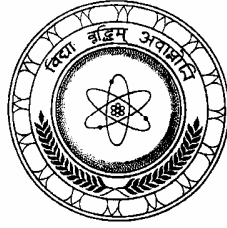


*Sri Lanka Association for the Advancement of Science
Proceedings of the 62nd Annual Sessions – 2006, Part I - Abstracts*

Sri Lanka Association for the Advancement of Science



*Proceedings of the 62nd Annual Sessions
10 - 15 December, 2006*

Part I - Abstracts

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Sri Lanka Association for the Advancement of Science

Vidya Madiraya, Vidya Mawatha, Colombo 7, Sri Lanka

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Preethi Randeniya, Assistant Editor

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MESSAGE FROM THE MINISTER OF SCIENCE AND TECHNOLOGY

It is with great pleasure that I send this message on the occasion of the 62nd Annual Sessions of the Sri Lanka Association of the Advancement of Science (SLAAS). The SLAAS has brought together all the scientists in Sri Lanka to promote scientific research and increase scientific awareness among the public. It has also contributed to keeping abreast of scientific developments abroad.

While continuing to play this important role, it is necessary that the scientists and technologists help the country to overcome the challenges posed by globalisation and contribute to achieving rapid economic development and overcoming poverty. This demands that the research effort should place more emphasis on development (development research) besides pure and applied research. Innovation has to play a key role in this process. The ultimate outcome must be high quality modern technology that would enhance productivity, resulting in goods and services being put on the market that can compete with those from abroad.

The Science and Technology Awards Ceremony held on 10th November 2006 recognised the contribution of those scientists and technologists who best helped to generate the technology that the country needs in the presence of the President and other dignitaries. This will ensure that the extra money that the government is allocating for science and technology will be put to best use to benefit the country and its people.

While Sri Lanka failed to benefit from the newer technologies like electronics, biotechnology and information communication technology to forge ahead industrially, we have a chance today to become a leader in Nanotechnology and develop industries based on this. The Budget has paved the way for this but we can succeed only if the commitment is there and the finances are made available in time, and the scientists respond.

The process of taking science and technology to the village is being promoted by the “Vidatha” programme. This has made satisfactory progress but there is still a long way to go and the support of the scientific community is vital for its success. Taken together with the “Gama Neguma” Programme of the President, a real impact can be made to reduce rural poverty by creating employment opportunities.

I hope that the scientists and technologists of Sri Lanka led by the SLAAS will make an active and significant contribution to the process that is taking place. I wish you a very successful Annual Session.

Prof. Tissa Vitarana MP

Minister of Science and Technology

**Vidatha programme of the Ministry of Science and Technology
("Gamata Thakshanaya")**

We invite the scientific community to participate in this programme.

*Contact: Mrs. P G P Abeyratne, Additional Secretary
Ministry of Science & Technology, 561/3, Elvitigala Marwatha, Colombo 5
Tel: 011-2559095, Fax: 011-2510550*

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SECTION A

001/A

Entomological and sociological investigations in dengue transmission areas in the Matale district

A M G M Yapabandara* and D M L S Bandara
Regional Office, Anti Malaria Campaign, Matale

Entomological and sociological surveillances were carried out, to determine the key premises and containers suitable for *Aedes aegypti* and *Aedes albopictus* breeding in the selected dengue and Dengue Hemorrhagic Fever (DHF) transmission areas of the Matale District from 2004 to April 2006. Serologically or clinically identified dengue/DHF cases were collected from the Regional Epidemiologist, Matale. All the cases were investigated and 124 indigenous cases were randomly selected. Entomological surveillance was carried out around these cases, covering an area of 100 m radius of each case using standard methods. A sociological survey was carried out at the same time using a questionnaire.

A total of 9133 water filled containers positive for *Aedes aegypti* and *Aedes albopictus* were encountered around 9661 places consisting of houses, dumping yards, government institutions and commercial sites. Eight types of artificial and natural containers namely, indoor and outdoor ground level water storage tanks and barrels, discarded receptacles, tyres, leaf axils of some plants and ornamental containers, refrigerator trays and roof gutters served as breeding places of vectors. Of all the types of water filled containers, a high proportion of outdoor ground level water storage cement tanks (48.47%) and discarded receptacles (34.39%) were infested by *Aedes aegypti* and *Ae. albopictus* larvae. The containers left outdoors (96%) showed a higher frequency of breeding vectors than those kept indoors. Middle income houses were significantly more likely to have *Aedes* larvae-infested containers than high ($W=213$, $n=12$, $P=0.003$) and low income premises ($W= 78$, $n=12$, $P<0.001$). These results suggest that *Ae. aegypti* and *Ae. albopictus* control programmes could be more cost effective and sustainable by concentrating efforts on key premises and key containers to control mosquito densities and dengue transmission while reducing manpower needs and insecticide use.

* Manel_Y@hotmail.com

Tel: 066-2222295

002/A

**Sensitivity of different larval collection methods in dengue vector surveillance
in the Kandy and Nuwara Eliya districts**

P H D Kusumawathie^{1*}, G A J S K Jayasooriya¹ and A R Wickremasinghe²

¹Regional Office, Anti Malaria Campaign, Dutugemunu Mawatha, Watapuluwa, Kandy

²Department of Community and Family Medicine, Faculty of Medicine, University of Kelaniya, Ragama

A study was carried out during the period June 2005 - May 2006 in the Kandy and Nuwara Eliya districts to determine the sensitivity of 1, 5, 10 and 15 larvae collection methods in dengue vector surveillance. *Aedes* larval surveys were conducted at 19 sites in 17 Divisional Director of Health services areas of the two districts. In each survey, a minimum of 100 houses were visited, all possible indoor and outdoor *Aedes* breeding sites were examined. Twenty *Aedes* larvae were collected randomly in groups of 1st, 2nd-5th, 6th-10th, 11th- 15th and 16th- 20th larvae, in separate containers, from each positive container (If a particular container had < 20 larvae, all larvae were collected and grouped as previously). Larvae were identified to species. Sensitivity of 1, 5, 10 and 15 larvae collection methods were determined taking the 20 larvae collection method as the gold standard. Five *Aedes* species, namely, *Aedes aegypti*, *Ae. albopictus*, *Ae. chrysolineatus*, *Ae. macdougalli*, and *Ae. vittatus* were found to be breeding in the containers in the study sites. Of the 353 positive containers, 236 (66.86%) were positive for a single *Aedes* species, 110 (31.16%) for two species and 7 (1.98%) for 3 species. For *Ae. aegypti*, the sensitivities of 1, 5 and 10 larvae collection methods were 68.26 (95% CI: 59.32 – 77.21), 91.35 (95% CI: 85.94 – 96.75) and 99.03 (95% CI: 97.16 – 100.0), respectively. 100% sensitivity was observed in 15 larvae collection methods. For *Ae. albopictus*, the sensitivities of 1 and 5 larvae methods were 74.66 (95% CI: 68.93 – 80.39) and 95.48 (95% CI: 92.73 – 98.22), respectively. Ten and 15 larvae collection methods were 100% sensitive. It is recommended to collect a minimum of 10 *Aedes* larvae (or all if < 10 larvae), to achieve a > 99% sensitivity for dengue vector surveillance. Entomological teams should be well trained in differentiating *Aedes* larvae from non-*Aedes* larvae in the breeding habitat, in order to prevent collection of non-*Aedes* larvae that occur commonly in the breeding sites of *Ae. aegypti* and *Ae. albopictus*.

Tel: 081-2210687

003/A

A study on the usage of anthelmintics among mothers in the Colombo district

C Siriwardena, V P Paliawadana, G S A Gunawardena, M M Ismail and S D Fernando*
Department of Parasitology, Faculty of Medicine, University of Colombo, Colombo 8

This is a descriptive cross sectional study to assess the knowledge of the mothers living in urban and rural areas of the Colombo district with regard to the use of anthelmintics for their children. The study population comprised of 200 mothers (100 each from urban and rural areas). A pre-tested interviewer administered questionnaire was used to collect data on income, educational background, knowledge, attitudes and practices with regard to anthelmintic usage.

No statistically significant effect of maternal age ($\chi^2=0.76$; $p=0.86$), parity ($\chi^2=0.50$; $p=0.48$), or residence -urban/rural ($\chi^2=0.13$; $p=0.75$) was observed on the use of anthelmintics. The rural mothers appear to commence deworming their children at an earlier age than their urban counterparts ($\chi^2=8.47$; $p=0.04$). Mothers who had studied up to tertiary level were less likely to deworm their children ($\chi^2=23.71$; $p<0.01$). The name of anthelmintic drug prescribed was known by 29.2% of urban and 35.9% of rural mothers ($\chi^2=1.96$; $p=0.37$). Only 12% ($n=25$) were aware that anthelmintics could cause minor side effects and this knowledge was similar in the urban and rural mothers ($\chi^2=0.35$; $p=0.56$). Among them only 44% could think of at least one side effect correctly. The General Practitioner was a significant source of anthelmintics with 63.8% ($n=67$) urban and 71.2% ($n=74$) rural mothers obtaining exclusively from a General Practitioner ($\chi^2=4.11$; $p=0.25$) and the price of the drugs varied from less than Rs. 20/= to more than Rs. 200/=. Among anthelmintic users, 70.0% gave anthelmintics regularly even in the absence of symptoms. This was of borderline significance ($p=0.04$) between urban and rural populations. (urban 63.4%, rural 76.8%; $\chi^2=4.28$; $p=0.04$). The majority (79%) believed that anthelmintics were safe to use during pregnancy (urban 72.1%, $n=75$; rural 85.0%, $n=91$; $\chi^2=5.26$; $p=0.02$). The basic knowledge regarding anthelmintics and their use is not satisfactory among mothers. As a majority of mothers received treatment from the General Practitioners, a more active role by them in educating patients is recommended. This study indicates that mothers who had a higher educational level used less anthelmintics. Hence special measures would have to be undertaken to address this group.

* deepfern@slt.lk

Tel: 011-2695300 Ext. 341

004/A

Genetic complexity of *Plasmodium vivax* infections in Sri Lanka

W T A Wickramarachchi¹, P H Premaratne¹, K V G S Dias¹, S M Handunnetti^{2,3}, A M Gunasekara⁴, D F Wirth⁴ and P V Udagama-Randeniya^{1*}

¹ Department of Zoology, Faculty of Science, University of Colombo, Colombo 3

² Malaria Research Unit, Department of Parasitology, Faculty of Medicine, University of Colombo, Colombo 8

³ Institute of Biochemistry, Molecular Biology and Biotechnology, University of Colombo, Colombo 3

⁴ Department of Immunology and Infectious Diseases, Harvard School of Public Health, USA

Using *Plasmodium vivax* Merozoite Surface Protein-3 α (PvMSP-3 α) marker, the existing genetic complexity of *P. vivax* infections was evaluated in individuals (N=146) from two malaria endemic areas, Kataragama (N=68), Anuradhapura (N=39) and from Colombo (N=39), a non-endemic region of Sri Lanka. A combination of polymerase chain reaction / restriction fragment length polymorphism (PCR/RFLP) techniques was used for this assessment.

Undigested PCR products showed a major size polymorphism. The product sizes were approximately 1900, 1500 and 1200 bp among which the former was the most predominant (72.8%), while the other two accounted for 25.8% and 1.4%, respectively. The predominance of the 1900 bp product was more significant [Chi square test: (with 1500 bp; P<0.05) and (with 1200 bp; P<0.01)] than the other two products in all three study areas. Despite the presence of only three size variations in undigested PCR products, RFLP analysis yielded highly diverse fragment sizes and banding patterns for all samples. The RFLP patterns of all isolates showed size conservation of the largest fragment obtained from *Hha* I digestion (~1,000 bp) and *Alu* I digestion (~500 bp), while smaller fragments showed considerable size variation. The summation of RFLP fragments of 27 samples (19%), was significantly greater than the size of the undigested product, indicating the presence of more than one PvMSP-3 α allele in these infections. The number of these multiclonal infections was significantly higher (Chi square test; P<0.05) in the two endemic areas as compared to the non-endemic area. From the samples in which single clonal infections were detected, where smaller fragments resulted from RFLP digestion, at least 10 different banding patterns from each restriction enzyme were detected, indicating the presence of a substantially high diversity at the nucleotide level.

These results demonstrate the prevailing genetic complexity among individual *P. vivax* infections in Sri Lanka, and also confirm the suitability of utilizing PvMSP-3 α locus to analyze the degree of polymorphism as well as clonality of *P. vivax* infections in this geographical region.

Financial support by the National Science Foundation, Sri Lanka [Grant NSF/RG/2005/HS/06 and scholarship for PHP (NSF/SCH/2004/07)] is acknowledged.

* dappvr@sltnet.lk

Tel: 011-2503399

006/A

An audit of research output and membership characteristics of Section A, SLAAS

R J Peiris-John*

Faculty of Medical Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda

An audit was conducted using membership records and published abstracts in the last 61 years available in the SLAAS office. For an analysis of membership characteristics and participation in activities of SLAAS section A, a questionnaire was included in the section A newsletter and the responses analysed.

Section A has contributed to the scientific sessions of SLAAS since 1947. Overall 1,287 presentations have been made at the sessions during the past 61 years. In the first 10 years, a total of 64 presentations were made. During the past 10 years, 320 presentations have been made. Of these, 264 presentations were on research conducted in Medicine and related fields, 11 in the Veterinary Sciences, 5 in the Dental Sciences and 40 in Ayurvedic Medicine and related fields.

A majority of the papers submitted on Medicine and related fields were from the University of Colombo (n=130), Peradeniya (n=52), Sri Jayewardenepura (n=35), Kelaniya (n=18) and Ruhuna (n=17) and the anti-Malarial campaign (n=18). The majority of abstracts from the University of Colombo during this period were in the sub-specialties of Parasitology (n=55), Biochemistry & Molecular biology (n=24) and Indigenous medicine (n=12). In the last 3 years, there have been no presentations from the Medical Research Institute, Dental Institutions or from the hospitals under the Ministry of health. As at end 2005, Section A has members from only 16 of the 25 districts in the country. Of the 343 members whose private addresses are available, 69% are resident in the Colombo district, 10% in the Kandy district, 7% in the Gampaha district and 5% in the Galle district.

This analysis revealed membership characteristics of highest academic excellence in both men and women. Expertise in a wide array of sub-specialties of the medical, dental and veterinary sciences is available. The decline in numbers of research papers in the recent past may be because researchers prefer to present their findings in the Associations in the different sub-specialties in Medicine, Dental and Veterinary Sciences rather than in the general research forum of SLAAS. However, the lack of representation in the membership from 9 of the districts is a matter of concern. It is important that Section A develops strategies necessary to harness the expertise to achieve the stated objectives of SLAAS.

