the farmers' choice of crops and adaptation strategies.

Keywords: Climate change, Adaptation, Perceptions, Crop choice, Ricardian

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Entrepreneurial Orientation and Business Performance: The Case of Micro Scale Food Processors in the District of Jaffna

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The functioning of Micro and Small Scale (MSS) businesses in the northern part of Sri Lanka was vulnerable due to three decades of internal conflict and the subsequent post-war economic openings has resulted new market prospects for MSS businesses. MSS businesses survive and operate with limited resources and struggle to access finance, raw material, markets and technology. This study attempts to identify the manner in which entrepreneurial orientation puts into practice by the business operators to overcome these business challenges. Business operators in the traditional food processing sector are taken for this study as this sub-sector of the food industry is developing at a rapid pace. A review of the literature was done to recognize the concepts of entrepreneurial orientation, defining MMS businesses and the manner in which business performance is measured. Direct interview method supported by a structured questionnaire is used to collect data from 80 respondents; based on a fixed interval random sampling technique. This study reveals that more than half of the business operators have opted to commence their business ventures as a result of identifying a market opportunity. 41 percent of the business operators are highly entrepreneurial oriented in a scale of 1 to 5. Entrepreneurial orientation shows significant relationship and strongly correlated with business performance. Proactiveness, innovativeness and competitive aggressiveness shows a significant relationship with business performance while risk taking is negative and autonomy is not significantly related to business performance. It is evident that entrepreneurial oriented business practices contribute to better business performance even though 70 per cent prefer the ideas/views of the support agencies than the stakeholders when making business decisions. It is recommended that appropriate training should be introduced to develop entrepreneurial skills focusing to improve business networks so that new business opportunities and innovative business practices are identified.

Keywords: Micro and Small Scale (MSS) businesses, Entrepreneurial Orientation (EO), Food processing business operators

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Determinants of Labour Productivity in Tea Plantations: A Case Study in Mattakele Estate

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The tea industry in Sri Lanka is faced with a number of challenges due to high cost of production associated with low land and labour productivity. Moreover, the declining trend in labour force has an adverse impact on tea production as tea industry is very labour intensive. Therefore, understanding on status and drivers of labour productivity is of paramount importance in decision making related to productivity and cost of production. Against this background, a study was carried to assess the current status and factors affecting labour productivity in tea estates in upcountry wet zone. The study was carried out in Mattakele estate in Nuwara Eliya district. Using the check roll of the estate, a sample of 75 tea pluckers were randomly selected to collect the primary data through a pre-tested structured questionnaire. First, the Labour Productivity Index (LPI) was estimated using the revenue-labor output and the net sale average of the estate. The determinants of labor productivity were estimated by employing a multiple regression model using socio-demographic factors, economic factors, motivation factors and technical factors. Results revealed that height, plucking income, skill and experience were positive and significant factors that affect the labour productivity of female pluckers. For the male pluckers, experience, height and land productivity had positive effect on labour productivity whereas off farm income had a negative influence. The selected estate showed an increasing trend in the LPI as depicted by 75% improvement in 2014 compared to that of 2010. It could be suggested that improving land productivity, pruning at correct time and selection of fields according to their heights help to improve the labour productivity. The results are useful in implementing programmes to improve the labour productivity in upcountry tea production.

Keywords: Cost of production, Land productivity, Labour productivity, Labour productivity index, Labour Productivity Index.

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The Productivity of Pesticide Use in Up-country Potato Production: A Damage Control Approach

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Pesticides are unavoidable inputs in vegetable cultivation in the upcountry districts of Sri Lanka. It has been observed that majority of farmers apply pesticide more than their recommended levels. An assessment of economic value of pesticides used in agriculture, considering their ability to enhance agricultural productivity, is important in formulating socially optimal policies on pesticide importation, distribution and usage. Cobb-Douglas functional form is the widely used model in estimating productivity of pesticides. However, it does not capture the damage control nature of pesticides, and hence overestimates pesticide productivity. The current study used an exponential model to assess economic value of pesticides using their value of the marginal product value. Primary data were collected from 90 randomly selected potato farmers from nine villages in *Uva-paranaguma* division in 2014 *yala*. It was revealed that farmers use one brand of herbicides, thirteen brands of insecticides and four brands of fungicides. All the fungicides contain same active ingredient. The exponential production function was specified treating quantity of fungicides as the damage control input and labor, fertilizer and seeds as conventional inputs. Fungicide level was measured by quantity of active ingredient applied. The parameter estimates of the econometric estimation suggest that the value of the marginal product is equal to the price of the fungicide when 2,912.50 g/acre of active ingredient is applied. However, the quantity of fungicides used by an average farmer is four times of the optimal quantity and 96% of the farmers use fungicides above the optimal quantity despite small marginal increases in yield attributable to additional application of fungicides. Fungicide productivity estimated through Cobb-Douglas production function was found to be quite larger than that obtained through damage control specification indicating the importance of specification of the appropriate functional form.

Keywords: Damage control function, Pesticide use, Potato cultivation, Active ingredient

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Influence of the Marketing Mix Tool on Purchase Decision: The Perception of Female Consumers' on Selection of Cosmetic Products

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Over the recent years Sri Lanka's cosmetic industry is growing at a rapid pace with a growth rate of 8.3 per cent in the year 2011. As a result, competition has become intense and marketers apply numerous strategies to sustain in the cosmetic industry. Application of marketing mix tools has become a common practice and this study attempts to identify the influence of the components of the marketing mix tool, namely; 7Ps, on consumers' decision making with special reference to female consumers. Perceptions of the visitors at a cosmetic fair organized by major cosmetic brands are taken for this study. Of approximately 700 visitors to the fair, 71 (female) visitors are interviewed on a random basis. Data is collected through a structured questionnaire, derived from literature, with a focus on identifying the manner in which the components of the 7Ps marketing mix tool influence the various stages of the consumer buying decision making process. The study identifies that perceived outcome (fairness, cleanliness) of using cosmetics is considered mostly in the product category whereas, surprisingly, consumers are less concerned of the chemical composition of the product. Brand name is identified as the second most important factor in the product element. Price is sensitive towards popular brands and consumers are of the view that products made from indigenous inputs (raw materials) should be relatively at a lower price. As promotion is considered, consumers are influenced by mass-media advertising. Usage of the internet in seeking information is thin whereas sales persons' enthusiasm to respond to consumer's questions, customer service and shop atmosphere are significant factors which influence the decision making process of the female consumers. Therefore, marketers should provide a total solution (i.e. in terms of all the marketing mix variables) and not merely for cosmetic product per se as one would expect.