* roshi@visual.lk

Tel: 011-2802182

007/A

DNA-based parentage testing in forty cases of statutory and aggravated rape: Some social issues

S Mohotti, T De Silva, R J Illeperuma and N D Fernandopulle*
Genetech Molecular Diagnostics, 54, Kitulwatte Road, Colombo 8

This study examines forty cases of paternity testing that was performed in incidents of statutory and aggravated rape. Thirty one cases of statutory rape were selected on the basis that the tested mothers were below the age of 16yrs at the time of conception, and nine cases of aggravated rape were selected because the tested mothers were physically or mentally handicapped. The objective of this study was to observe trends in the parentage testing process for these two offences, and to examine the DNA typing data for possibilities of consanguinity between parents, which is indicative of unreported cases of incest.

These cases were referred to us by Courts in 13 districts. In the statutory rape cases, the age of the mother ranged from 11yrs to 16yrs at the time of delivery with an average of 14.7yrs. The age of the father ranged from 15yrs to 56yrs with an average of 28.8yrs. Of the forty cases, 25 (62.5%) proved to be positive in the paternity test, and 15 (37.5%) proved to be negative. A negative result indicates that the accused is not the biological father. By extension, it also means that the actual father/rapist was not accused, and was not brought to trial in that case.

We further examined the DNA data from the cases which gave negative results. We observed that of the degree of homozygosity in the child (3.0) was greater than in the overall average (2.6) for a random Sri Lankan. Further, we observed that the genetic similarity between mother and child in these cases was 3.3, which is greater than the national average (2.3) for a mother-child duo in the Sri Lankan population. A greater degree of homozygosity in the child and genetic similarity between the tested mother and child is strongly indicative of consanguinity between the actual parents of the child. From the above observations, it was found that there was a distinct possibility that in these cases, the rapist was a close family relative, and that another person had been falsely accused of the offence. In the above cases, we informed the Court of the possibility that the actual father may be a blood relative of the mother. However in all such cases, we were not requested to perform any further tests. As a consequence, in these cases the offence of statutory rape which is also incest went unprosecuted, and the offender was not even brought to trial.

While a positive DNA test is very good proof of statutory and aggravated rape, a negative DNA test result must be further investigated for the underlying cause, which is likely to be the grievous offence of incestuous statutory rape, and all possible suspects must be subjected to testing in order to determine the identity of the rapist.

* genetech@slt.lk

Tel: 011-2696992

008/A

DNA-based detection of Herpes Simplex Virus 1 and 2 in clinical samples and its usefulness as a screening test for viral encephalitis

R Abbas, D Senevirathne, D Ranaweera and N D Fernandopulle*
Genetech Molecular Diagnostics, 54, Kitulwatte Road, Colombo 8

Both Herpes Simplex Virus (HSV) types 1 and 2 are contagious, and may be transmitted by asymptomatic carriers. HSV has been associated with encephalitis and meningitis where 70% of infections occur in individuals with a previous history of HSV.

For acute infections, virus detection is the method of choice. Viral culture takes 24 hours, and allows detection of asymptomatic shedding. PCR is the most practical method available for the early detection of HSV in Sri Lanka. It can detect the virus in primary infections, asymptomatic shedding, and latency.

The objective of this study was to optimise and establish a low-cost in-house PCR-based molecular diagnostic assay to detect HSV 1 and 2 in clinical specimens, and determine its usefulness as a screening test for viral encephalitis. Samples suspected of HSV infection (n=358) were tested between June 2003 and April 2006. Of the samples received for testing 307 (85.8%) were cerebrospinal fluid specimens, 36 (10%) were blood, and 15 (4%) were samples from vaginal swabs, blister fluids and eye swabs. DNA was extracted from these clinical specimens using an in-house guanidium thiocyanate method followed by nested PCR and agarose gel electrophoresis, using primers specific for the glycoprotein D gene of both HSV 1 and 2 viruses. The assay was controlled for sensitivity, specificity and contamination by the use of known HSV specimens and water blanks. No cross-reactivity was seen with *Varicella zoster*, *Haemophilus influenzae* and *Neisseria gonorrhoeae*. Validation of the PCR was done using a reference strain of HSV 1 and 2. Estimation of the sensitivity of the PCR was done using dilutions of the culture, for which the viral titre had been specified. Sensitivity was set at one hundred virus particles in 0.1 ml of specimen.

Of the samples suspected of HSV, 26 were found to be positive for HSV Type 1 or 2 (7.26%). Most patients tested belonged to the age group 16-45 years (52.3%). 15.4% belonged to the 0-15 years age group, while the rest were over 46 years old. Of the suspected CSF samples, 6.2% were positive; of the blood samples, 8.3% were positive. Of the other mentioned samples, 28.6% were positive for HSV 1 or 2. The chemical cost for offering this test using a commercially available kit would range from Rs.1,400 (Cinnagen, Iran) to around Rs.18,000 (Roche, USA). The chemical cost of performing our in-house assay is Rs.750. We have optimised and established a rapid PCR-based test for HSV, which is useful as a screening test in viral encephalitis.

* genetech@slt.lk

Tel: 011-2696992

009/A

**PCR-based detection of Y-chromosomal microdeletions
in a selected group of infertile males**

K Thiruchelvam¹ and N D Fernandopulle^{3*}

¹ *Postgraduate Institute of Science, University of Peradeniya, Peradeniya*

² *Genetech Molecular Diagnostics, 54, Kitulwatte Road, Colombo 8*

Male infertility is commonly associated with severe spermatogenic impairment. The Azoospermic factor region (AZF) located at the long arm (Yq-euchromatin) of the Y chromosome harbors crucial candidate genes in its sub regions AZFa,b,c for spermatogenesis and its control. In the last decade microdeletions in these sub regions have been shown to be associated with the spermatogenic defects of azoospermia and oligospermia. The objective of this study was to establish a molecular diagnostic system for detecting Y-Chromosomal microdeletions and to assess the microdeletion pattern (type and frequency) in a selected sample of infertile Sri Lankan males.

DNA was extracted from venous blood samples of 62 infertile men who were azoospermic (34), oligoseprmic (7), severe oligospermic (18) and normospermic (3) patients from infertility clinics. Six non-polymorphic, single copy STS markers were selected from the AZF region – AZFa (sY84, sY86), AZFb(sY127, sY134), and AZFc (sY254, sY255). Adjacent STS primers were grouped into two sets of multiplex PCR master mixes, set A and B. PCR products were size fractionated by agarose gel electrophoresis with ethidium bromide staining. Two internal controls and three external controls were applied to control for false negatives, specificity, sensitivity, DNA contaminations and reagent contaminations.

Deletions were detected in 9 infertile men (14.5%) out of 62. No deletions were observed in fertile men and normospermic infertile men. Deletions were observed in 7 (20.6%) of the 34 azoospermic patients and 2 (11%) of the 18 severe oligospermic patients. Single deletions in the AZFc region had the highest frequency (n=4, 44.4%), followed by AZFb (n=2, 22.2%). Combined deletions were detected in 2 patients who were azoospermic AZFb+c (n=1, 11.1%) and AZFa+b+c(n=1, 11.1%). In this study, single and combined deletions of AZFa and b loci were associated with azoospermia and single AZFc deletions were associated with severe oligospermia and azoospermia in similar proportions and AZFc combined with a (AZFa+b+c) and b (AZFb+c) were associated with azoospermia. The molecular diagnostic system developed in this study for the first time in Sri Lanka, effectively detected deletion patterns similar to previous studies in other geographic locations.

* genetech@slt.lk

Tel: 011-2696992

010/A

**Zinc levels in seminal plasma and its relationship with semen parameters
in male partners of subfertile couples**

D M A B Dissanayake^{1*}, P S Wijesinghe¹, W D Ratnasooriya² and S Wimalasena³

¹ *Department of Obstetrics and Gynaecology, Faculty of Medicine, University of Kelaniya, Ragama*

² *Department of Zoology, Faculty of Science, University of Colombo, Colombo 3*

³ *Department of Chemistry, Faculty of Science, University of Kelaniya, Kelaniya*

The objective of this study was to evaluate semen Zn levels in male partners of subfertile couples and to observe the relationship between seminal plasma Zn levels and semen characteristics. The study was carried out as a hospital based prospective observational study from November 2004 to May 2006 at the Subfertility Unit, Department of Obstetrics and Gynaecology, Faculty of Medicine, Ragama.

A total of 150 male partners of subfertile couples were recruited after excluding confounding factors (according to WHO). Semen samples were obtained from masturbation and analyzed for semen parameters. Seminal plasma Zn concentrations were assessed with atomic absorption spectrometer. Group means were compared with Student's t- test at a significance of $p < 0.05$.

The mean (SEM) seminal plasma Zn concentration in the study population was 121.87(5.60) $\mu\text{g}/\text{mL}$. Mean Zn concentration was significantly high ($p < 0.05$) among subjects with asthenozoospermia (low sperm motility) in comparison to normal motile group. Mean Zn concentrations were not significantly different between normal and abnormal groups of other parameters (volume, pH, concentration, viability and morphology). Our study failed to demonstrate a significant difference in the mean Zn concentration between normozoospermics (115.10 $\mu\text{g}/\text{mL}$ \pm SD 57.01) and others (122.66 $\mu\text{g}/\text{mL}$ \pm SD 76.51).

A weak negative correlation ($r = -0.0193$, $p < 0.05$) was found between seminal plasma Zn concentration and pH. There was no correlation between Zn concentration and other seminal parameters. Total Zn per ejaculate also demonstrated a correlation ($r = -0.280$, $p < 0.01$) with seminal fluid pH but not with any other parameter.

We conclude that semen Zn levels in male partners of subfertile couples were comparable with other such populations that have been studied elsewhere. A significantly higher Zn concentration was observed among subjects with asthenozoospermia. Seminal plasma Zn levels correlated negatively with semen pH.

Financial assistance by National Science Foundation research grant (RG/2004/M/14) is acknowledged.

* anuradissa@lycos.com

Tel: 011-2958039 Ext.21

011/A

***In-vitro* study of milk protein on Angiotensin converting enzyme activity**

L V Athiththan¹, S D Jayaratne² and H Peiris^{1*}

¹*Department of Biochemistry, Faculty of Medical Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda*

²*Department of Medicine, Faculty of Medical Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda*

Angiotensin II is involved in blood pressure, blood volume, and blood electrolyte homeostasis. Some of the drugs that are currently used to control hypertension such as captopril, enalapril are inhibitors of Angiotensin Converting Enzyme (ACE). Peptides formed from milk proteins have an inhibitory effect on ACE. An *in-vitro* study was carried out to assess the effect of locally produced low fat sterilised milk and low fat curd. 5ml of de-ionised water was added to 5g of milk and curd and the pH was adjusted to 3.72 using lactic acid and centrifuged at 10,000 g for 10 minutes. The fat on the top layer was removed and the pH was readjusted to 8.3 with 10 N NaOH, the optimum pH for the reaction. Another 5g of curd and milk were digested overnight with 4ml of 25% (w/v) pepsin at pH 1.5 followed by 1 ml of trypsin at pH 7.8 so that the total volume would be maintained constant. After complete digestion, the pH was adjusted to 8.3 using 10 N NaOH and centrifuged at 10,000 g for 10 minutes. 0.08 ml of the above samples was used as the substrate for analysis.

The ACE inhibitory activity was carried out using the modified version of Cushman and Cheung. 0.3% (w/V) Hippuryl-L-Histidyl-L-Leucine as the buffer and ACE of Sigma products were used. Absorbance of the product formed was measured at 228 nm using suitable cuvettes. The substrate free buffer was considered to have 100 % activity and the blank as 0% activity. The digested curd had the maximum inhibitory activity of 78.98 %, curd had 49.41%, digested milk had 48.09 % and milk had 3.99 %.

The highest inhibition of digested curd may be due to competitive inhibition of the enzyme ACE by peptides produced from curd both by the bacteria and digestive peptidases. A small inhibition by milk may due to the fewer amounts of peptides present in it. The curd has an inhibitory effect on ACE. The inhibitory effect is increased with digestion. The digested milk also had an inhibitory effect slightly less than curd.

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* hempiris@yahoo.com

Tel: 011-2803578

012/A

Isolation and characterisation of proteases of *Toxocara canis* infective larvae

Y L P Jayananda^{1,2}, S B P Athauda² and R P V J Rajapakse^{1*}

¹*Division of Parasitology, Department of Pathobiology, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya*

²*Department of Biochemistry, Faculty of Medicine, University of Peradeniya, Peradeniya*

Eggs of the ascarid nematode *Toxocara canis* are infective to a wide range of mammals including humans. Eggs when ingested by a non-canid host, hatch and release tissue-penetrating larvae that do not mature to the adult stage. Instead they migrate through various tissues, often causing ocular and visceral larval migrans. Proteases are responsible for the tissue damage.

SDS-PAGE revealed 11 protein bands in excretory-secretory products of *T. canis* between 28 - 280 kDa, out of which only two show enzymatic activity in gelatin zymography at pH 7.2. Molecular weights of these two proteases were approximately 205 kDa and 166 kDa. Sera prepared from rabbits against these two proteases showed two bands in western blot with apparent molecular weights of 205 kDa and 166 kDa. In gelatin zymography, pre-incubation of *T. canis* with the two proteases with immunised rabbit serum at 37°C led to 90% loss of activity in comparison with that observed in the controls. Immunofluorescence studies with *T. canis* larvae incubated with immunised rabbit (positive) sera revealed prominent fluorescence along the alimentary tract, particularly in the middle area. These two proteases were found to be optimally active at pH range of 5.5-6.5 when using albumin as the substrate. Activity was less when gelatin and casein were used as substrates.

Further studies will be carried out with mice immunised with *T. canis* proteases to determine the protective efficacy of these proteases in an animal model. Effects of different inhibitors on enzyme activity will be investigated to determine the classes which these proteases belong. The present study clearly shows that *T. canis* proteases do possess antigenicity and the fluorescence studies indicate that the alimentary tract might be the location of the secretions, involved in the parasite digestive processes. The feasibility of producing an anti-*T. canis* vaccine will also be studied.

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* jayanthar@pdn.ac.lk

Tel: 081-2395717

013/A

***In vivo* effects of *Areca catechu* and *Adhatoda vasica* extracts on goats infected with gastrointestinal nematodes**

W I T Fernando¹, R P V J Rajapakse² and H R W Dharmaratne^{1*}

¹ *Natural Products Programme, Institute of Fundamental Studies, Kandy*

² *Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya*

In our search for inexpensive and acceptable alternatives to gastrointestinal nematode control in goats, medicinal plants used in Sri Lanka were evaluated for their anthelmintic activity by Larval migratory inhibitory (LMI) assay using exsheathed infective larvae from gastrointestinal nematodes of goats. The toxicological properties of *in vitro* active plant extracts were studied using Swiss mice. The non-toxic plant extracts were subjected to efficacy trials using goats. In the efficacy trials, goats treated with methanol extracts of *Areca catechu* immature fruit kernel (2mg/ kg BW) and *Adhatoda vasica* leaves (24 mg/kg BW) showed anthelmintic efficacy of 80% and 75%, respectively. Above doses were based on the maximum significant LMI achieved from the *in vitro* assay.

Based on above results, a long-term prophylactic trial was conducted on three groups of goats (10 X 3), by separately drenching *Areca catechu* immature fruit kernel extract, *Adhatoda vasica* leaf extract and phosphate buffered saline (control) orally. Above drenching was continued at 14-day intervals for a period of six months. The log transformed mean monthly faecal egg counts (FEC), analysed by repeated measures of analysis of variance (RMA), showed that mean monthly FEC remained high in the untreated group throughout the trial, whereas in the groups treated with extracts, FEC decreased significantly ($p < 0.05$) from the second month until the end of the trial. The one way analysis of variance of the total worm burdens showed that the worm burdens of the treated groups were significantly lower when compared with the control. When analysed by RMA, live weight gain of the group treated with *Areca catechu* extract showed a significant ($p < 0.05$) difference only during the last two months of the trial, and the *Adhatoda vasica* extract treated group showed a significant live weight gain during the last month of the trail when compared with the untreated group. The packed cell volume level and haemoglobin concentration of the treated groups increased gradually throughout the study period and the levels for the control group decreased with the time.

Our findings indicate that the potential use of the above two extracts are an inexpensive and acceptable alternative to gastrointestinal nematode control in goats.

* hrwd@ifs.ac.lk

Tel: 081-2232002

014/A

Histopathological, haematological and serum biochemical changes in Wistar rats after oral administration of *Alternanthera sessilis* water extracts

B M G K Balasuriya¹, G S P de S Gunawardena² and H R W Dharmaratne^{1*}

¹*Natural Products Programme, Institute of Fundamental Studies, Kandy*

²*Department of Veterinary Pathobiology, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Peradeniya*

Alternanthera sessilis commonly known as Mukunuwenna is a leafy vegetable popular among Sri Lankans. This investigation was carried out to study the histopathological, haematological and serum biochemical changes in Wistar rats, after oral administration of *A. sessilis* water extracts.

Eight-week-old Wistar rats weighing 170 ± 10 g were grouped into eight experimental groups (A I, A II, A III, A IV, B I, B II, B III, B IV) each consisting of 3 rats. Each rat of A I & B I received 10 times of the calculated dose (assuming a human of 50kg consumes 50g of *A. sessilis* per day, and amount per unit weight of human was calculated and converted to the average weight of rats, 170g) which amounted 82.1 mg/day of the freeze-dried water extract of aerial parts of *A. sessilis* in 2 mL of water. A II & B II received 20 times (164.2 mg/day), and the highest dose 40 times (328.4 mg/ per day) was given to A III & B III. Water (2 mL) was given orally to A IV & B IV as the control. Haematological, serum biochemical and histopathological studies were carried out by employing standard techniques on all the animals A I, A II, A III & A IV on the 21st and B I, B II, B III & B IV on the 42nd day. The tested doses of *A. sessilis* were not lethal to Wistar rats and there were no significant changes in haematological parameters, viz., total RBC and WBC counts, PCV and hemoglobin concentration. However, significant elevations ($p < 0.05$) in the levels of AST (158%- 52%) and ALT (73%- 27%) were found in the treatment rats on the 21st day. Significant changes were also observed in AST (192%-126%), ALT (67%-33%), ALP, urea, creatinine, magnesium and albumin levels in all the treatment groups on the 42nd day.

Histopathological changes characterised by congestion and mild degenerative lesions were observed on the 21st day in the liver and kidney of the rats that received the highest dose (A III). The histological lesions indicative of mild to moderate hepatocyte degeneration and/or necrosis and mild degenerative changes in the kidney tubules were found in the rats of all treatments on the 42nd day. In contrast, the liver and kidney of the rats of both control groups (A IV & B IV) were devoid of histopathological changes.

The present findings indicate that, the oral administration of fresh *A. sessilis* water extract leads to hepatic and renal toxicities in male Wistar rats. Further investigations with smaller quantities of cooked *A. sessilis* are necessary to confirm the long-term hepatic and renal toxicities observed.

* hrwd@ifs.ac.lk

015/A

Presence of toxic materials in herbo mineral formulations

V P S Seneviratne¹ and A P G Amarasinghe^{2*}

¹ *Organization for Serving Humanity and Nature (OSHAN)*

² *Institute of Indigenous Medicine, University of Colombo, Rajagiriya*

Herbo mineral preparations are the major remedial tools in ayurveda and traditional system of medicine and have made a great contribution to maintain human health. It is very accessible, affordable and considered integral to every day life and well being. But in the recent past, wide spread use of ayurveda and traditional medicine has extended far beyond its original ethnic settings and has also created many health challenges in terms of safety, efficacy and quality of these medicines. At the same time, a growing number of reports documented mild to severe fatal adverse or toxic effects of misuse or irrational use of herbo mineral medicines.

The objective of this study was to determine the safety and possible toxicity contamination that could occur in use of herbo mineral formulations. It was a random study of selected ayurvedic medicine screening for possible contamination with heavy metals i.e. Mercury.

Selected herbo mineral formulations were analysed for Hg contamination according to the Atomic Absorption Spectrophotometry (AAS) method at the Industrial Technology Institute (ITI). Mercury contamination of Yogaraja guggulu pills, Seetharama pills, Chandrapraba pills, Kaishora Guggulu pills, and Makaradwaja powder are 0.3 mg/ Kg, 47 mg/ Kg, 01.0 mg/ Kg, 0.4 mg/ Kg, 2.3 mg/ Kg, respectively. Safety exposure standards – As per EPA/FDA, US 0.1 mcg/ Kg of body weight for a 70 Kg average adult this would be 7mcg.

This study reveals that some ayurvedic medicines contain Hg at toxic levels. This is a fairly small and random study and it does not represent the whole picture of medicine in general. But it opens avenues to start more research work in the evaluation of safety and ethno pharmacological studies of herbo mineral formulations.

* drgamarasinghe@hotmail.com

Tel: 011-2694308

016/A

Identification of alcohols in selected *arishta* and *asava* used in ayurvedic medicine

W M B Weerasooriya¹ and Janitha A Liyanage^{2*}

¹ *Gampaha Wickramarachchi Ayurveda Institute, University of Kelaniya, Yakkala*

² *Departments of Chemistry, University of Kelaniya, Kelaniya*

Arishta and *Asava* have been used as medicines for over 3000 years to treat several disorders. In addition, they are being consumed as herbal wines, appetisers and stimulants. Quantitative standard parameters of *arishta* and *asava* have not been documented. Research for determination of constituents and contaminants of these products highlight the importance of analyzing these products to ensure their quality and safety. As natural fermentation is the main preparation process of *arishta* and *asava* alcohols, flavouring compounds and other toxic material could be present. Hence identification of types and levels of alcohols and other chemicals that are present in these preparations is important to prepare the standards for them.

In this preliminary study, a qualitative determination of alcohols in commercially available 12 brands of *Ashvagandharishta* and 6 brands of *Aravindasava* was carried out using gas chromatography. Samples were distilled and the distillate was used for the analysis.

Quantitative determination of 12 brands of *Ashvagandharishta* showed that in addition to ethanol, methanol (max 209.4, min 31.1; mean 101.9 ± 48.6 ppm), n-propanol (max 28.1, min 3.2; mean 12.3 ± 7.6 ppm), iso butanol (max 65.3, min 7.9; mean 24.9 ± 17.1 ppm), amyl alcohol (max 155.3, min 53.7; mean 99.3 ± 34.5 ppm) and isopropyl alcohol (max 9.3, min 4.6; mean 5.9 ± 1.4 ppm) were present in all the products. Similarly, methanol (max 132.6, min 28.3; mean 57.5 ± 39.5 ppm), n-propanol (max 12.1, min 1.6; mean 4.8 ± 3.8 ppm), iso butanol (max 31.3, min 19.9; mean 23.8 ± 5.6 ppm), amyl alcohol (max 103.8, min 75.8; mean 92.0 ± 11.2 ppm) and isopropyl alcohol (max 6.3, min 4.3; mean 5.1 ± 0.7 ppm) were present in the 6 brands of *Aravindasava*.

The presence of toxic compounds like methanol in these products highlights the need for further studies related to the manufacturing process of *ayurvedic* preparations.

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*janitha@kln.ac.lk

Tel: 011-2914486

017/A

A comparative preliminary study of anti-bacterial effect of ayurvedic compound preparations of Dathree choorna and Hinguastaka choorna

B M Nageeb^{1*}, A P G Amarasinghe¹ and S Widanapathirana²

¹ *Institute of Indigenous Medicine, University of Colombo, Rajagiriya*

² *Department of Microbiology, University of Kelaniya, Kelaniya*

Dathree choorna and Hinguastaka choorna are compound preparations commonly used in ayurvedic system of medicine in Sri Lanka. These powder preparations are being used specially in gastro intestinal disorders, such as diarrhoea, dysentery, indigestion and vomiting. Most of these conditions may develop due to bacterial infections. The main objective of this study is to evaluate the anti bacterial effect of these preparations. Minimum human single dose of these drugs (2.5g) was dissolved in sterile distilled water and kept in the shaker at 100 rpm, continuously for 04 hours in order to get the maximum soluble liquid extract of these drugs. 0.7g of nutrient broth was dissolved in 50 mL of distilled water and transferred in to five test tubes (10 mL /tube) and sterilised by autoclaving at 121 °C for 20 minutes. These nutrient broth tubes were inoculated by using inoculating needle with pure test cultures of *Pseudomonas aeruginosa*, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhi* and *Klebsiella*. These tubes were incubated at 37 °C for 18 to 20 hours. 2.8 gram of nutrient agar was dissolved in 100 mL of distilled water and sterilised by autoclaving at 120 °C for 20 minutes. This Agar was transferred into five sterilised Petri dishes at 40 °C and allowed to solidify on a horizontal plane. These plates were sealed and kept in the incubator at 37 °C for 24 hours to exclude any contaminations and to reduce the moisture content. Measured, 0.05 mL of each nutrient broth culture was added to these solidified Agar plates by using sterile 1.0 mL glass pipette and spread evenly by using a sterilised glass spreader. On this seeded Agar plates already sterilised metal cylinders were kept with gentle pressure. These cylinders were filled with 0.1 mL of the liquid extract of Dathree choorna, Hinguastaka choorna, and de ionised sterilised distilled water. These plates were sealed and incubated at 37 °C. This same procedure was repeated three times for each organism with antibiotics Gentamycin and Chloramphenicol as control drugs. Clear inhibition of 1 cm zone of the bacterial lawns were observed repeatedly around the metal cylinder containing extract of Hinguastaka choorna in the plates of *Salmonella typhi* indicating that the water extract Hinguastaka choorna has anti bacterial effect on *Salmonella typhi*. The results of this preliminary study may justify scientifically the use of Hinguastaka choorna in some infective conditions of gastro intestinal tract such as diarrhoea, dysentery and indigestion.

* bmnageeb@yahoo.com

Tel: 011-2687215

018/A

Effect of Flabelliferin B on wound healing: A preliminary study

A A P Keerthi¹, W Sunil J Mendis², E R Jansz¹, S Ekanayake^{1*} and M S A Perera³

¹ Department of Biochemistry, FMS, University of Sri Jayewardenepura, Gangodawila, Nugegoda

² Colombo South Teaching Hospital, Kalubowila, Nugegoda

³ Department of Family Medicine, FMS, University of Sri Jayewardenepura, Gangodawila, Nugegoda

Wound care and management developed rapidly after the discovery of the antibiotics. However, still there is a need to identify more effective antibacterial agents for effective management of wounds. Previous studies reported one such compound called Flabelliferin B (F_B) isolated from palmyrah palm fruit pulp. F_B is a steroidal saponin having proven structure β Glc α 1, 2 Rha and α 1, 4 Rha attached to 3rd position of β -sitosterol. F_B had a wide range of activity against several bacterial species and yeast. The present study was carried out to observe the possible toxic effects and wound healing effects using animal models and humans.

F_B (0.45 mg in saline) indicated no toxic effects on wounds made on Wistar rats (n = 8). Standard experiments resulted lowering of microbiological colony counts on above wounds. As our intention was to have infected wounds, no attention was paid to maintain aseptic conditions when wounds were inflicted. Ocular toxicity studies were carried out using Wistar rats (n = 8) and New-Zealand white rabbits (n = 6). Above experiments confirmed the absence of the possible local and systemic adverse effects. Patch test carried out on normal healthy human volunteers' skin (n = 7) indicated no adverse effects.

A pilot study was carried out in Colombo South Teaching Hospital using 2% F_B in white soft paraffin against current hospital treatments as controls. A double blind study was not possible in the ward due to logistical reasons. Patients with ulcers with underlying pathologies were not included in the study. Average wound healing rates per week were 23.7% for test and 17.5% control (p = 0.512).

In conclusion, all animal studies together with the human patch test did not indicate any possible toxic effects from F_B on test subjects. Wound healing was clinically significant. In addition, it was observed that new F_B formulation could act as a wound debridement agent as well as a cleanser.

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* sagarika@hotmail.com

Tel: 011-2803578

019/A

An investigation of toxicity of *Trichosanthes cucumerina*

L D A M Arawwawala^{1*}, M I Thabrew² and L S R Arambewela¹

¹ *Industrial Technology Institute, Baudhaloka Mawatha, Colombo 7*

² *Department of Biochemistry & Clinical Chemistry, University of Kelaniya, Thallagolla Road, Ragama*

Trichosanthes cucumerina (S. dummella; F. cucurbitaceae) is a medicinal plant used traditionally in Sri Lanka as a remedy for diabetes, fever, acute bronchitis, boils, sores, etc. To date, no attempts have been made to evaluate whether the plant has any toxic effects. Therefore, the objective of this study was to determine whether a decoction prepared from aerial parts of *T. cucumerina* (TCD) has any toxic effects. ICR mice (6 weeks; weight 35 – 40g) were used as the experimental model.

Short term and a long term toxicity studies were carried out. In the short term toxicity study, mice were randomly divided into 2 equal groups (n = 12/group). Group 1 (test group) received the TCD at a dose correspondence to the normal human therapeutic dose (1.5 g/kg/mouse/day) and group 2 (control group) received 1 ml of distilled water/mouse/day for 14 consecutive days. In the long term toxicity study, the same treatment procedure was followed as in the short term toxicity study up to 42 consecutive days.

In both studies, mice were checked twice daily for overt signs of toxicity such as salivation, diarrhoea, fur erection etc. Average food and water intake was determined weekly for each group. The consistency of faeces and colour of urine were noted daily. Further, liver and kidney functions and haematological parameters (red blood cell counts, white blood cell counts, packed cell volume and hemoglobin concentration) were assessed. Liver function was assessed by estimation of serum levels of alanine transaminase, aspartate transaminase and alkaline phosphatase. Renal toxicity was determined by estimation of serum urea and creatinine levels. In the long term toxicity study, effect of TCD on histology of main body organs (heart, liver, kidney, spleen, intestine) were also assessed by microscopic examination of haematoxylin/eosin stained sections of these organs.