Keywords: Marketing mix tool, Decision making process, Female consumers

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Economic Effects of Rice Price Ceilings in Sri Lanka

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As a response to increased rice prices, the Sri Lankan government imposed maximum retail prices for rice under the Consumer Affairs Authority Act No. 09 of 2003. The objective of this study is to evaluate the economic effects of this policy on different rice markets using a partial equilibrium model. Markets for *Samba*, *Nadu*, *Basmati* and traditional rice varieties were calibrated to the equilibrium prevailed in 2012 assuming own price elasticities as -0.5 and cross price elasticities as 0.125. Counterfactual equilibria associated with removal of the ceiling price of *Samba* and *Nadu* rice were simulated under alternative market closures. They include; closed markets under perfect competition and monopoly, and open markets. The baseline equilibrium is characterized by a ceiling prices and imports of *Samba* and *Nadu* at the world market prices, which are lower than the ceiling price, adjusted to tariffs. In the baseline equilibrium, the market for traditional rice is closed and the entire *Basmati* requirement is imported. When ceiling prices are removed while allowing for imports of *Samba* and *Nadu*, social welfare of both *Samba* and *Nadu* markets are increased by 0.1014% and 0.0004% respectively, *Basmati* and traditional rice reduced by 1.28% and 0.73% respectively. Welfare losses by 0.14% and 0.10% can be observed in *Nadu* and *Samba* markets and gains by 0.81% and 1.42% for traditional rice and *Basmati* respectively when ceiling prices are removed with a ban on imports. If *Samba* and *Nadu* markets become monopolistic after the ceiling prices are removed, there will be losses in all rice markets except for *Basmati*. Overall, there will be a welfare loss but *Basmati* market gains due to substitution effect. The above simulation results clearly show that the effects of price regulations depend on the structure of the markets. Further studies to estimate price elasticities and degree of market power are recommended.

Key words: Ceiling price, Partial equilibrium analysis, Static Simulation, Rice, Sri Lanka

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The Influence of the Institutional Environment in Increasing Wealth: The Case of Women Business Operators in a Rural Setting

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In Trincomalee, a post conflict area, resettlement project and policy initiative are taking place to improve the wealth of the rural communities through promoting economic activities by way of encouraging the rural women to opt to commence and operate Micro and Small Scale (MSS) businesses. This study attempts to identify the manner in which the institutional environment could facilitate these MSS businesses owned and operated by women in the rural environment. The respondents of the study are the beneficiaries of the *Divi Neguma* Development Training Program (DNDTP); project designed to aid women owned MSS businesses, in Trincomalee district. 96 women business operators, who had obtained financing facilities from the DNDTP, are taken as the sample based on fixed interval random sampling method. The study reveals that, primary challenges encountered by 82% of women business operators are lack of capital followed by 71% initial market finding and 35% access to technology. The low level of education and language barriers are the constraints in accessing support agencies/service providers. Institutional support; specially management and marketing services, have a significant relationship with wealth augmentation. Institutional support at the setting-up stage of businesses are thin whereas terms and conditions of the finance facilities are perceived as “too challenging”. Although diversification enhances wealth of the rural women business operators, assistance from the institutional framework to prepare financial reports that are required for business expansion is skinny. The study further reveals that, institutional support very much weak in terms of providing new technology and identifying new market networks. A mechanism that could facilitate the institutional framework to support the rural women business operators to access new technology and untapped market segments, and assistance in preparation of legal and financial documentation is recommended.

Keywords: Business facilitation, Institutional support, Rural women business operators, Wealth augmentation

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Economic Value of Mangrove Management Options in Mannar Region: A Discrete Choice Experiment

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Mangrove ecosystems are being destroyed around the world due to anthropogenic activities. Sri Lanka is not an exception. Lack of information on the environmental value of mangroves, especially non-market values has contributed to this degradation. Conservation of mangroves also cannot be successful without the support the people living in the vicinity as they are both beneficiaries and culprits. In this context, an attempt has been made to value ecosystem services and analyze the trade-offs among different mangrove management options in the Mannar region, using Discrete Choice Experiment (DCE). The objectives of the study were to estimate the economic value of mangroves through willingness to pay (WTP) and relative importance of management options. Necessary attributes and levels for DCE were obtained through focus group discussions with Government officers and NGOs. Four attributes; community based management, replanting, area to be protected, and penalty, each with three levels were evaluated using 3^4 factorial. Using fractional factorial design, where higher order interactions were sacrificed, 36 different choice sets were obtained. The data were collected through face-to-face interviews with 81 respondents in Mannar region. Data has been analyzed using Conditional logit model. Marginal willingness to pay values for each attributes and levels and relative importance of the each management options attribute were found. The highest WTP was associated with the area to be protected at 100% level, followed by the attribute replanting with the level of high density and higher growth rate plants. The attributes, area to be protected followed by replanting had the highest relative importance as perceived by the respondents. Results are useful to the policy makers who involve in mangroves management.

Key words: Discrete Choice Experiment, Mangrove management, Non-market valuation, Willingness to pay, Conditional logit model.

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Willingness to Pay for a Crop Insurance Scheme by the Rain-fed Farmers in the Presence of Climate Change

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Paddy cultivation in Sri Lanka is vulnerable to climate related risks. This is more serious with rain-fed paddy cultivation. Prevalence of adverse climate events are expected to increase due to global climate change. Crop insurance can serve as a useful tool to cope up with these climate induced risks. Against this background, this study attempted to estimate farmers' willingness to pay for crop insurance in presence of the climate change. The study was conducted in the *Anamaduwa* DS Division of the *Puttalam* district, which has emerged as one of the most vulnerable areas to climate change in Sri Lanka. Following the principles of non-market valuation, a surrogate market was created within the framework of contingent valuation. Three hypothetical insurance schemes were developed and these were presented to a random sample 80 rain-fed farmers in the study area. Participants were informed about the insurance coverage (LKR 10,000, 25,000 and 50,000) and coverage period (2, 3 and 5 years) which will be implemented by private sector insurance companies with the collaboration of the government. Dichotomous bidding was adopted to elicitate their willingness to pay. In addition to descriptive statistics, a bid function was fitted using a logit model. The results revealed that 88 % of respondents were willing to join a crop insurance scheme specifically designed to address risks associated with climate change. The mean willingness to pay for a season was LKR 1243, 1900 and 4011 for these insurance packages, respectively. The logit modeling ($P < 0.05$) indicated that farm income, age of the farmer, land extent and land ownership are the important determinants of their willingness to pay for a crop insurance premium. The results could be utilized to develop appropriate insurance schemes for climate change by the private sector with the partial financial support of the climate change adaptation fund.