LD₅₀ of TCD was also determined by administration of several doses (3, 6, 12, 15 & 30 g/kg body weight) in mice (n = 10/group). Each dose was given once and the number of deaths and any apparent toxic effects such as salivation, diarrhoea, fur erection etc were noted up to 7 days.

No toxic effects or treatment related deaths were observed in the short term and long term toxicity studies. Food and water intakes were normal. The consistency of faeces and color of urine remained similar to that of respective controls. Further, the therapeutic dose of TCD did not have any significant effect (P>0.05) on kidney or liver function nor the haematological parameters and the histology of major body organs in ICR mice. In the LD₅₀ study, no deaths or toxic effects were observed. The overall results suggest that TCD at a dose corresponding to the human therapeutic dose does not produce any significant toxic effects in ICR mice.

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* menuka@iti.lk

Tel: 011-2683128

020/A

Clinico-pathological changes caused by ammonia toxicity in cultured *Oreochromis niloticus* (Nile Tilapia)

S G P B Samarasinghe* and G S P de S Gunawardena

Department of Veterinary Pathobiology, University of Peradeniya, Peradeniya

Ammonia is the principal nitrogenous waste product of teleosts and many invertebrates in both freshwater and seawater. Since, high un-ionised ammonia concentrations are toxic to aquatic organisms, this study was carried out to determine the clinico-pathological changes caused by ammonia toxicity in cultured Nile Tilapia (*Oreochromis niloticus*).

A total of 300 *O. niloticus* fingerlings of both sexes weighing 2.1 g – 2.7 g and length of 3.5 cm – 5.1 cm were randomly assigned to glass tanks (15 cm x 15 cm x 45 cm) in groups of 10 fish each. The fishes were hand-fed with commercial fish feed at the rate of 5 % of body weight per day. Water quality parameters except ammonia concentration were maintained at standard levels throughout the experiment. Of the 300 fingerlings, 270 were exposed to a series of un-ionised ammonia concentrations (8.06, 7.26, 6.45, 3.88, 3.32, 2.77, 1.48, 0.73, 0.20 and 0.01 mg/ L) in three replications. Treated fish in each tank were examined for clinical manifestations and mortality at 20 minute intervals during the first four hours and hourly intervals up to ten hours and subsequently at 12, 14, 16, 18, 24, 30, 36 and 48 hours. Dead and moribund fish were subjected to detailed post-mortem examination including histopathology.

The fingerlings exposed to higher concentrations of ammonia showed hyperventilation, violent abnormal movements including convulsions, swimming at the surface and loss of balance. Subsequently, they show body spasms and sank down to the bottom of the tank and died after a period of coma. Gross pathological changes included congestion, oedema and abundant secretion of mucus in the gills. Chronic exposure to sub-lethal levels of ammonia caused histopathological changes characterised by proliferation and thickening of the gill lamellae epithelium and degenerative changes in the blood vessels, spleen and haemopoietic tissue in the kidney.

The present findings indicate that high levels of un-ionised ammonia in water lead to clinical manifestations and pathological changes causing disease and death in *O. niloticus*.

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* bhavetpath@yahoo.com

Tel: 081-23955727

SECTION B

101/B

Medicinal plant industry in Sri Lanka: A case study

R M Dharmadasa* and A Moramudali

Herbal Technology Division, Industrial Technology Institute, Baudhaloka Mawatha, Colombo 7

According to the World Health Organization, about 80% of populations in developing countries are still dependent on traditional systems of medicine for their basic health care needs. Despite the fact that Sri Lanka is blessed with all necessary requirements for the cultivation of medicinal plants, about 60-65% of raw material requirement is imported from India and 8 other countries due to lack of systematic cultivation in the country. The present survey was undertaken to identify constraints faced by different stakeholders of medicinal plant based industry in 5 districts, especially at the village level. A survey was conducted using a formal questionnaire. Education level of the participants varied from GCE O/L to degree level. Main constraints identified were lack of planting materials to set up large scale cultivation, lack of knowledge on how to cultivate, lack of awareness of methods to control pests and diseases, post harvest aspects and lack of proper market to sell medicinal plant materials. Further, land availability, lack of credit facilities and lack of irrigation facilities were also noted. The main sources of planting materials were natural forests, own nursery, and Department of Ayurveda and Forest Department nurseries. Only 10% of participants were aware on all aspects of medicinal plant cultivation. However, participants' awareness of the quality of herbal materials is very high (66% of participants). As to the quality, price and availability of local and imported herbal materials, the response of 82% of participants was that the quality of local raw materials was excellent, while 45% of participants answered that the price of local herbal material was at an affordable level. 28% of participants indicated that it is cheap compared to the imported materials. The main source of information/awareness of medicinal plants was the Industrial Technology Institute followed by the Department of Ayurveda, and the electronic media. The majority of participants (52%) expressed that the government involvement in the medicinal plant industry was satisfactory. In addition, 69% of participants possessed ½ - 1 acre of land. Therefore, systematic cultivation of medicinal plants at the village level is possible as a home garden system of group of farmers. According to the results, it can be concluded that major constraints faced by stakeholders of medicinal industry are lack of a marketing channel, lack of planting materials and knowledge on cultivation and processing.

* dharmada@iti.lk

102/B

Effects of hormone on the rooting of semi hard wood, double-nodal leafy stem cuttings of *Gymnema sylvestre* (Masbedda)

K K I U Arunakumara^{1*}, U Wickramasinghe¹, B C Walpola² and S Subasinghe¹

¹Department of Crop Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

²Department of Chemistry, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

Medicinal plants have always been a part of man's life and thus conservation of rare species is of prime importance. The effects of rooting hormone, indole-3-butyric acid (IBA) on the rooting of semi hard wood, double-nodal leafy stem cuttings of *Gymnema sylvestre* were investigated in order to determine the possibility of raising plants through cuttings with or without using a rooting hormone. The cuttings were treated with hormone at four levels of 0 (T1), 10 (T2), 50 (T3), and 100 (T4) ppm. The Randomise Completely Block Design (RCBD) was used with four replicates. Assessments of percentage survival of cuttings, callused cuttings, rooted cuttings, number of roots per cutting, length of the longest root per cutting were made 75 days after the treatments. Percentage survival of the cuttings differed among the treatments, but differences were not significant ($p \leq 0.05$). Cuttings treated with 10 ppm (T2) had the highest mean percentage survival of 89%, while the lowest (86%) was recorded from the control (T1). Results showed that callusing of cutting was significantly ($p \leq 0.05$) higher in IBA treated cuttings than that of the control (T1). However, figures of percentage callusing were not significant ($p \leq 0.05$) among the different IBA levels. The highest mean percentage of callused cuttings of 82 % was recorded from T4, followed by T3 with 79 %. Results of percentage rooting showed that rooting was influenced by the IBA treatments. However, even in the control 54% cuttings had produced roots. In conclusion, better performance observed from the control in terms of survival and rooting rates compared to those treated with rooting hormones at higher concentrations, may imply that *Gymnema sylvestre* can be propagated vegetatively by means of cuttings at reduced cost.

* kkiuaruna@yahoo.com

Tel: 041-2292200

103/B

Screening of Goraka (*Garcinia quaesita* Pierre) cultivars for high yield and fruit quality

Indrani Medagoda* and P P Bandusiri

Horticultural Crop Research and Development Institute, Gannoruwa, Peradeniya

Goraka (*Garcinia quaesita* Pierre) belongs to family Clusiaceae and is a medium sized evergreen shade loving multipurpose tree species. It can be successfully grown in a wide range of soils in the wet and intermediate zones of Sri Lanka and there is a tremendous potential for introduction into home gardens as a cash crop. It also has an export potential but the demand cannot be satisfied due to lack of continuous production and poor quality of the product. There are two types of plants, male and bisexual. These cannot be identified when they are at seedling stage. Therefore, studies were carried out in the Horticultural Crop Research and Development Institute, Gannoruwa and the Horticultural Research Farm at Weerapana to develop a bisexual type of variety having high yield and quality fruits.

Exploration for goraka varieties was mainly done at Weerapana Horticultural Farm in Hambantota district during 1997-1998. Five accessions including one yellow fruited accession was collected and bud woods of these were cleft grafted on to seedlings raised from goraka seeds. The grafted plants were planted in Weerapana and Gannoruwa in the year 2000. One accession that bears fruits early in both locations was characterised and evaluated for yield and fruit quality. Fruits of this variety were also analysed for acidity and Brix.

The variety had bisexual flowers, early bearing and bushy type tree. The tree was short and small statured around 2.5 m height. It bears fruits within three years, and days to fruit maturity ranged from 100-120 days. The main flowering and fruiting periods were February-March and June- August, respectively. The average yield of five-year-old plant was 100 fruits, and dry weight of segments per tree was 500g- 750g. The fruit weight varied from 83g to 226g, and dry weight of segments varied from 8g to 26g. The colour of the fresh segments was reddish orange. The percentage of tartaric acid and Brix (dry wt. Basis) was 18.9% and 6.0 respectively. The variety was designated "Weerapana" and released by the Department of Agriculture in 2005, for cultivation in home gardens.

Tel: 081-2388011-3

104/B

Maheshi: A locally developed new tomato hybrid with high yield potential and bacterial wilt resistance

Ranjani Peiris*, T K Wickremesinghe and S P Indrasena
Horticultural Crop Research and Development Institute, Gannoruwa, Peradeniya

Tomato (*Lycopersicon esculentum* Mill) is a popular vegetable crop cultivated in Sri Lanka. Many exotic hybrids are available in the market and farmers tend to cultivate these hybrids with the intention of obtaining high yield and income. However, many farmers reported several problems in exotic hybrids. Therefore, there is an urgent need to introduce a promising local hybrid having high yield potential with bacterial wilt resistance. This study was undertaken at Horticultural Crop Research and Development Institute, Gannoruwa during the year 2000-2005. The hybrid developed from a single cross combination, was officially released as Maheshi in 2005. The hybrid Maheshi which possesses determinate plant growth type consistently gave a significantly higher yield (58 t/ha) than the tested 09 exotic hybrids and T 245 variety in replicated yield trials. Maheshi hybrid showed moderate resistance to bacterial wilt disease, and it also qualified as a variety in Distinctness, Uniformity and Stability test which is a basic requirement for varietal release. The fruits of Maheshi are red in colour and slightly flattened. The weight of a fruit is about 125 g and peel thickness is 8 mm. The hybrid Maheshi is highly preferred by the consumers.

* hordiresearch@yahoo.com

Tel: 081-2388011-3

105/B

Callus induction and plant regeneration in *Dendrocalamus giganteus* (giant bamboo)

K M M N Maddegoda and S M S D Ramanayake*
Plant Biotechnology Project, Institute of Fundamental Studies, Kandy

Dendrocalamus giganteus is a bamboo with a high potential for income generation in Sri Lanka. Tissue culture techniques have been developed for the mass propagation of the species by axillary shoot proliferation. Another method is somatic embryogenesis, where a separate step for rooting is not required. Somatic embryogenesis is not reported in this species. Encapsulation of somatic embryos to form artificial seeds could overcome the unpredictable and rare seeding in nature. Callus induction and somatic embryogenesis in this species was investigated with these objectives in view. Single shoots of 1 to 1.5 cm length from continuously proliferating in vitro axillary shoots were inoculated in a basal MS medium with 2,4-dichlorophenoxyacetic acid (2,4-D)(0, 4,12, 20,30 μ M L⁻¹) and kinetin (0, 1.25, 2.5, 5.0. μ M L⁻¹), 2g L⁻¹ phytagel and 4% sucrose with six replicate jars per treatment. A translucent soft white callus developed after three weeks, which further developed into a friable soft callus. 2,4-D was essential for callus induction and development, as callus developed in all treatments with 2,4-D but not in the control without growth regulators. When transferred to fresh medium after two months, the

friable callus proliferated and a hard creamy white callus developed after a further two months. The treatment with $20 \mu\text{M L}^{-2}$, 4-D and $2.5 \mu\text{M L}^{-1}$ kinetin gave rise to the highest percentage of hard callus. The hard callus was separated and cultured in medium with lower levels of 2,4-D ($2, 4 \mu\text{M L}^{-1}$) and kinetin ($2.5 \mu\text{M L}^{-1}$) or without growth regulators. After a week friable hard globular structures that resembled somatic embryos developed in all these. Shoots and roots regenerated after a month from the globular structures. On exposure to light, the globular structures turned green. Plantlets developed further on exposure to light. Thus, it was not necessary to have a separate rooting step as required during axillary shoot proliferation for producing plants. However, further studies on verification of somatic embryogenesis and scaling up the different stages are required for application of this method for commercial production.

* shantha@ifs.ac.lk

Tel: 081-2232002

106/B

Heat ratio method to measure sap flow in palm trees

W S Madurapperuma*

Plant Physiology Division, Coconut Research Institute, Lunuwila

A reliable tool to measure water use in palm trees is needed for the management of palm crops. Thermometric sap flow methods are preferred because they hold many advantages over other direct estimates of transpiration. Countless studies have shown that thermometric methods are extremely useful for studies of whole plant water use, physiology, water stress, water use efficiency etc. Despite all these applications, thermometric sap flow methods remain largely unproven in monocots including many species of palms. Hence, the objective of this experiment was to evaluate the suitability of Heat Ratio Method (HRM) in order to study the whole plant water use by comparing water use measurements using a gravimetric weighing lysimeter.

The experiment was conducted under ambient condition in a glass house and the measurements were made on five-year-old potted cocopalms (*Syagrus romazoffiana*), which was placed on a lysimeter. Heat pulse velocity and the gravimetric water loss were recorded at 10 minutes intervals and pooled to calculate at hourly intervals.

The hourly sap flow measured by HRM corresponded closely to that measured gravimetrically by the lysimeter ($r^2 = 0.84$; $p > 0.0001$; Figure 3-a). The daily average water loss measured by the gravimetric method showed much better correlation with daily average thermometric sap flow measurements ($r^2 = 0.91$; $p > 0.0001$). Daily average sap flow measured by HRM showed a response to drying and wetting cycles imposed during the experimental period. Younger fronds seemed to have a higher demand for water than mature fronds and all four fronds showed a similar pattern of sap flow despite the rates being different among fronds. Results indicated that HRM method could be used to measure the sap flow in palms.