Keywords: Surrogate market, Coping strategy, Crop insurance, Rain-fed farming, Logit model

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Farmers' Willingness to Supply Produce to Collecting Centres: The Case of Pepper Farmers

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The supply chain of spices comprises of many intermediaries and it is identified that almost 15 to 20 per cent of the produce is left as post-harvest losses. As a consequence the intermediaries tend to keep a larger monetary margin which result a lower (farm gate) price for the farmer and the comparatively higher price for the consumers. This scenario is no different in pepper supply chains. Lessening the intermediaries is identified as a solution for this problem and hence this study attempts to identify farmers' perception towards supplying their produce to collecting centres. Firstly, the existing pepper supply chains in *Matale* District is identified mainly due to the reason that the District of *Matale* produces the largest quantity of pepper. Among the Divisional Secretariats of *Matale*, *Pallepola* comprise the largest cultivation of pepper and henceforth 72 farmers from *Pallepola* area are selected, on a simple random sampling technique, as the sample of this study. The study reveals that 72% of the farmers prefer to supply to collecting centres. Farmers' educational and income level positively influence towards the perception of supplying pepper to collection centres whereas the farmer (cultivation) experience and age have a negative influence. In addition, farmers prefer to supply their produce in person to the collection centres. Farmers also prefer that appropriate marketing links and ability to handle large volumes are pre-requisites of the collection centre/s. Farmers stress that a sound and appropriate mechanism should be in place for the collection centre to be in operation when pepper is in short supply and more importantly, farmers feel less risky when the collection centres are equipped with processing (value addition) facilities. Therefore, it is recommended that collection centers needs to operate in dual manner; collection and processing.

Keywords: Supply Chain, Collecting Centre, Pepper (*Piper nigrum*)

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The Relationship of Entrepreneurial Motives and Subjective Well-being with Business Start-up and Success of Agriculture Business Operators

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In 2013, The Central Bank of Sri Lanka announced that GDP growth rate has increased by 7.2%. Yet poverty and food insecurity prevail as the two main issues in the country. Policy papers indicate these problems can be eliminated through increasing growth in the agriculture sector through developing entrepreneurs from farmers. The objective of this study was to identify the relationship of entrepreneurial motives and subjective well-being with performance of business operators. Farmer entrepreneurial motivations was separated into startup motivation and growth motivation, which respectively focused on why farmer started the business and the nature of their motivation to continue with the business. Motivation was conceptualized as push and pull motives. Subjective well-being of farmers was also examined. Simple random sampling was used to select farmers who have completed from training programmes in *Gannoruwa In-Service Training Institute* in 2012. That is, 148 participants were interviewed by using semi structured questionnaire. The collected data was analyzed through descriptive method and regression analysis. It was found that the majority who participated in the training programme did not start businesses, and some participants had already started it before training. As a result, 34% started the business afterwards. Results of the multinomial analysis indicated that push motives were related to business startup. Among those who start the business after the training programme, push motives and subjective well-being were positively related to business performance. Among those who had already started the business, push growth motives were negatively and subjective well-being was marginally positively related to business performance. The findings of this study suggest that motivation to start and continue a business needs to be addressed when developing programmes to enhance agribusiness.

Keywords: Subjective well-being, Growth motives, Business performance, Push and Pull factors

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Potential Welfare Gains to the Sri Lankan Consumer through South Asian Economic Integration

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South Asia has the largest number of chronically poor people in the world. Lower capacities and inefficiencies in production followed by high food prices are found to be fundamental causes of poverty in South Asia. Intra-regional cooperation among South Asian countries has been considered as a potential mechanism to alleviate poverty. Objective of this study is to assess potential savings to urban, rural, estate sector households in Sri Lanka due to a hypothetical lowering of food prices resulting from importation of food from cheapest source in South Asia. Thirteen food items were considered under alternative assumptions on own and cross price elasticities of demand. Food consumption baskets reported by the Department of Census and Statistics were considered as the baseline. Potential welfare gains for the households were calculated by taking the difference between current expenditure incurred and likely expenditure if Sri Lanka were to import the same products from South Asian trading partners at a lower price. Results revealed that food expenditure of urban, rural, estate sector households can be reduced by 33%, 24% and 34.5% respectively if the food demand is perfectly inelastic, i.e., they continue to purchase same quantities even after reductions in prices. For certain product categories, the savings would be as high as 60%. When own and cross price elasticities of demand are considered for the analysis, households in the urban sector increase consumption of wheat flour, rice, potatoes by 53%, 26% and 36% respectively while rural consumers increase their demand for same products by 73%, 21% and 39%. Consumption of wheat flour will elevate by 76% in estate sector due to expected price reduction. Further research on assessments of losses to food producers and effects government revenue due to food trade liberalization in South Asia will be needed arrive at policy recommendations.

Keywords: Trade liberalization, Food basket, Consumption expenditure, South Asia

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Fluoride Uptake by Native and Modified Cattle Bones from Aqueous Medium by Batch Adsorption

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Fluoride causes dental fluorosis, skeletal fluorosis, crippling fluorosis and interferes with metabolic activities of lipids, proteins and vitamins. The WHO has recommended F^- level in drinking water as 0.5–1.5 mg L⁻¹. There are several defluoridation techniques available and among them adsorption is the most effective and common method. The objective of this study was to investigate eco-friendly, low cost materials such as plant leaves and cattle bone for removal of fluoride ion from drinking water using the batch adsorption method. Bio-adsorbent materials were collected and rinsed with tap water, then by deionized water. Materials were air dried for 48 h and oven dried at 60 °C for 48 h. Dried materials were sieved to obtain particle size between 250 – 350 µm. A mass of 0.2 g of different adsorbents were added in 50 mL of 3 mg L⁻¹ fluoride solution and shaken at 80 rpm in an orbital shaker for 3 h. Thereafter suspension was filtered and final F- concentration determined by a fluoride ion-selective electrode. Chemical and physical modification such as base treatment using 0.05 M and 0.1 M NaOH and bone char preparation was done to enhance the adsorption efficacy. Native bones were heated at 500 °C for 3 h in a muffle furnace to prepare bone char (BC). Effect of contact time and dosage were determined for chemically modified bones and effects of pH, suitability of kinetic and isotherm models and desorption and adsorbent characterization of BC were carried out. Pseudo second order kinetic model and Langmuir isotherm model explained the adsorption process. The highest desorption of 38% was given with 0.1 M NaOH. BC enhances the efficacy of defluoridation from aqueous medium and is a cost effective and eco-friendly biosorbent.

This research project was conducted at the National Institute of Fundamental Studies (NIFS) in Kandy, Sri Lanka.