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* ppd@cri.lk

Tel: 031-2255300

107/B

Pedigree-based genetic diversity estimates of parental lines and recommended tea (*Camellia sinensis* L.) cultivars in Sri Lanka

H A C K Ariyaratne*, K K Ranaweera and M T K Gunasekare
Division of Plant Breeding, Tea Research Institute of Sri Lanka, Talawakelle

Crop genetic uniformity is today a main concern of plant breeders. Although detail pedigree information is available for recommended cultivars of tea in Sri Lanka, that information was not utilised for analysing genetic diversity in tea. Coefficient of parentage (COP) is a realistic estimate of diversity based on pedigree information. The objectives of this study were to quantify the level of genetic diversity/similarity among the tea cultivars recommended by the Tea Research Institute of Sri Lanka, with the aim of identifying material that contributed most to the present cultivated gene pool as well as to assign genotypes into groups of genetic similarity. In the present study, fifty-seven cultivars, including their parental lines were analysed based on pedigree information and COP.

COP values estimated for pair-wise combinations of the 57 cultivars ranged from 0.00 to 0.75 with a group mean COP of 0.097 (COD, Coefficient of diversity: 0.903). Yet parental lines ASM 4/10 and CY 9 contributed most to the present gene pool, while the contribution by the other six parental lines (N2, DT 95, TRI 777, DN, DT1 and NAY 3) were marginal, suggesting that the present recommended cultivars is constituted by a restricted and mainly the adapted germplasm as ancestral genotypes.

Among the pair wise relationships computed, 31.09% had 0.00 COP suggesting that there is more potential to be tapped in future breeding programmes. Group mean COP of the different TRI cultivar series (TRI 2000 series: 0.18; TRI 3000 series: 0.08; TRI 4000 series: 0.11) further indicate restricted utilisation of the genetic resources in tea breeding programmes conducted in the past.

Identifying genealogically similar groups and estimations of genetic diversity within and among the groups as revealed in this study are of immense value in developing effective breeding strategies in future programmes.

* ckariyaratna@yahoo.com

Tel: 051-2222601

108/B

Genotype environment interaction as a tool for screening drought tolerance in coconut (*Cocos nucifera* L.)

W G D Lakmini^{1*}, N P A D Nainanayake² and W A J M De Costa³
¹*Department of Crop Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya*

²*Plant Physiology Division, Coconut Research Institute of Sri Lanka, Lunuwila*

³Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Peradeniya

The genotype environment interaction (G×E) derived from gas exchange measurements of four coconut genotypes (the accession Clovis [CL] is believed to be tolerant to drought while the rest, Dwarf Green [DG], Dwarf Brown [DB] and Cameron Red Dwarf [CRD] are sensitive) subjected to 80 day natural drought in early 2005 was studied to examine the potential for using G×E as a tool of screening for drought tolerance in coconut. All palms were about 15 years of age and in adjacent plots at the Potthkkulama Research Station, Pallama in IL₁ Agro-Ecological Region (Aquic Quartzipsamments) and under general management practices recommended by Coconut Research Institute. Eight adjacent palms from each of four genotypes were selected from experimental plots arranged in Completely Randomised Design. Stomatal conductance (g_s), rate of photosynthesis (A), and transpiration (E), were measured during the drought period along with the corresponding soil moisture contents (θ).

More conspicuous varietal differences were shown by the G×E derived from A and instantaneous water use efficiency (A/E). According to the G×E derived from A , CL and DG showed above average stability and CRD and DB had below average stability over the range of θ environments. Genotypic differences with A/E also identified CL , as a more stable genotype while DG , DB and CRD were grouped together with only minor differences. These four genotypes can be ranked in terms of the degree of drought tolerance based on G×E as $CL > DG > CRD > DB$. These results were consistent with earlier findings and thus, the method appears as a promising tool that can be used in screening coconut genotypes for drought tolerance. However additional research is needed to use this screening tool for drought tolerance in coconut. In particular, further research under longer dry spells is needed to reach a more comprehensive and repeatable results before the application of these findings for practical purposes.

* lakmini077@yahoo.com

Tel: 041-2292200

109/B

The effect of plant density on growth and yield of Citronella cv. [*Cymbopogon nardus* (L) Rendle]

K G G Wijesinghe and K P C K Kumara*

Cinnamon Research Station, Department of Export Agriculture, Palolpitiya, Thihagoda

This study was conducted at the Farmer's field at Katuwana in Hambantota district during the year 2003-2006 to investigate the different plant density levels of "Heen Pengiri" (*Cymbopogon nardus*) in relation to their growth and yield. Five different spacing levels $1' \times 1'$, $1' \times 1 \frac{1}{2}'$, $1 \frac{1}{2}' \times 1 \frac{1}{2}'$, $1 \frac{1}{2}' \times 2'$, and $2' \times 2'$ with three suckers per a planting point were tested using Randomised Complete Block Design with three replicates. During the three year period, nine harvests were collected and recorded data were taken on plant height (cm), number of shoots per planting point, wet grass yield (kg/ha), oil percentage and oil yield (kg/ha).

According to the results on data of growth parameters and yield, wider spacing of $2' \times 2'$ with three suckers per point gave significantly higher plant height (103.0 mm) followed

by medium spacing level of 1 1/2' × 1 1/2' (100.60 cm) while wider spacing level of 2' × 2' also had significantly more number of shoots (60.0, 79.8 and 85.6) during the first three years, respectively. Due to a lesser number of planting points in a unit area, a low oil yield was recorded. Therefore, highest average oil yield (367.96 kg/ha/yr) was obtained by medium spacing level 1 1/2' × 1 1/2' followed by 1' × 1 1/2' (352.88 kg/ ha/ yr).

With regard to the overall performances of growth characters and yield, high leaf oil content can be obtained from medium level of spacing of 1 1/2' × 1 1/2' with three suckers in a point for "Heen pengiri".

* cinrs@sltnet.lk

Tel: 041-5673931

110/B

Correlation of some pod and bean characters in cocoa (*Theobroma cacao*.L) *Trinitario* and estimation of pod yield

A Raveendran* and H A Sumanasena
Research Station, Department of Export Agriculture, Matale

Cocoa (*Theobroma cacao*.L) is one of the important export agricultural crops and the export volume seems to be decreased from 3000 MT in 1950's to 1100 MT in 2003 (Anon, 2003). Therefore, research on plant genetic improvement of cocoa would be a very important area to improve the production. The variability in characters attributed to the yield in present population of cocoa is ascribed to regular cross pollination and several re-introductions of cocoa genetic resources into Sri Lanka. As a part of a characterisation study on available cocoa germplasm, a correlation study was made using important bean and pod characters of cocoa. The study was conducted using randomly selected pods from twenty five year old *Trinitario* type cocoa trees in the germplasm nursery and in the field blocks at Research Centre, Matale. According to the correlation studies, the characters such as pod length, weight of beans with pulp and weight of beans without pulp seem to be important yield contributing characters in cocoa. Finally, following stepwise regression equation was derived to show the correlation among the important characters.

$$* Y = 0.6408 L - 1.1155 D + 0.1144 W + 0.3842 B + 2.2537 C - 3.3218$$

This implies that the above yield components can be considered as important characters in cocoa mother plant selection programme, leading to a reduction in the workload. Estimated yield would be more beneficial for selection of mother plants from cultivations in remote areas than the final harvest since the latter may not be possible due to squirrel damage or theft problem.

*Y = Bean weight per pod (g), L = Pod length (cm), D = Pod diameter (cm), W = Weight of beans with pulp (g)
B = Weight of beans without pulp(g), C = Cotyledon weight (g)

111/B

Leaf litter decomposition and carbon dioxide evolution of some potential agroforestry species in southern Sri Lanka

M K T K Amarasinghe*

Faculty of Agriculture, University of Ruhuna, Kamburupitiya

Decomposition of leaf litter of six agroforestry species, namely, *Gliricidia sepium*, *Macaranga peltata* (kande), *Alstonia macrophylla* (hawari nuga), *Artocarpus heterophyllus* (jak fruit), *Terminalia catappa* (Indian almond) and *Mangifera indica* (mango) was studied using the litter bag technique, and carbon dioxide evolution from leaf litter was determined under laboratory condition by soil respirometry at the Faculty of Agriculture, Mapalana, Sri Lanka. All the experiments were arranged in a Randomised Complete Block Design with five replicates.

Considerable inter specific variations in decomposition and carbon dioxide evolution from leaf litter were evident among the litter types ($p < 0.05$). *G. sepium* showed the greatest mass loss, losing 60% of its initial dry weight by 30 days. On the other hand, *M. indica* was the slowest to decompose. It showed a remarkable resistance to decomposition and maintained over 50% of its mass up to five months. Decomposition rate of leaf litter was highest in *G. sepium* followed by *A. heterophyllus*, *T. catappa*, *A. macrophylla*, *M. peltata* and *M. indica*.

Carbon dioxide evolution for all the species was significantly greater during the first week ($p < 0.01$). The peak carbon dioxide release was observed after 1 week in *G. sepium*, 2 weeks in *A. macrophylla*, *M. peltata*, *A. heterophyllus* and *M. indica* and 3 weeks in *T. catappa*. Thereafter, carbon dioxide release showed a downward trend over time. The highest amount of carbon dioxide was released by *A. macrophylla* ($0.5023 \text{ mg CO}_2 \text{ g}^{-1} \text{ litter h}^{-1}$) where as the lowest was by *M. indica* ($0.1703 \text{ mg CO}_2 \text{ g}^{-1} \text{ litter h}^{-1}$). Unlike in the other species, a clear peak in carbon dioxide evolution was not evident in *M. indica* and its rate of carbon dioxide evolution remained almost constant for 14 to 28 days of incubation which was unique to this species.

* mktkamarasinghe@yahoo.com

Tel: 041-2292200

112/B

Properties and availability of cinnamon fuel wood in the Matara district

I R Palihakkara*, M K T K Amarasinghe and M de S Liyanagae

Department of Crop Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

Energy has become a crucial issue in both domestic and industrial sectors in Sri Lanka. Biomass energy, particularly fuel wood is the most extensively used source of energy and nearly 70% of country's biomass energy requirement is obtained by none forest tree

sector. True cinnamon, (*Cinnamomum verum*) offers one of the popular energy options in cinnamon growing areas in Sri Lanka. Although there is a great interest on cinnamon as an export agriculture crop, little attention is paid on fuel wood value of cinnamon. Hence a scientific study was carried out with a field survey (40 growers) to identify the properties and availability of cinnamon fuel wood in Matara District. Results were statistically analyzed and it showed that cinnamon land has a higher potential of supplying good quality fuel wood. Fuel wood yield obtained by 1 ha of cinnamon land is varying with management condition of the land. Under poor, average and good management conditions 1 ha of cinnamon land offers 7.04 m³/year (2.89 t), 16.2304 m³/year (6.65 t) and 28.16m³/year (11.55 t) of fuel wood yield respectively. The average fuel wood production of 1 ha land in Matara district in year 2003 was 9.06m³ (2.89 t). Income obtained by selling fuel wood was 5% of the total income of cinnamon land. Average wood: bark ratio was 8.14 and that value varies with stem diameter. Number and weight of sticks per cubic meter were 750 and 410 kg respectively. Average length, weight and price of one cinnamon wood stick were 1.5 m, 825 g and Rs.1.00 respectively. Cinnamon fuel wood has a higher calorific value (4900 kcal/kg) and very low ash content of 0.86%. Therefore cinnamon demonstrated a very high potential for use as renewable energy source.

* mdika@crop.ruh.ac.lk

Tel : 041-2292200

113/B

***In vitro* evaluation of selected fungicides against *Sclerotium rolfsii*,
causal organism of stem and pod rot of groundnut**

W A R T Wickramaarachchi*

*Regional Agricultural Research & Development Center, Department of Agriculture,
Aralaganwila*

Efficacy of several fungicides namely thiophanate methyl 50% + thiram 30% WP (Homai), thiophanate methyl 70% WP (Topsin M 70), tebuconazole 250 g/l EW (Folicur EW 250), carbendazim (Bavistin SL), tricyclazole (Sivic), copper 50% WP (Kocide 101) and pyraclostrobin 250 g/l EC (F 500) was tested *in vitro* against *Sclerotium rolfsii* Sacc., causal organism of stem and pod rot of groundnut based on the percent inhibition of mycelial growth on fungicide amended agar medium using poison food technique. Thiophante methyl+thiram, tebuconazole and pyraclostrobin totally inhibited *Sclerotium rolfsii* at 40 g/10 l, 18 ml/10 l and 8 ml/10 l respectively showing higher efficacy. Carbendazim at 11 ml/10 l, tricyclazole 6 g/10 l, thiophanate methyl at 16 g/10 l and copper 40 g/10 l were found to be less effective. Efficacy of thiophante methyl+thiram was adversely affected upon dilution of the fungicide. Thus diluted dosages of thiophante methyl+thiram (20 g/ 10 l and 10 g/ 10 l) were not much effective for the management of *Sclerotium rolfsii* while the dosage of 40 g/10 l showed total effectiveness. Lower dosages of tebuconazole were as effective as the highest dosage (18 ml/10 l) tested indicating the possibility of use of lower dosages (4.5 ml/10 l and 9 ml/10 l) with total effectiveness under *in vitro* conditions. Lower dosages of pyraclostrobin (4 ml/ 10l and 2 ml/ 10l) showed over 95% inhibition of the pathogen. Tebuconazole at 4.5 ml/10 l, pyraclostrobin at 2 ml/10 l and thiophante methyl+thiram at 40 g/10 l are the lowest dosages found effective against *S. rolfsii* and recommended for testing at field level against the stem and pod rot of groundnut.

* wartwa@gmail.com

Tel: 060-2279699

114/B

Determination of susceptible age/stage of seedlings, leaves and fruits of papaya to anthracnose disease caused by *Colletotrichum gloeosporioides* (Penz.) Penz. and Sacc

K L Wasantha Kumara*

Department of Agricultural Biology, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

Papaya fruits and leaves representing four developmental stages ($\frac{1}{4}$ normal size, $\frac{1}{2}$ normal size, $\frac{3}{4}$ normal size, and normal size or fully matured leaf/fruit size) were spot inoculated with 10^6 spores/ml spore suspension of *Colletotrichum gloeosporioides* isolated from papaya, to determine the susceptible stage of the fruit and leaf to the pathogen. Disease development at seven days after the spot inoculation was recorded as lesion size and percentage of fruits/leaves infected. Ten papaya seedlings of different ages were also inoculated with 10^6 spores/ml spore suspension of *C. gloeosporioides* by carefully spraying over the seedlings to study the seedling susceptibility to the disease. Per cent seedlings with anthracnose symptoms were recorded.

Fruits at all test stages developed characteristic anthracnose lesions. Disease incidence and the size of the lesions of fully matured and $\frac{3}{4}$ normal size fruits were significantly ($P=0.01$) high compared to less developed fruits. All inoculated leaves showed anthracnose symptoms. Disease incidence of $\frac{1}{4}$ normal size and $\frac{1}{2}$ normal size was found to be significantly ($P= 0. 01$) higher than the normal size leaf. The $\frac{1}{4}$ normal size leaves had significantly higher lesion size compared to the rest of the leaves representing different developmental stages. Susceptibility of seedlings to *C. gloeosporioides* was noticed only up to the tenth week after the seed germination. Seedlings at first and second week after the seed germination found highly susceptible for the pathogen.

* wasantha@agbio.ruh.ac.lk

Tel: 041-2292200

115/B

Control of *Aspergillus* rot in wood-apple (*Ferronia acidissima*)

R M R N K Ratnayake*, H J Sumithra, M D Fernando and K B Palipane
Institute of Post Harvest Technology, Jayanthi Mawatha, Anuradhapura

Wood apple (*Ferronia acidissima*) that belongs to family Rutaceae is a nutrient rich underutilised fruit crop in tropical countries. In Sri Lanka, *Aspergillus* rot is a major post harvest problem in wood apple. However, the species level of the pathogen has not been identified yet.

In this study, the Pathogen of wood-apple rot was identified up to the species level using the description of International Mycological Institute (IMI). Effect of four Generally Recommended As Safe (GRAS) compounds; sodium bicarbonate, calcium chloride, citric acid and sodium benzoate on the control of the *Aspergillus* rot, was evaluated under *in vitro* and *in vivo* conditions. Under *in vitro* conditions, effect of those compounds on the growth of mycelium was investigated and the most effective compound was used

for the *in vivo* experiments. In the *in vivo* experiments, healthy, mature wood-apple fruits were subjected to different treatments; 1) Stem scar of the fruits were inoculated with 10µl of the conidial suspension and allowed to air dry, and they were treated with different concentrations of the selected GRAS compound. 2) Fruits were treated with different concentrations of the selected GRAS compound followed by the inoculation with the conidial suspension 3) fruits were treated with that compound without inoculation. Fruits, with and without inoculation prior to the application with distilled water and also non-treated, non- inoculated fruits were used as controls.

Results revealed that *Aspergillus niger* was the causative agent of the wood-apple rot. Under *in vitro* condition sodium bicarbonate (SBC) inhibited the growth of the pathogen by 100% at the concentration of 4%. In the *in vivo* experiments, wood-apple fruit inoculated with the pathogen followed by the treatment of 4% SBC aqueous solutions gave 53.6 % control of the disease, whereas fruits treated with SBC followed by inoculation have shown 98.4 % disease control. Non-treated, non-inoculated fruits and the fruits treated with distilled water were diseased completely after three days. Fruits treated with 4% SBC without inoculation gave 100% control of *Aspergillus* rot and the storage life of the fruits were extended up to 23 days at ambient conditions (28 °C±2 & 85-90% Relative humidity). No sign or symptom development was observed during the storage to confer them a 100% marketable value.

In conclusion, post harvest treatment of wood-apple fruits with 4% sodium bicarbonate can be used to control the infections of *Aspergillus niger*.

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* rratnayake@hotmail.com

Tel: 025-2225765

116/B

Identification of two new species of the Genus *Phytophthora* causing black pod disease of cocoa, (*Theobroma cacao* L.) in Sri Lanka and a possible non-chemical method of its control

Y S P Kumari¹ and D P P de Silva^{2*}

¹ Faculty of Agriculture, University of Ruhuna, Kamburupitiya

² Plant Pathology Division, Export Agriculture Research Station, Matale

Different *Phytophthora* species were isolated from infected black pods obtained from the fields of Export Agriculture Research station, Matale and Millawana estate, Melsiripura.

Microscopic observations of pure cultures of the isolated fungi consisted of three different species and were identified and categorised according to l/b ratio and stalk length of sporangium. They were *P. palmivora*, *P. megakarya* and *P. capsici*. *Phytophthora* isolates from both locations had different percentages of above three species; highest populations of *P. palmivora* and *P. megakarya* were found in Millawana and Matale isolates respectively. In both the locations *P. capsici* showed lowest percentages. However, Millawana and Matale isolates consisted of 25% and 10% of *P. capsici* respectively.

Fungal isolates examined consisted of sporangium with different sizes, shapes and stalk lengths. Different l/b ratios and stalk lengths confirmed the presence of different spp. of *Phytophthora*. Sporangia with l/b ratios ranging from 1.2 – 1.8µm and stalk lengths 2 – 5µm were identified as *P. palmivora* (MF-1) and sporangia with l/b ratios ranging from 1.2 – 1.6µm and stalk lengths ranging from 10 – 30µm were identified as *P. megakarya* (MF-3). Sporangia which had l/b ratios in between 1.6 – 2.0µm and stalk lengths ranging from 20 – 15µm were identified as *P. capsici* (MF-4). Besides, the *in vitro* experiments conducted with the extracts of mature *Adathoda vasica* leaves in the culture medium showed suppression of mycelia growth. Culture media prepared with either 4% (v/v) or higher concentrations of *A. vasica* leaves suppressed the growth of *Phytophthora* mycelia. This indicates the possibilities of using *Adathoda* in black pod disease control. However more research has to be carried out on *Adathoda* extracts before application of this finding in controlling black pod disease.

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* pdmndesilva@yahoo.com

Tel: 066-2222822

117/B

Potential use of *Beauveria bassiana* (Balsamo) Vuillemin for the control of pepper lace bug *Diconocoris distanti* (Drake)

M Dharmadasa^{1*}, D P P de Silva and T Nagalingam
Research Station, Department of Export Agriculture, Matale

Black pepper, *Piper nigrum* L. is cultivated in about 32,000 ha in Sri Lanka and earns about Rs. 1,234 mn annually. The average yield of pepper in Sri Lanka is about 240kg/ha which is very low when compared to the yield of other pepper growing countries, where one of the problems is pests and diseases prevailing in the cultivations. Pepper lacebug, *Diconocoris distanti* is the major pest in Sri Lanka that causes 15-20% yield loss. Use of insecticides for control of this pest is not advisable because pepper is mainly for the export market. Use of entomopathogenic fungi for control of this pest would be one of the solutions to overcome this problem.

Beauveria bassiana is one of the most intensively studied entomopathogenic fungi that shows pathogenicity in about 700 species of insects worldwide. Hence, it was decided to investigate the pathogenicity of locally isolated *B. bassiana* on pepper lacebug. It was isolated from the field collected infected coffee berry borer (*Hypothenemus hampei*) and cultured in potato dextrose agar (PDA) media. Different concentrations of conidia suspensions of fungi were tested against field collected pepper lace bug adults under the laboratory environment to investigate the pathogenicity. The fungal isolate tested showed greater mortality with mycosis among lace bugs. Estimated LC₅₀ value was 1.3x10⁸ (95% confidence interval, 8.9x10⁷ to 2.2x10⁸), for the adult lacebug and the estimated LT₅₀ value was 3.5 days. These data suggest a high potential for using *B. bassiana* in the management of *D. distanti* in pepper cultivations.

* maduradh@yahoo.com

Tel: 066-2231249

118/B

**Identification of storage insect pests of cocoa (*Theobroma cacao* L.)
and use of plant materials for their management**

S I C Silva*

Research Station, Department of Export Agriculture, Matale

Infestation due to storage pests in processed cacao (*Theobroma cacao* L.) beans is very fast and affects drastically the quality and quantity of the product. Insecticides to prevent the post harvest losses during storage are hardly used as cocoa beans are taken to make secondary products viz; chocolates. Plant materials may contain volatile compounds, non-volatile compounds and oils which could be used to kill or repel the insect pests. These plant materials are low cost, biodegradable, safe and environmentally friendly.

This study was conducted under laboratory conditions and used Completely Randomised Design (CRD) with four replicates using leaves of Maduruthala (*Ocimum sanctum*), Heen Pangiri (*Cymbopogon nardus*), Maha Pangiri (*Cymbopogon winterianus*), Citrus sp, Neem (*Azadirachta indica*), Cinnamon (*Cinnamomum verum*), Black Pepper (*Piper nigrum*) and dried roots of Vetiver (*Vetiveria zizanioides*) as treatments. Five grams of dried plant materials were added to each 500g of cocoa bean samples and compared with a control without any plant materials. Undamaged cocoa bean percentages were recorded weekly and the emergence of insect pests during 147 days of the whole stored period was observed.

Araecerus fasciculatus (Coleoptera: Anthribidae), *Ephestia elutella* (Lepidoptera: Pyralidae), *Tribolium* sp. (Coleoptera: Tenebrionidae) and one unidentified Coleopteran insect species were observed in stored cocoa bean samples. Results revealed that cocoa beans can be stored without significant pest damage by adding 1% dried leaves of Maduruthala (*Ocimum sanctum*), Heen Pangiri (*Cymbopogon nardus*), Maha Pangiri (*Cymbopogon winterianus*) and Black Pepper (*Piper nigrum*) up to a period of two weeks. But both Maduruthala (*Ocimum sanctum*) and Black Pepper (*Piper nigrum*) treatments significantly reduced the damage percentage up to two and half months compared to the control and other treatments.

* sadrmt@slt.net.lk

Tel: 066-2231249

119/B

Parasitoids of melon flies infesting *Trichosanthes anguina* (snake gourd)

A G S Sammani* and D Ahangama

Faculty of Agriculture, University of Peradeniya, Peradeniya

Cucurbits grown as vegetables are damaged by melon flies causing economic losses prompting farmers to resort to heavy insecticide applications. A few efforts have been made for biological control of the pest by early attempts of importation and release of two pupal parasitoids, *Spalangia* sp. and *Dirhinus auratus* Ashmead from India in 1936.

As the knowledge base on natural enemies of pests of vegetables in the island is not complete, a field survey was carried out to identify the natural enemies of melon flies infesting snake gourd, *Trichosanthes anguina* around Kandy. Samples of snake gourd fruits infested with melon flies and samples of soil from infected snake gourd fields were collected from farmers fields in Kapuliadda, Kandy District and were kept in rearing cages in the laboratory for the emergence of melon flies and parasitoids. Adult melon flies and parasitoids emerged were preserved as dry mounts and were identified using taxonomic keys and reference insect collection maintained at Horticultural Research and Development Institute, Gannoruwa.

Two melon fly species, *Bactrocera cucurbitae* Coquillett (Diptera: Tephritidae) and *B. near tau* (Diptera: Tephritidae) were found infesting snake gourd pods in this study. According to available literature, *B. near tau* is reported only from fruit species and not from cucurbits. Two larval parasitoids, *Psytalia fletcheri* (Silvestri) (Hymenoptera: Braconidae) and *Diachasmimorpha* sp. and the pupal parasitoid, *Spalangia* sp. were found parasitising melon fly species. Out of these three parasitoids, *Spalangia* sp. is an exotic parasite imported and released in 1936 and these results indicate the successful colonisation of the exotic parasitoid species in Sri Lanka.

Tel: 081-2380123

120/B

Estimation of weed seeds associated with consumable seeds

K K S D Pradeepika^{*}, M Rambukkana and D P P Jayakody
National Plant Quarantine Service, Katunayake

As there is a risk of entering alien invasive type plant species into Sri Lanka, an investigation was initiated to find out the weed seeds associated with imported consumable seeds. Three composite samples of each of Coriander (*Coriandrum sativum*), Cumin (*Cuminum cyminum*), Fenugreek (*Trigonella foenum-graecum*) and Mustard (*Brassica juncea*) were taken from different wholesale centers at Petta, Colombo during March 2006. Weed seeds were separated manually observing under illuminated magnifier and were identified observing under stereoscopic microscope using seed identification manuals and reference collections. Except Fenugreek seeds, other three were contaminated with a large number of weeds/unit weight. The highest number of weed seeds (4218/kg) was found with Cumin seeds. Seeds of Mustard and Coriander were contaminated with 1688 and 612 weed seeds per unit weight respectively. Cumin and Coriander seeds were contaminated with a considerable amount of seeds of *Cuscuta* species which are total parasitic and *Convolvulus arvensis* and *Rumex crispus* which have been identified as noxious weeds. *Chenopodium album* and *Sorghum halepense* which have been classified as world's worst weeds were found with Mustard and Coriander seeds respectively. Most of the *Polygonum* species are invasive weeds and seeds of *Polygonum* species were found with Coriander, Cumin and Mustard seeds. Seeds of *Papaver* and *Bromus* species were found with Cumin seeds and seeds of *Physalis* species were found with Mustard seeds. Some of the species of *Papaver*, *Bromus* and *Physalis* are noxious weeds. A large number of seeds of wild species of *Brassica* was found with Cumin seeds. Therefore, entering of such weeds to Sri Lanka through seeds should be minimised or stopped by introducing a proper purification procedure for consumable seeds.

121/B

Soil nutrient status of pepper growing soils in Kegalle

P R Idamekorala^{1*}, W D L Gunaratne² and H D A K Gunaratne¹

¹ *Research Station, Department of Export Agriculture, Matale*

² *Department of Export Agriculture, Peradeniya*

Pepper is the most widely used spice all over the world. In Sri Lanka, pepper is cultivated over an area of 31300 ha and Kegalle is one of the major pepper growing districts in the island with a pepper extent around 3878 ha.

National productivity of pepper is about 300 kg/ha/year but the potential yield would be over 1000 kg/ha/year. The major reason for low yields is the negligence of soil fertility management. The objective of this study was to determine the soil nutrient status of some selected pepper growing areas in Kegalle district in order to recommend a site specific fertilizer. The locations were selected based on the extent of pepper cultivation of the three agro ecological zones namely, WL2b WM2b and WL1a. Ten soil samples were randomly collected at the depth of 0- 20cm from each site.

The soil samples were analysed for pH, organic matter, total N, available P, exchangeable K, and Mg. The soil pH of WL2b (5.63) and WM2b (5.83) are favorable for black pepper. But it is very low in WL1a (4.26). It can be expected that basic cations leach down due to high rainfall and increase the soil acidity. Application of dolomite is suggested to adjust the pH to required level in WL1a.

In WL2b, exchangeable Mg content is sufficient for pepper cultivation and exchangeable K content is moderately sufficient. But in WM2b and WL1a both exchangeable Mg and K contents are not adequate for pepper cultivation. Therefore, farmers are encouraged to apply inorganic fertilizer based on the soil analysis. Organic matter content in both WM2b and WL2b is not sufficient for pepper. Therefore, the nutrient and moisture retention is low in this soil. To correct this situation, application of green manure is recommended. However organic carbon in WL1a is found to be favorable. This is due to high rainfall and low environmental temperature that cause reduction of microbial activity which leads to accumulation of organic matter. Due to high organic carbon in WL1a, average total N content has increased (0.29%). In the other two sites, it is only 0.21%. Inadequate P content is a common factor for the entire district. Therefore, application of inorganic P fertilizer is recommended.