Keywords: Fluoride, Batch adsorption, Desorption, Bone-char, Cattle bone

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Factors Related to the Women's Choice of Banking Careers

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Sri Lanka has achieved many of the Millennium Development Goals (MDG) including gender equity. Yet women's participation in the labour force although improved, shows disparities among the sectors. This study is conducted to identify why women choose banking careers. Both socio-economic and the human resource management factors can influence women's career choice. This study sheds light on how the situation can be improved to have greater gender parity in the workforce. The research was done as a comparative study between the banking and the teaching service sectors. The purposive sampling method was used to select the samples. Self-administered questionnaires were used for the data collection and qualitative data was gathered by conducting personal interviews. Thirty one bank branches from both public and private sectors located in the Puttalam and Gampaha districts were selected. Data was analyzed using non-parametric Mann-Whitney U test and descriptive statistics. Derived from the conceptual framework, nine hypotheses were tested. There is a significant ($P < 0.05$) difference in the satisfaction of the availability of training and development opportunities, the compensation package, providing work-life balance initiatives, perception on the working conditions and age of the respondents between the two sectors. But there is no significant ($P > 0.05$) difference in the gender equality in the recruitment and selection procedure, satisfaction on the career stability and the safety of the working environment and the monthly income of the respondents between the two sectors. The major factors influencing women's choice of the banking sector for the careers are gender equality in the recruitment and selection procedure, availability of training and development opportunities, safety of the working environment and the satisfactory compensation package offered by the banks studied. Enabling access to careers at an early age, gender equitable recruitment processes, enhanced professional development opportunities, safe working environments and satisfactory compensation packages may help attract more women to specific sector workforces and need to be studied further.

Keywords: Feminization, Workforce, Work-life balance

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Perceived Value of Agricultural Extension Services among Onion and Paddy Farmers in Dhambulla

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Agriculture extension services have contributed immensely to improve agricultural productivity and agrarian life. However, in Sri Lanka this service has not been given its due recognition. "To what extent do farmers value agricultural extension services" is a vital question to ask when justifying strengthening the system to meet farmer expectations. This study is aimed to measure the value of agricultural extension services as perceived by farmers. A contingent valuation method drawn from resource economics is used to investigate farmers' willingness to pay for five hypothetical extension packages. They included a (i) purist model which includes only education and information and four others with different subsidized inputs such as (ii) fertilizer, (iii) transport, (iv) guaranteed buyback system and (v) crop insurance. The models were an attempt to discriminate the willingness to pay for services offered. Data were collected using an interview schedule from 100 farmers randomly selected from Digampathana and Kibissa villages of the Dhambulla agricultural division. The mean willingness to pay for the purist extension service is Rs. 2,250±1,247.838 per year per farmer, for both extension services and other supportive services is Rs. 6,346.57±3,251.485 which is significantly higher. The total average willingness to pay is Rs. 4,425.61±2866.2017. Additional services to extension are valued by farmers. The results of the regression analysis suggest that farmers with a high gross income and education levels are willing to pay more. Onion farmers value extension more than paddy farmers. However, experience is inversely correlated with the willingness to pay for agricultural extension services ($P<0.05$). Further, compared to education and the health services, respondents ranked agriculture extension as third most important. Commercialized farmers who derive more direct benefits from extension services tend to value the service more. The evidence suggests that agriculture extension services should be prioritized for public investment to match farmer expectations.

Keywords: Willingness to pay, Contingent valuation, Agricultural extension, Buyback system

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Factors Affecting Adoption of Standardized Work in Lean Manufacturing: A Case Study in the Cutting Department of MAS Linea Clothing

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Lean Manufacturing (LM) is practiced by many organizations in the world to improve customer satisfaction through eliminating wastage. Standardized Work (SW) procedure is considered as an essential tool of the LM process. Since this concept is new to Sri Lankan organizations, studies on factors affecting adoption of SW in LM are hardly found. Therefore, this study was carried out to determine the individual and organizational factors affecting the adoption of SW in LM. The study was conducted in the MAS Linea Clothing manufacturing plant located at the Industrial Park in Pallekale. The study population was 79 employees in the cutting department, consisted of 68 team members, nine supervisors, an executive and a manager. A structured questionnaire was used to collect data from 68 team members. Key informant discussions and observations were also conducted to collect qualitative data. The data analysis was done using descriptive and inferential statistics. None of the individual factors *viz.* gender, age, education, and work experience were related significantly ($P > 0.05$) with the adoption of SW. Among the organizational factors, management support and training and development programs were significant ($P < 0.05$) and positively related with adoption of SW procedure. Other organizational factors analyzed namely; resource availability, performance evaluation and rewards, definition of SW, and material type were not significantly related with adoption of SW. In conclusion, to gain competitive advantage using SW in LM, MAS Linea Clothing should provide more management support and conduct training and development programs. Further studies in other departments and organizations are recommended to precisely decide the factors affecting SW in LM in Sri Lanka.

Keywords: Lean manufacturing, Standardized work, Adoption

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Development of a Video Documentary on Best Practices in Agrochemical Usage in Tea Cultivation

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Tea cultivation is one of the major sectors that use agrochemicals such as inorganic fertilizer, pesticides and herbicides. Overuse and misuse of these agrochemicals are critical environmental and health issues in the country. Therefore, it is necessary to provide relevant knowledge and promote positive attitudes on best practices in storage and application of agrochemicals to mitigate the problem. Video is an effective way of conveying messages to an intendant audience. The objectives of this study were to develop a video and evaluate its effectiveness in influencing knowledge and perception on best practices in agrochemical usage in tea cultivation. The message content and message treatment dimensions were identified by key informant discussions with estate workers, technical experts and reviewing literature to develop the script. A video documentary was produced in Sinhala and Tamil languages. The product was pre tested and improved according to the comments made by experts. Effectiveness of the final product was evaluated as individual interviews using a questionnaire with 22 workers who engage in agrochemical spraying (intended audience) before and after showing the video. The knowledge change was significant ($P < 0.05$). The immediate response on the perception of protecting the environment and health by correct use of agrochemicals was also significant ($P < 0.05$). Therefore, it can be concluded that this video can be used as an effective educational and training material to enhance knowledge and promote positive attitudes on best practices in agrochemical usage in tea cultivation.

This research project was partially funded by Finlays Tea Estates Sri Lanka (Pvt) Ltd, Nambapana, Ingiriya.

Keywords: Video documentary, Agrochemical usage, Best practices, Tea cultivation

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An Assessment of Key Stakeholders' Expectations of On-the-Job Training of Vocational Trainees in Northern Province and Kandy District

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The vocational training sector is receiving enhanced attention and policy priority in Sri Lanka. In post-war North, the vocational training system is being strengthened. A two tier approach is adopted to ensure that vocational trainees develop the required competencies. All trainees are provided with on-the-job-training (OJT) where trainees learn in real work settings. The study is designed to identify the status of OJT placements, employer and trainee expectations, and the level of satisfaction among the key stakeholders. The main factors associated with expectations and satisfaction were identified. A cross sectional survey was undertaken using self-administered questionnaires with trainees, trainers and OJT providers. The Kandy district was selected to compare findings from the Northern Province. A survey was designed to obtain information on OJT placements, level of satisfaction, respondents' expectations and the determinants of the level of satisfaction. A conceptual frame was developed based on a literature review. The findings reveal that when compared to Kandy most of the OJT placements are outside of the Northern Province. All the respondents show less than fifty percent satisfaction on the measures used except trainees and trainers from Kandy. Gender of vocational trainee, vocational trainee's school education, quality of class learning, attitudes of trainee, quality of training provided at OJT and satisfaction of trainers' expectations have significant relationships with the satisfaction of employers' expectations. Age of vocational trainee, monthly family income, parents' education, trainee perception of quality of class learning, attitudes of vocational trainees of OJT, trainee perception of quality of training provided at OJT and monitoring of OJT by NAITA are the factors having significant relationships with the satisfaction of trainees' expectations. To achieve higher levels of satisfaction of stakeholders' expectations on OJT, increased efforts should be made to improve the social competencies of vocational trainees and make vocational trainees familiar about the expectations of employers.

This work was funded by the Vocational Training in North Project, GIZ

Keywords: Vocational training, On-the-job-training, Employer expectations, Trainee satisfaction

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Development of an E-Based Learning Material on Project Management

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At present, education and learning has become more student centered rather than teacher centered. A computer based learning system is one of the key components in this learner centered education system. Within this system, e-based learning has become more popular among learners because of its user friendliness, convenience and flexibility. The objective of the study was to develop a well-designed, attractive and useful product on Project Management as supplementary material for a course which is offered for final year agriculture students by the Department of Agricultural Extension. The methodology followed was: (1) Idea generation, (2) Setting objectives, (3) Need identification, (4) Gathering information, (5) Outlining the major content, (6) Product Development, and (7) Product evaluation. The initial need identification was conducted obtaining input from 50 undergraduates. The website was developed mainly by using Word Press. A local host was used in developing the website. Eleven Topics and related subject matter, a glossary, eight quizzes, a contact form and two search boxes were included by using several software applications, plugins and html code to develop the product. During the development stage, several modifications were carried out according to the comments of the subject matter specialists and feedback from the evaluation. After developing the product, it was evaluated with 20 students. Responses were as follows: Structure of the information - excellent (70%) and good (30%), Quality of the information - excellent (25%), good (70%), and somewhat good (5%), Page navigation - excellent (55%) and good (45%), Page design - excellent (60%), good (35%) and need to be improved (5%). 65% Respondents stated that the product was extremely helpful in learning, 60% stated that they would strongly recommend it to other students. The overall evaluation was mainly that it was excellent (45%) and good (50%). The product could be recommended as a supplementary learning material for the undergraduates who follow the Project Management course to enhance their knowledge. The product should also be integrated with the faculty Learning Management System to enable easier student access. It should also be updated periodically.

Keywords: E-learning, Project management

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Assessing Information Needs and Potentials for Backpack Tourism in Kandy District

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The general purpose of this study was to identify the services related information needs and potentials for backpack tourism in Kandy district to develop an information directory. Presently, accommodation, transport and other activities serving the backpack tourism sector in Kandy is growing. The purpose of this study is to bridge the backpack tourists and local service providers through an "information bridge" in the form of a website devoted to information needs of backpacker tourists. Further, this study reveals the different types of services that backpackers expect from the Kandy district tourism sector. A cross sectional study was designed using both quantitative and qualitative data collected from sixty backpackers, thirty local service providers and ten key persons in Kandy municipal area. Information from backpackers was obtained from a self-administered questionnaire. To identify the service requirements and information needs of backpackers, ranks based questions on Likert scales were used. All respondents were contacted using the snowball sampling method. Backpackers were defined as youth, who stayed short duration at a certain destination due to travelling. The evidence indicates that the main reasons to visit Kandy are to explore culture and sight-seeing. Seventy percent backpackers are Europeans. Thirty eight percent being the highest proportion of their daily budget was spent on accommodation. Twenty seven of the service providers and key persons expect the backpacker tourism sector to expand. A preliminary assessment suggests that there is room for expanding the sector, justifying further, the need to improve backpacker information. The findings support the proposition of improving information compilation and delivery to improve the sector as a means of developing the low-end tourism sector. The contents of the website suggested focuses on accommodation, recreation, cultural sites, travel, costs, food, avoiding harassments, etc. identified as information needs of backpackers to Kandy.

Keywords: Backpacker tourism, Information needs, Website

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Assessment of Sustainability of Urban Home Gardens in Kandy District

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Home gardening is a subsistence-oriented and profitable production system with multiple benefits. Government invested heavily on promoting sustainable home gardens through *Api Wawamu Rata Nagamu* and *divi neguma* programmes. However, they have not reached the expected targets. Therefore, this study was focused to assess the sustainability by reviewing the present status and constraints of urban home gardens in Kandy district. Data was gathered using a social survey with 40 randomly selected urban home garden farmers in Gampola. Majority of the respondents were females (85%) and, 50% belongs to 46-55 age category. Nearly 45% of the respondents had small size land (2.0 - 3.9 perches), 32.5% had medium size (4.0 - 8.3 perches) and, 22.5% had large size lands (8.4 - 12.0 perches). Majority (65%) used their produce only for their home consumption. Majority (81%) used only organic manure, while 19% also used inorganic fertilizer. Only few (15 %) were rearing poultry as livestock. Lack of time, labor, planting material and marketing opportunities and, wild animal attacks were the major problems faced by the farmers. The sustainability was tested using six criteria *i.e.* crop diversification, income, availability of livestock, usage of fertilizer, time allocation, knowledge and attitudes. According to the score, 72.5% were in the medium level of sustainability. The overall sustainability showed a significant positive relationship ($r = 0.340$, $P < 0.05$) with education and, a negative relationship ($r = -0.449$, $P < 0.01$) with monthly income of the family. The age and land extent were not related to sustainability. Knowledge of selection of a mixed set of planting material, vertical structures and, agronomic practices to minimize soil erosion and, waste management should be promoted. Proper marketing is also needed to make the home gardening projects economically viable and sustainable.