* prasadri@yahoo.com

123/B

Influence of the herbicide glyphosate on soil microbial biomass carbon as affected by the rate of application

B C Walpola^{1*}, S D Wanniarachchi¹ and J A Liyanage²

¹*Department of Soil Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya*

²*Department of Chemistry, Faculty of Science, University of Kelaniya, Kelaniya*

A laboratory study was conducted at the Faculty of Agriculture, University of Ruhuna in order to assess the effect of glyphosate on soil microbial biomass carbon. The experiment was set according to Completely Randomised Design (CRD) with four replicates. Soil belongs to Red Yellow Podzolic great soil group collected from Matara district was treated with glyphosate at the rate of 0.3546, 3.546 and 35.46 $\mu\text{g/g}$ soil, corresponding to field rate (C1), 10 times (C2) and 100 times (C3) of the field rate. Untreated control (without glyphosate) was also included. Determination of soil microbial biomass carbon was carried out at 1, 3, 5, 7, 14, 21, 35 and 56 days after herbicide application.

No significant ($p \leq 0.05$) differences of soil microbial biomass carbon contents were found between the glyphosate treatment of 0.3546 $\mu\text{g/g}$ soil (field rate) and the control throughout the incubation period. However, when the application rates were increased up to 3.546 $\mu\text{g/g}$ soil (10 times) and 35.46 $\mu\text{g/g}$ soil (100 times), soil microbial biomass carbon content were decreased significantly ($p \leq 0.05$), compared to that of the control, in particular during the first 10 days of incubation.

The highest reduction (43 %) of the soil microbial biomass carbon was observed at the application rate of 35.46 $\mu\text{g/g}$ soil. But the maximum reductions were only 27 % and 7 % for the application rates of 3.546 $\mu\text{g/g}$ soil and 0.3546 $\mu\text{g/g}$ soil, respectively. Glyphosate is tightly adsorbed to the soil particles when it is applied to the soil and it gradually breaks down by microbes. Therefore, it inactivates in the soil solution. This might be the reason for no significance at lower level of glyphosate and not affecting 10 days after application even with higher dosages (100 times)

* buddhiwalpola@yahoo.com

Tel: 041-2292200

124/B

Impact of long term application of straw alone and in combination with inorganic fertilizers on organic matter levels in rice soils of low country intermediate zone of Sri Lanka

D P P Jayakody^{1*} and W K Hirimburegama²

¹*National plant Quarantine Service, Department of Agricultura, Canada Friendship Road, Katunayaka*

²*Faculty of Plant Science, University of Colombo, Colombo 3*

Long term effect of application of rice straw and inorganic fertilizer in different combinations on the improvement of organic matter level in rice soils of Low Country Intermediate Zone was investigated. Treatments used in the experiment were straw 2t /ha with inorganic fertilizer, straw 3t /ha with inorganic fertilizer, straw 2t / ha alone, straw 3t / ha alone, recommended inorganic fertilizer only and the control (no straw, no inorganic fertilizer). Statistical design used in the experiment was Randomised complete Block Design with nested treatment arrangements. A field trial was conducted over 8 cultivation seasons at the Regional Agricultural Research Centre, Makandura, and the last two seasons (*Maha* 1998/99 and *Yala* 1999) were selected for the present study. Rice variety Bg 94-1 (3.5 months) was cultivated and standard cultivation practices were followed avoiding the application of pesticides as much as possible. The soil samples were taken at 1, 2 and 3 months after sowing at 0 -2, 2 – 4, 4 – 8 and 8 – 12 cm depths from the soil surface. Soil samples were stored according to the standard procedures. Results showed that, irrespective of the treatment or season, organic matter levels of surface soil layer were significantly ($p=0.05$) decreased with the soil depth. Straw amended treatments, straw 2t /ha with inorganic fertilizer, straw 3t /ha with inorganic fertilizer, straw 2t /ha and straw 3t /ha showed significantly increased organic matter percentages of 1.81, 1.94, 2.03 and 2.10 respectively than organic matter percentages of 1.50 and 1.32 of inorganic fertilizer alone and the control respectively in *Maha* 1998/1999. In *Yala* 1999, straw amended treatments, straw 2t /ha with inorganic fertilizer, straw 3t /ha with inorganic fertilizer, straw 2t /ha and straw 3t /ha showed significantly increased organic matter percentages of 1.57, 1.65, 1.78 and 1.90 respectively than organic matter percentages of 1.18 and 0.87 of inorganic fertilizer alone and the control respectively. Generally, straw amended treatments considerably improved the soil organic matter percentage over no straw treatments, after long-term application of straw in different combinations.

Tel: 011-2252028

125/B

Estimation of dependable monthly rainfall from monthly average rainfall in southern region of Sri Lanka

D G I S Ariyatilaka*

Central Research Station, Department of Export Agriculture, Matale

Probability values of rainfall are essential in hydropower projects, for Planning of Agricultural activities. However, daily to monthly rainfall values for individual years are meager, particularly in dry zone of Sri Lanka.

A model was developed to use available monthly average rainfall values to calculate monthly dependable rainfall values in selected fifteen rain gauge stations in southern dry zone of Sri Lanka. First, the average monthly rainfall values and dependable monthly rainfall values were obtained for twelve months in selected rain gauge stations. Then, the coefficients of the simple linear association between monthly average rainfall and monthly dependable rainfall were calculated by fitting a simple linear trend line to the two data sets of the twelve months. The model directly gives the dependable rainfall value of a respective month when average monthly rainfall value is given.

Applied pesticides of MCPA, Propanil, Diazinon, Carbofuran, Dimethoate, Chlorpyrifos, Oxyfluorfen, 2,4 D and Fenthion did not reach to shallow boundary wells, depth (0.4–3 m), water consumption (1-2 m³), located 1 to 3 m distance from treated paddy fields.

Residues of Chlorpyrifos, Dimethoate, Propanil, MCPA and 2.4D were detected in Field samples but residue levels of these 5 pesticides were below detection levels at first dilution points within 100 m distance.

Even in KW and MW which are fed by agricultural drainage, no pesticide residues were detected in water under present pesticide application rates. Changes of pesticide load, distribution of application time of pesticides, photo degradation, chemical degradation, and microbial degradation may cause these low values. However, further studies are required to understand the behavior of pesticides in this environment.

* dir_ceo@iti.lk

Tel: 011-2674461

127/B

Mapping the risk of the use of carbofuran in the wet zone in Sri Lanka

Ransilu C Watawala, Janitha A Liyanage* and Ananda P Mallawatantri
Department of Chemistry, University of Kelaniya, Kelaniya

Pesticides play an important role in global agriculture. However, potential adverse impacts of the use of pesticides on ecosystem and human health continue to be a cause for concern in Sri Lanka. The agriculture system, therefore, needs to minimise the usage and develop a better understanding of the management of pesticides applications. Pesticides residues, fate and other type of analysis are highly expensive and time consuming. Therefore, modeling strategic innovation can play a great role for a better understanding of pesticides practices.

Pesticides Impact Rating Index (PIRI) is one of the best management models. It can be used to rank the pesticides according to their relative pollution and to compare different practices, and land use at regional scale. In this study, PIRI was used to rank the pesticides according their risk levels in various soil types in the wet zone in Sri Lanka and the risk was mapped according to their relative potentials.

PIRI needs some data on chemical, environmental and farmer practices, such as land use, soil type, soil organic matter, half life and adsorption coefficient of pesticides, rainfall, recharging rate, temperature, water table depth, catchments information, topography of land, soil erosion, pesticides application, application period and frequency and amount of pesticides used. Among them adsorption coefficients (Kd) and half life of pesticides for Sri Lankan conditions were lacking and they were experimentally determined for carbofuran as a widely used pesticide in the selected area. Surface soils were collected from 28 wet zone soil series and Kd values were determined. Four soils were selected from them for half life determination, and the risk from carbofuran to surface and groundwater was modeled.

According to PIRI, risk for surface water depends on slope of the land, distance to the edge of the water body, buffer zone size, rainfall and width of the water body. Risk to groundwater mainly depends on the level of groundwater table and rainfall. The risk was estimated for groundwater for the depth of 1m, 10m and 20m and the rainfall of 750 mm, 1500 mm and 3000mm levels. Risk maps for surface water were produced by varying the slope of the land and rainfall levels. Hence, it can be seen that awareness programmes are needed for users to be educated on water consumption and selection of pesticides according to the geographical conditions of the area.

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* janitha@kln.ac.lk

Tel: 011-2914486

128/B

A case study in Kalatuwawa Catchment Area on soil erosion using Caesium – 137

S M A Wasantha Anuruddha^{1*}, R Hewamanna² and W N Wilson³

¹National Science Foundation, Maitland Place, Colombo 7

²Department of Nuclear Science, Faculty of Science, University of Colombo, Colombo 3

³Department of Geography, Faculty of Arts, University of Colombo, Colombo 3

Water is a powerful eroding force in tropical countries. Siltation is a major problem associated with erosion contributing to a reduction of the reservoir water storage capacity which shortens the lifetime and increases the maintenance cost of dams. The objective of this study was to use environmental ¹³⁷Cs radioisotope tracer present in the soil due to radioactive fallout to study erosion in the Kalatuwawa Catchment area.

¹³⁷Caesium activity in a soil sample when compared to activity in a reference soil site is an indication of soil erosion or deposition. The fallout radionuclide ¹³⁷Cs in soil has been widely used to investigate the rates and patterns of soil erosion and sediment deposition. Depth incremental soil samples were collected at eight different points along two directly opposite slopes in the Kalatuwawa Catchment area. The ¹³⁷Cs content in the soil was measured using high resolution gamma ray spectrometry.

The ¹³⁷Cs activities of the top soil layers (00-05 cm) of the first and second reference sites are 17.6 Bq kg⁻¹ and 18.9 Bq kg⁻¹ respectively. ¹³⁷Cs activities of the top soil layers in site one on both slopes were 28.8 Bq kg⁻¹ and 25.1 Bq kg⁻¹ suggesting that erosion has occurred. Erosion is intensive on the top soil layers (00-05 cm) compared to the bottom layers (15-20 cm) in both slopes. It was physically observed that the erosion is more of the gully type than sheets and rills. Further, it was noted that the natural rock layer formed along the bank as a barrier prevents soil erosion/washing off soil to the reservoir. Slope two shows greater erosion than slope one in respect to the ¹³⁷Cs measured in three of the sites studied. It was also observed that the slope angle does not have an effect on the erosion in both slopes. Although the soil loss could not be quantified in this study, it demonstrates the applicability of the ¹³⁷Cs technique to study soil loss and redistribution.

* anurudha@nsf.ac.lk

Tel: 011-2696771-3

129/B

Performance assessment of bell pepper (*Capsicum annuum*) in a newly formulated hydroponics nutrient solution

A D G Udeni¹, Indumini S Kariyawasam¹, K D N Weerasinghe¹ and Janitha A Liyanage^{2*}

¹ Department of Agric. Engineering, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

² Department of Chemistry, University of Kelaniya, Kelaniya

Hydroponics is an intensive method of production, where the production is more often done within controlled environmental structures, while a range of parameters like light, relative humidity, temperature, water, nutrients, diseases etc. are strictly controlled. This study was carried out to compare the performance of bell pepper (*Capsicum annuum*) variety 'EDINO' in newly formulated crop specific nutrient solution compared to Albert's solution in coir dust medium. The experiment was conducted under the protected house located in the Faculty of Agriculture, Mapalana, Kamburupitiya using a drip irrigation system.

During the experiment, air temperature in the green house varied between 27 °C and 36 °C. In the protected house, light intensity was in the range of 648*100 to 88*100 Lux and the relative humidity fluctuated in the range of 61 % and 86 %. Medium temperature of the crop varied within 24.8 °C and 30 °C.

The results of the performance of the plant revealed that, plant height, number of leaves, number of flowers, number of fruits and yield (first harvest) per plant were considerably high when bell pepper is grown in the new solution compared to Albert's solution. Number of flowers per plant had a 20 % increment over the Albert's solution when the plants were grown in the new solution. Corresponding yield per plant was 267.94 g and 318.41 g when bell pepper was grown in Albert's and New solution respectively. Plants grown in new solution have shown 18.8 % increment in yield. Further the production cost is less for the new solution than for the Albert's solution.

Hence, the newly formulated solution can be recommended as a low cost hydroponics medium for bell pepper.

Financial assistance from CARP is acknowledged.

* janith@kln.ac.lk

Tel: 011-2914486

130/B

Roof water harvesting model for domestic use

C M Navaratne*

Department of Agricultural Engineering, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

A study was carried out to address the water scarcity problem in the areas where available water resources are limited. A software model was developed to use runoff

water through roofs of the area for domestic purpose using the computer language Visual Basic.

The optimum tank capacity for the area was designed based on maximum dry period and daily water demand for average family. The maximum dry period over the area was calculated using daily rainfall data over 50 years.

A field survey was conducted to find out the daily water demand, the members of an average family, roof area and roof type. The roof water harvesting potential in the area was determined by dependable rainfall method. The average roof area and roof run off coefficient for particular roof type were also considered for determining the optimum tank capacity and roof water harvesting potential in the area.

The optimum tank capacity was tested by water balance method in the region. The developed software model was applied for the Yatiyana area (IL₂ Agro ecological region) in Matara district. The roof water harvesting potential and the optimum tank capacity, for that area were 42.75 m³ and 2.37 m³ respectively. The tank capacity by water balance method was 2.97m³. The analysis shows that the roof water availability is sufficient for an average family even when the area reached its maximum dry period.

The developed software programme is successfully used for calculating the optimum tank capacity and the roof water harvesting in an area.

* champa@agracc.ruh.ac.lk

Tel: 041-2292200

131/B

Social phenomenon of bottled water consumption in Sri Lanka: Hypes and reality

N N R N Nugera¹, M K N Kumari² and L M Abeywickrama^{3*}

¹ *Department of Animal Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya*

²*Department of Agricultural Engineering, Faculty of Agriculture, University of Ruhuna, Kamburupitiya*

³*Department of Agricultural Economics, Faculty of Agriculture, University of Ruhuna, Kamburupitiya*

The world bottled water market amounted to an annual volume of more than 89 billion litres. At present, the annual compound growth rate (CGR) of bottled water consumption in the world is about 10.4 percent while in the Asian region, it is 26 percent. Although, in the Asian region, the annual per-capita consumption of bottle water consumption remains at lower level (3 litres per head per year), environmental and sanitary problems associated with careless disposal of empty bottles are increasing at an alarming rate with the dramatic growth of consumption of bottled water in the region. In Sri Lanka, there are more than 300 companies which produce bottled water in different scales and brands, with only 14 companies that have obtained SLS standards. The objectives of the study were: (1) to find an overview of the bottled water market, (2) to find attitudes of people towards consumption of bottled water, and (3) potential environmental and health hazards of using bottled water.

A sample of 125 respondents representing different categories of the society was interviewed for primary data by using a pre-tested questionnaire. In addition to the consumers, 30 retail outlets of bottled water were investigated to find the ways of displaying and storing of water bottles. The importance of different criteria in purchasing bottled water was ranked from 0 (not important) to 4 (extremely important) according to consumers' view and the Kruskal-Wallis one way rank ANOVA was used as analytical tool.