Keywords: Home garden, Urban, Sustainability, Crop diversification

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Climate Change Perception and Adaptation of the Farming Community of Anuradhapura District in Sri Lanka

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It is evident that agriculture, water resources, ecological systems and, human settlements are seriously affected by the climate change. In Sri Lanka, some regions are highly vulnerable to the changes of climate. This study attempts to find out the perception of one of the seriously affected farming community on the changes of climate, its impacts and the level of adaptation to climate change. Three GN Divisions in Padaviya, were selected for the questionnaire survey. Sixty farmers were selected by simple random sampling. Meteorological Data for the past 40 years were used to assess the actual changes in climate. Majority of the farmers have over 40 years farming experience, but have very low income. All have experienced significant changes of; shifting of cultivation season, cultivated extent and yield of paddy and other field crops. The majority have experienced changes of number of hot and rainy days, amount and duration of rainfall, and extreme weather events. As they had perceived, infestation of pest, disease and weeds have also increased. More than 50% farmers have perceived that social relationships and interest in farming have decreased, while migration for alternative job opportunities increased. Lack of capital, inefficient information dissemination and water scarcity are the major constraints for adaptation. The majority (74%) have medium level awareness of adaptive measures. The attitudes of the majority were also at medium level. The overall level of adaptation of 35%, 38% and 27% of the farmers were low, medium and high respectively. The level of awareness has a significantly positive correlation with the adaptation, while income and constraints have significantly negative correlation. It is recommended to develop irrigation facilities, conduct training programs and demonstrations of appropriate technology, and introducing alternative income generation methods such as cottage industries.

Keywords: Climate change, Livelihood of farmers, Constraints, Adaptation

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A Comparative Study of Perceived Service Quality in Selected Private and Public Banks

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Service quality is a vital factor for achieving customer satisfaction which leads to customer loyalty and long term success and profitability of an organization including banks. The objective of the study was to compare the expectations and perceptions of service quality contributing to customer satisfaction in selected private and public banks. Three main hypotheses were formulated to compare the differences in relation to expectation, perception and the gap between these two. Fifteen hypotheses related to the five dimensions of service quality according to SERVQUAL model were tested. Customers of the Hettipola branches of the two largest public banks and two well established private banks was the target population. Data collection was done through a questionnaire with a sample of 120 respondents with 30 customers from each bank. For analysis descriptive statistics, gap analysis and t-test were used. The findings revealed that there was no significant difference in expectation, but there was a significant difference in perception of service quality with private banks scoring higher. However, when considering the detailed dimensions, expectation of responsiveness from the private banks was higher. Further, regarding perception there was no significant difference in assurance. Public banks had a higher score only on safety. Findings revealed that private banks are perceived to provide better services than the public banks. The ranking of dimensions from highest to lowest was reliability, responsiveness, assurance, tangibility and empathy. With regard to public banks they should improve regarding almost all the aspects. Private banks should enhance the customers' perception about the safety of their assets. Even though private banks seem to be providing a better service, both sectors have to improve since neither sector has equaled, or surpassed, the expectations of the customers.

Keywords: Service quality, SERVQUAL model, Expectation, Perception, Service quality gap

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Perceptions of Extension Officers on the Production and Use of Organic Manure: A Study of Agricultural Instructors in Kandy District

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Intensive agricultural activities throughout the world contribute to environmental degradation. In Sri Lanka government and non-government organizations promote the use of organic manure to reduce the usage of inorganic fertilizer, which is known to cause many health and environmental problems. Programs such as “*Api Wavamu Rata Nagamu*” food production program has paid attention to promote the use organic manure. Even though the authorities promote farmers to use organic manure, the production seems inadequate to meet the expected levels. One of main reasons is that extension programmes conducted by the field extension staff have not been effective. A field survey was carried out with all extension officers (45) of the Central Provincial Department of Agriculture. Data on demographic characteristics, reasons for usage and non-usage of organic manure, and knowledge and attitude on organic manure were collected using a structured questionnaire. The main reason for the farmers not using the organic manure in the respective extension ranges were inadequate labour and lack of raw material. The knowledge and attitudes were tested by employing a series of questions and the mean knowledge and attitudes related to the biological, chemical and physical aspects of the organic manure were estimated. The majority of the officers (80%) have a moderate knowledge on chemical and physical properties and, only 13 % had low knowledge. However, nearly 30 % had low knowledge on biological properties, especially on the newly introduced sources of organic material. A significant negative correlation ($r = -0.56$, $P < 0.001$) was observed between knowledge level and experience of extension officers, suggesting that the younger officers having a satisfactory knowledge. Based on the research findings, it can be concluded that there is an urgent need to improve the knowledge and attitudes of extension officers in order to obtain the expected results from the promotion programmes.

Keywords: Organic manure, Attitudes, Knowledge, Agriculture instructor

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Evaluation of the Present Socio-Economic Status between Inland and Coastal Fishing Community around Mullaitivu Town Fisheries Inspector Division in Post-War Situation

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Fisheries sector is an important part of the Sri Lankan economy and its contribution to the Gross Domestic Production (GDP) was about 2.6%. Mullaitivu is one of the fisheries district in northern part of Sri Lanka, where disturbance has affected to the livelihood of the community for last three decades and there are no proper records regarding socio-economic status of the community. Assessment of socio-economic issues of fishing community is an important aspect in framing a strategy for the sustainable fisheries management. This study was mainly focused on the present situation of socio-economic status of inland and coastal fishing community in Mullaitivu town Fisheries Inspector (F.I) division. The socio-economic indicators in the study include demography, social and economic aspects. The relevant details were collected from 100 coastal and 60 inland fisher folk families by conducting field survey through a well prepared questionnaire in the selected villages around the Mullaitivu town F.I. division. According to the results, occupation, subsidy details, subsidy organization, education level and marketing method are highly influenced the income of the inland fishing community. Meanwhile in coastal fishing community, occupation, household assets, subsidy details, educational level were significantly related ($P < 0.05$) to the income level. Income level variation is the main reason for the gap between in socio-economic development in inland and costal fishing community. Stopping the illegal fishing, strengthening the policies, conducting awareness programme, introducing innovative technologies for fishing, providing infrastructure, constructing harbours and hatcheries are the essential needs in order to have a sustainable fishery in the area. The information and observations from this study will be useful in resource conservation and the implement the socio-economic goals of management.

Keywords: Socio-economic status, Inland fishery, Coastal fishery, Mullaitivu district

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An Epidemiological Study on Bovine Subclinical Mastitis in Ampara District of Sri Lanka

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This preliminary study was carried out to investigate prevalence, major pathogens, risk factor and economic losses associated with Subclinical mastitis (SCM) in dairy cows of Ampara District in Sri Lanka. In the study, a total of 352 lactating cows were screened using California Mastitis Test (CMT) for SCM from randomly selected 110 farmers in all veterinary ranges of Ampara District. Then, milk samples were collected aseptically from cows that showed CMT positive but had no clinical signs. The microbiological and biochemical analysis for isolation of common pathogen were carried out according to standard methods. According results prevalence of SCM is 59.1% (65/110) at farm level and a total of 45.1% (161/352) cows showed CMT positive for at least one quarter. Out of the CMT positive samples a total of 41.57% (143/344) showed a bacterial growth after on culturing. The pathogens isolated were *Staphylococcus spp.* 92.3% (132/143), *Escherichia coli* 6.3% (9/143) and *Streptococcus spp.* 1.4% (2/143). Among the observed risk factors, farming system, age, breed, use of calves in milking, hygienic measures and source of water significantly ($P < 0.05$) affected prevalence of SCM. Prevalence was relatively higher in intensive farming system (OR: 30.82, 95%CI: 5.85-162.23), older animal (OR: 11.99, 95%CI: 4.66-30.84), European crosses (OR: 23.91, 95%CI: 5.94-96.23), unused of calf in milking (OR: 6.37, 95%CI: 2.3-17.64), poor hygiene (OR: 7.44, 95% CI: 3.53-15.68) and well water source (OR: 3.06, 95%CI: 1.44-6.52). Estimated economical loss of due to SCM in 161 cows per lactation was LKR Rs. 1,621,620. In conclusion, this study expressed importance of SCM and associated risk factors. Therefore, early diagnosis of SCM, formulation of cost effective treatment methods and education of farmers in clean milk production are suggested as the essential urgent task to address to overcome the prevailing situation.

Keywords: Ampara district, Prevalence, Subclinical mastitis

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Present Status of Inland Fisheries and Aquaculture among Villagers Adjacent to the Giant Tank, Mannar

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Giant tank is one of the major tanks in the North province, which many rural communities benefited in different aspects including fishing. The main objective of this study was to investigate the present status of the aquaculture and inland fisheries in villages adjacent to the tank. The data were gathered using a structured and pre-tested questionnaire interview among 105 randomly selected fishermen near to the Giant tank. The findings revealed that 69% of fishermen were young aged group category between 20-40 years and their overall education level is up to primary and secondary school level. More than 86% of fishermen possessed more than 10 years of experience in fishing and aquaculture. However many fishermen possessed low to medium level of knowledge about aquaculture. About 75% of the fish farmers belonged to no land ownership, which governs them to be in aquaculture or fisheries other than agricultural activities. The attitude of the fishermen in villages adjacent to the Giant tank varied from medium favourable to more favourable attitude towards inland fishery and aquaculture. Out of 12 variables included in the study, 3 variables, such as age, education, training programme were positively and significantly related with attitude towards aquaculture ($P < 0.05$). Attitude of the farmers regarding cast of fishermen, training programmes, land ownership were the main factors which need special consideration. To mitigate these problems, awareness programmes and the education can be given to explain the farmers that aquaculture and the fishing are different. In addition, extension services have to take proper actions to overcome the cast based misconception among the people. Moreover, financial support and training programmes should also be implemented in villages to a better improvement in aquaculture.

Keywords: Aquaculture, Inland fisheries, Fishermen attitude, Giant tank

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Human Elephant Conflict of South Western Region of Anuradhapura District- A Case Study

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This research was carried out in order to identify characteristic of human elephant conflict of South Western region of Anuradhapura district. For this field study eight villages were selected with representing 160 individuals. Obtained data were analyzed by descriptive and non-parametric analysis. Majority (91.66%) of the respondents were predominantly crop farmers while others main occupations included cattle-herding (7.7%) and carpentry (11.6%). Education level of the respondents varied from no schooling (37.1%), many (47.6%) had primary education, and (15.3%) had secondary education. Severity of conflict villages were measured as following. Extreme Z value of 5.6, 5.41 Median of 4.0, 4.0 (Raswehera and Habarawaththa) respectively, highly severe Z value 3.09 Median of 3.0 (Watakoluwegama), intermediately severe Z value -0.98,-1.06,-1.47 Median of 2.0, 2.0, 2.0 (Pothanagama, Nelumpathgma, Tammannawa) respectively, low severe category Z value -5.1,-5.6 Median 1.0, 1.0 (Manneruwa, Siyabalangamuwa), respectively. As a crop protecting technique 21.33% adopted noise and throwing objects, 6.7% adopted fire and lighting and rest (72%) are adopted by combination of above approaches. Crop guarding techniques as a team approach 96.2% adopted using physical barriers(wire fences ,ditches, electric fences) and 3.8% use biological barriers (Repel crop and Palmyra fences).cultivated crop were ranked according to degree of cultivation and frequency of damage cause by elephants. Rank (6, 6) was given to paddy for cultivation and damage, respectively. Followed by chilli (2,2), soybean (1,3), maize(3,4), cow pea (4,5) and cassava (5,1), respectively. Actual value of crop damage and amount of recovered for farmers were asses as a percentage. Amount of actual crop damage varied from Rs. 1,000 to Rs. 50, 000 and actual payment also varied from 50.1% to 8.47%, respectively that shows when amount goes high actual payment become reduce. Cost of human elephant conflict can be categorized in to direct & indirect cost and 97.5% affected form direct cost and 100% were affected from indirect cost.

Keywords: Asian elephant, Human elephant conflict, Crop damage

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Application of Animal Assisted Therapy for Psychological Enrichment of Elders in a Long Term Care Facility

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This study was carried out with the objectives to assess the human animal interaction in elderly population and to enrich psychological condition of elders in a Long Term Care Facility using Animal Assisted Therapy (AAT). Ninety two elders in Colombo district were surveyed with pre tested questionnaire to identify perception of elderly population about pet animals. Eighteen elders in Moratuwa Elders Home were subjected to 4 AAT sessions within one month period as one session (90 minutes) per week and elders were allowed to interact 15 min with the pet dog within session time. Control groups were not subjected to AAT. Pre and post evaluation were done one day before AAT and after forth AAT session for both groups. Changes of anxiety level and loneliness in general life were assessed by using a State and Trait Anxiety Inventory (STAI). Perceptions about AAT programs were separately evaluated from treatment group. Survey on human animal interaction revealed that 80 % of the sampled elder population prefers pet dogs and 65% of them owned a pet dog. Majority (83%) of elders believe that having a pet is a way to reduce boredom. There was reduction ($P < 0.05$) of anxiety score in treatment group after AAT and no difference ($P > 0.05$) in control group. From the treatment group 61% mentioned AAT made them very much happy while 39% indicated moderate happiness. In addition, 72% mentioned that AAT very much helpful for reduce their loneliness and all of the participants mentioned that AAT made the facility much better place for elders. The results of the study suggest that AAT is culturally adaptable and potential of its use in Long Term Care Facilities

Keywords: Animal Assisted Therapy, Elderly people, Psychological condition, Long Term Care Facility

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A Study on Prevalence of Parasitic Infections in Ornamental Fish in Kandy District

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The ornamental fish industry is a fast growing industry in Sri Lanka. There are lots of potential for development of this industry in Kandy District which endowed with favorable climatic conditions for rearing and breeding freshwater fish. Among the constraints in the area, parasitism is one of the crucial problems for cultured fish industry. The aim of this study was to identify the magnitude of parasitic infection in ornamental fish industry in this area. A total of 156 ornamental fish of 6 species from 23 aquariums in Kandy district were collected between September-November in 2014. Those collected species of fish were Guppy *Poecilia reticulata*, Gold fish *Carassius auratus*, Platy *Xiphophorus maculatus*, Barbs *Puntius spp.*, Angel *Pterophyllum scalare*, Koi Carp *Ciprinus carpio*. These fish species were examined for parasites, grossly and microscopically. Among the common parasites, two genus of monogenean species (*Dactylogyrus* and *Gyrodactylus spp.*) and 3 genus of protozoan parasites (*Ichthyophthirus*, *Oodinium*, and *Trichodina spp.*) were found from the study. Out of 23 aquariums, 22 revealed the presence of parasitic infection with single and multiple infections. The fish infection rates of *Dactylogyrus*, *Gyrodactylus*, *Ichthyophthirus*, *Oodiniu* and *Trichodina* were 26.71%, 15.75%, 8.22%, 10.96%, and 38.36 % respectively. The susceptibility of fish species to parasitic infection can be ranked from highest to lowest as Koi carp (90.47%), Goldfish (71.42%), Guppy (66.07 %), Platy (61.29%), Angel (53.33%) and Barb (41.66%). Also there was no significant difference between parasite and breed specificity.

Keywords: Parasite, Prevalence, Ornamental fish

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A Study on Current Status of Dairy Production in Monaragala District of Sri Lanka

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The present study was conducted to determine the current status of dairy cattle production in Monaragala District. Semi-structured questionnaire survey was used to collect primary data from 120 randomly selected cattle farmers from all eleven veterinary divisions in the District. The survey was carried out from August to October 2014. The majority (70.8%) of the farmers were male and the rest (29.2%) was female. The ages of them were varied between 21 to 78 years with the mean age value of 46.8 ± 11.2 years. It was found that most of the farmers (70.8%) had other income sources while minority (29.2%) depended only on dairy production as the main source of income. The majority (82%) of the farmers practiced semi-intensive management system and had their own land extent higher than 0.5 acres (77.5%) and 73% of the farms had cattle shed. The average number of milking cows was 2.7 ± 1.7 per farmer and artificial insemination was used as the common method of breeding (81%). The average daily milk production was 12.91 ± 8.73 L/farm with once milking per day (58%) was the common practice. It is notable that farmers (42%) who practiced evening milking kept the milk in the refrigerator until following morning (88%), boil and cool at room temperature (6%), add preservative (2%) or keep in water bath (4%). The most available dairy cattle breed (55.5%) in the area was Jersey crosses. When all the observed animals were considered the age at first calving, calving interval and lactation periods were 2.98 ± 0.72 years, 1.12 ± 0.23 years and 8.54 ± 2.00 months, respectively. Among the reported diseases sub-clinical mastitis, diarrhoea and tick fever were common. The average farm gate price of milk was in between 45-55 Rs./L. The majority of the farmers (81%) sold their milk to MILCO. Also it is important to note that a considerable number of farmers (69.2%) prefer drinking fresh milk. The unavailability of suitable feedings and water scarcity during the dry season were identified as the major constraints for successful dairy production in the area.

Keywords: Dairy production, Potentials, Monaragala, Sri Lanka

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Assessment of Welfare of Dairy Cattle in Four Veterinary Ranges of Mid Country, Kandy District

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The objective of this study was to assess the welfare status of dairy cattle in small scale farms in Yatinuwara, Gampola, Poojapitiya and Thalatuoya veterinary ranges in Kandy district by using a modified Animal Need Index (ANI) method. The recommended ANI method was developed primarily to be used at farm level as an instrument for assessing and grading of farms with respect to welfare of animals. The approach pursued in Austria considers five husbandry conditions; (1) Possibility of mobility (2) Social contact (3) Condition of flooring (4) Light and air (5) Stockmanship. The overall sum of the points gives the ANI value. The ANI values have been divided up into different grades of good or poor animal welfare. The data were collected from 59 randomly selected dairy farmers from intensive and semi-intensive management systems who engaged with MILCO Farmer Managed Societies. The pre-tested structured questionnaire included a modified ANI score. The overall score of Austrian ANI have values between -9.0 and +45.5 points and the modified one used contained values of -5.0 to +37.0. The calculated overall ANI scores in evaluated intensive system were between 8.5 to 22.0 points with a mean value of 16.7 and obtained a grade 3, which indicates little suitable welfare condition. In semi-intensive system the scores were between 14.3 to 24.5 points with a mean value of 19.5 and the obtained grade was 2, which indicates fairly suitable welfare condition. The mean score of all selected farms in Kandy district (4 veterinary ranges) was 18.1 and the overall obtained grade was 3, which indicates little suitable welfare condition. The results showed that only 8.5% of the investigated farms obtained grade 1, which indicates suitable welfare. In conclusion, it is imperative to make remedial measures to improve welfare of dairy cows in the studied area of Kandy district.

Keywords: Dairy cattle, Welfare, Welfare assessment, Animal Need Index

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A Study on Potential for Introduction of Artificial Insemination of Swine in Puttalam District

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Swine industry is considered as a valuable industry in livestock farming in the north western and western coastal areas of Sri Lanka. Lack of quality breeding material has been a major drawback to improve the swine industry in Sri Lanka. The objectives of the study was to evaluate the status of swine farming, existing breeding strategy, potential to start Artificial insemination (AI) and estimate the future demand for providing AI program among the swine farmers in Puttalam district of Sri Lanka. A total of 40 swine farms were selected from Puttalam district and a survey was carried out using a structured pre-tested questionnaire. The results revealed that 88% of farms practicing natural breeding, where as 12% are already undertaking AI. Within that, 70% farms use their own farm boars for mating sows without frequently changing resulting high chance of inbreeding. 15.4% small scale, 68.8% medium scale and 72.7% large scale farms were willing to start AI program. The potential of starting an AI programme was significantly higher among the large scale farms. Knowledge about swine AI is different among farmers which affect the decision making on starting AI. At present, 93% farms have breeding unit where as 7% only practicing fattening operation with potential for providing an AI service. 65% farms favor to receive service from private sector with a recompense of 1,000-1,500 rupees. Whereas 35% farms liked receive it either from private or Government veterinary service. According to the survey results, there is a high potential to introduce a commercial swine AI service in Puttalam district of Sri Lanka.

Keywords: Swine, Artificial Insemination, Puttalam district, Potential

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