Sogo, American, Fern, Ice-mountain, Harvest, Safari were the main brands of bottled water in the market. According to the traders, consumers consider appearance and cleanliness of the bottle when purchasing, but not whether the bottles were exposed to the sun or assurance of the cleanliness of the storing place. Most of the people use bottled water for long distance traveling and when there is no alternative reliable water source. People mostly prefer medium sized, thick, light blue, round, normal (not chilled) bottles with light blue labels. About 89 percent of the respondents believe that the bottled water is safer than other sources, free from micro-organisms and adverse chemical compounds.

When buying bottled water, priority is given to the factors such as expiry date, SLS, seal of bottle, absence of inner material and outer cleanliness, but not the composition, place of storage, trade name and source of water.

As people have misconception about purity and sanitation of bottled water, the industry is flourishing despite environmental problems associated with the industry and several uncontrolled bogus filling of unhygienic water into the bottles.

* abey@agecon.ruh.ac.lk

Tel: 041-2292200

132/B

Evaluation of marketing channels of coconut in the Matara district

L M Abeywickrama^{1*}, W M S Shantha¹ and M T N Fernando²

¹ Faculty of Agriculture, University of Ruhuna, Kamburupitiya

² Division of Agronomy, Coconut Research Institute, Lunuwila

Although substantial progress has been achieved in technological improvements in the coconut sector, marketing was not emphasised as an essential element in Sri Lanka till recently. The gap between producer's price and consumer's price of coconut has been widening during the last two decades. This study focuses on the price spread and efficiency of different market channels of coconut products in Matara district.

Matara, Weligama, Dikwella, Akuressa, Kamburupitiya and Hakmana were selected for the study considering diverse cropping patterns and degree of urbanisation. Using the sampling method of *probability proportionate to size* (PPS), 120 growers and 45 intermediaries were selected for the study. Shepherd's Index of marketing efficiency and marketing margins were calculated as indicators of efficiency of marketing channels. Simple descriptive statistical methods and Chi-square analysis were used as analytical tools.

The study found significant relationships in the size of holdings, regularity of harvesting and yield. The highest cost component was the harvesting which accounts for 51.7 % of

the total cost of production. Income derived from other products such as husks, shells etc, was negligible in the district.

The market efficiency index 1.625 of dominant market channel implied that the market channel was efficient for fresh nuts. The marketing shares of the producer, wholesaler and retailer were 66.6%, 17.5% and 20.9% respectively. The gross margin for grower (Rs.3.93 per nut) was sufficient to cover the imputed costs, and therefore, existing system of marketing was sustainable under existing prices (Rs.12.32 per nut). Moreover, the margin (Rs. 1.13 per nut) of wholesaler– the risk bearer – is also a perceptible amount to cover the imputed costs and the risk. However, the share of retailer of the consumer's rupee which was about 21 % was excessive compared to the contribution made by the retailer to the marketing functions. Scarcity of labour for harvesting and consequential high costs of harvesting were the biggest problems for the producers. Price fluctuation in the market due to different external forces was the major problem faced by intermediaries. It is recommended to find ways and means to utilise the by-products in order to increase the efficiency of marketing channels.

* abey@agecon.ruh.ac.lk

Tel: 041-2292200

133/B

The effect of virgin coconut oil and essential fatty acids enriched virgin coconut oil on serum cholesterol levels in Wistar rats

S Ekanayake¹, J M M A Jayasundera^{2*} and J M N Marikkar²

¹ *Department of Biochemistry, Faculty of Medical Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda*

² *Coconut Processing Research Division, Coconut Research Institute, Lunuwila*

Virgin coconut oil (VCO) is a colourless oil obtained either by wet process or dry process without being subjected to any chemical change. Results of a recent study revealed that a maximum of 4 % of sesame seed oil could be blended with VCO to formulate a consumer acceptable essential fatty acid enriched (EFA) virgin coconut oil. Sesame seeds (*Sesamum indicum*) are a cheap source of linolenic acid. Studies on nutritional aspects of virgin coconut oil are highly important for the purpose of popularization. Thus the objective of the present study was to compare total cholesterol levels in Wistar rats (n=24, 8 rats/group) fed with a control diet containing 2% soya oil and with isocaloric test diets made with VCO and EFA enriched VCO substituting soya oil in the control diet. The rats were maintained under standard conditions at the Animal House, Faculty of Medical Sciences, University of Sri Jayewardenepura, and had access to food (control and two test diets) and water ad libitum. The feeding was continued for 10 weeks. At the end of the 5th and 10th weeks, serum cholesterol of the control and test rats was determined using a commercially available kit.

At the end of the 5th week, total cholesterol levels of rats fed with control diet and two test diets (VCO and EFA enriched VCO) were 52.8± 2.5 mg/dL, 52.5±5.8 mg/dL and 51.5±7.6 mg/dL, respectively. These results revealed that there was no significant difference ($p > 0.05$) between the control and two test groups. It was observed that there was no significant difference between the weights of the rats of all groups at the end of the 5th or 10th week. However, it was statistically shown that the total cholesterol level and the weight of rats in all 3 groups increased with time ($p < 0.05$). At the end of the 10th week, total cholesterol levels of 61.8± 8.4 mg/dL, 57.2±5.3 mg/dL and 55.9±8.4 mg/dL were observed for rats fed with control and the two test diets. A significant difference between the cholesterol levels or the weights of the control and test rats was not observed. Thus, it can be concluded that neither VCO nor EFA enriched VCO increases the total cholesterol levels in Wistar rats and could be used in food formulations or in food processing successfully.

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* cprd@cri.lk

Tel: 031-2255300

134/B

Evaluation of fish silage as a feed substitute for growing pigs

S S K Madage and Y Sultanbawa*

Food Technology Division, Industrial Technology Institute, Baudhaloka Mawatha, Colombo 7

Swine production is one of the growing farming industries in Sri Lanka. One of the main problems faced by this industry is the lack of a low cost feed. Feed cost (50-60%) is one of the highest individual costs involved in pig farming. Fishmeal is an important but most expensive ingredient in commercial pig feeds. Fish silage is protein rich, value added product produced from fish by-products, which could be easily digested and absorbed by pigs. The fishery harbours alone in Sri Lanka collect about 1500 t of by-products annually which is available for value addition. Therefore, the objective of this study was to evaluate the performance of pigs fed with fish silage by substituting commercial pig feed rations.

Substituting commercial pig grower ration with fish silage at 25% and 50 % and incorporating 25 % of fish silage into farm practice pig diets were carried out as two experiments. Feed intake of fish silage incorporated diet was higher in both experiments. Increasing level of fish silage increased protein and dry matter digestibility significantly ($P < 0.05$). In experiment 2 higher daily weight gain of 327 ± 16 g was achieved by silage fed pigs than the control diet (322 ± 8.48 g). Average carcass weight of silage fed pig was 78.4 ± 10.79 kg and pig fed with control diet was 75.2 ± 9.5 kg. There was no significant difference in carcass recovery ($P > 0.05$) between the silage fed pig 79.6 ± 1.7 and the pig fed with control diet 75.4 ± 4.5. The Back fat thickness and feed conversion ratio did not show significant differences ($P > 0.05$). Therefore it was concluded that fish silage could be incorporated in pig ration up to 25%.

* yasmina@iti.lk

Tel: 011-2693807

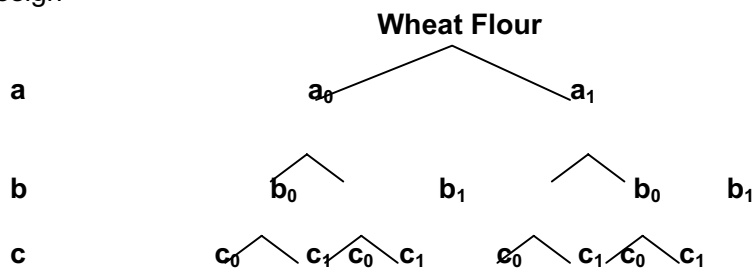
Development of a bread improver for bakery industry

S B Navaratne*

Harischandra Mills Limited, Matara

Appearance, texture and mouth feel of baked bread are very important quality parameters that promote a better perception of the product in the dynamic market. Since properties of these three key factors are depend on the quality of breadcrumb, formation of a well developed crumb is an important prerequisite. Hence, activities of yeast are to be enhanced by incorporation of growth inducers such as bread improvers. Therefore, with a view to developing a better bread improver, 5 kg of clean wheat flour, moisture content of which was predetermined, was subjected for this experiment with respect to the two factor factorial design. Three variables Sugar, Yeast and Leaving time at two levels 1% & 3%, 1% & 3% and 3 hrs & 6 hrs respectively were taken into account and 8 dough samples in 50g at 60% moisture content were prepared.

The Design



Treatment combinations $a_0b_0c_0$, $a_0b_0c_1$, $a_0b_1c_0$, $a_0b_1c_1$, $a_1b_0c_0$, $a_1b_0c_1$, $a_1b_1c_0$, $a_1b_1c_1$

a_0 – 1% sugar, a_1 – 3% sugar, b_0 – 1% yeast, b_1 – 3% yeast, c_0 – 3hrs leavening time, c_1 – 6hrs leavening time

All samples were dried in an oven maintained at 100°C for 3¹/₂ hrs to get moisture content at 8.0%. Dried samples (bread improvers) were packed in triple laminate pouches and stored under normal environmental condition (RH 70-72%, Temp 28^o-32^oC) for 3 months. All samples were replicated thrice and used as bread improvers for subsequent tests. One present from each of prepared bread improvers was incorporated with a normal bread dough (1% yeast, 1% sugar, 58% moisture) and monitored, least time taking treatment to reach the optimum leaving index 2.0, a prerequisite to have a soft and better bread crumb.

$$\text{Leaving index} = \frac{\text{Volume increment}}{\text{Initial value}}$$

Result revealed that 3% sugar level with 1% yeast and 6 hrs leavened treatment was the best improver, as which was capable to reach leavening index 2.0 within a matter of 2.25 hrs even after three months of shelf life. The control sample of normal bread dough without having the improver took 4.25 hrs to reach the leavening index 2.0. Hence, the best treatment showed comparatively a 47% improvement as against control in terms of leaving time comparatively a 47% improvement as against control in terms of leavening

time. The best treatment combination tried out with same bread dough with 0.5% vit C, was able to reduce leavening time by 15 minutes or 12% improvement.

* harischandra.mh@slt.net.lk
8

Tel: 041-2224701-

136/B

Incorporation of rice flour in preparation of bread

P A B N Perumpuli* and V Wijerathne¹

¹*Department of Food Science and Technology, Faculty of Agriculture, University of Ruhuna, Kamburupitiya*

Bread is a popular food that is consumed by many people throughout the world. Hence, it is important to improve its nutritional quality. The major objectives of this study are to find out whether rice flour can be substituted for wheat flour, and also to find out the best combination of rice flour and wheat flour that can be used in preparing bread.

Five major treatments were employed to investigate the above task. They are: 100% wheat flour, 90% wheat flour + 10% rice flour, 85% wheat flour + 15% rice flour; 80% wheat flour + 20% rice flour; 75% wheat flour + 25% rice flour. Except for the rice flour and wheat flour combination, all the other conditions were constant in the experiment. Commercially available wheat flour (Prima brand) and rice flour (Harischandra brand) were used in preparation of bread. The baked bread samples were subject for sensory evaluation on a five – point hedonic scale for appearance, colour, texture, taste smell and overall acceptability using a panel of 10 judges. A sensory score of 5 was rated as super good and 1 was considered as super bad. The data obtained were analysed statistically by employing Friedman test.

The results demonstrated that there was no significant difference between the products under five treatments except for appearance. In comparison with control bread (100% wheat flour) , panelists gave higher sensory scores for all attributes of test bread samples containing up to 20% rice flour except for appearance. Thus, rice flour can be incorporated up to 20% in bread making.

* buddhikawanninaika@yahoo.com

Tel: 041-2292200

137/B

Substitution of rice flour and kurakkan flour in the preparation of wheat flour cakes

V Wijeratne*, E H Dammalage and A A M Subodinee

Department of Food Science & Technology, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

Cake is the most popular bakery product around the world. Normally most cake types are prepared by using wheat flour as its major ingredient. The purpose of using flour in cakes is to allow an aerated structure to be retained after the cake has been made.

Rice production in Sri Lanka has increased during the past thirty years and the country is now almost self sufficient. Both Kurakkan and rice have a large potential to be used to formulate value added products, due to several reasons, e.g. high nutritional value, medicinal value, special taste and the year around availability.

Therefore, the objectives of this study were to formulate high quality nutritive cake by substituting wheat flour with rice flour and kurakkan flour, and also to examine the sensory properties of the formulated cakes.

Three cakes were prepared by using 100% wheat flour (250g), 100% rice flour (250g), and 95% rice flour + 5% kurakkan flour (237.5g +12.5g). Margarine and sugar were creamed until light and fluffy by using an electric mixer. Eggs (4) were gradually added, one at a time while beating. Flour sifted together with baking powder (5g) was added little by little to the cream and finally vanilla essence and baked in the pre-heated oven at 190 °C for 40 minutes. Sensory evaluation was conducted for prepared cakes by a panel of ten panelists using five point hedonic scale for color, taste, texture, odor and overall acceptability. Obtained results were analysed by Kruskal-wallis test method.

The results of the sensory evaluation revealed that 100% wheat flour and 100% rice flour cakes were not significantly different in color, texture and overall acceptability. Panelists rated cakes highest in taste and odor when it was prepared with 100% wheat flour and lowest made with kurakkan mixed flour. Scores obtained for kurakkan mixed cake were between 2 to 3 in all the attributes. Hence, it cannot be considered as completely rejected. This study reveals that the wheat flour can be substituted with rice flour and kurakkan flour to make high value cakes. Further development is necessary to increase the sensory properties of kurakkan mixed cakes.

Tel: 041-2292200

138/B

Exploring the possibility of using Davul Kurundu leaf extract (*Neolitsea involucrata*) to develop rice based noodles

S B Navaratne*
Harischandra Mills Limited, Matara

The objective of this study was to incorporate edible grade binding material from Davul Kurundu leaves into rice flour with a view to produce rice based noodles in order prevent occurring of more breakages and easy extrusion. Hence a study was carried out using 8 kg of rice flour with respect to the Thaguchi's special set of designs of orthogonal arrays with three variables at two levels. They were with (a_1) & without (a_0) wheat flour, with (b_1) & without (b_0) leaf extract and adopting two drying methods oil frying (c_1) & mechanical drying (c_2) to get moisture content less than 8.0 %.

In extraction of Davul Kurundu leaf extract, leaves were blanched at 100°C for 5 min and rubbed each other at slightest acidic media (PH 6.5). Eight rice noodles samples (diameter 2 mm) with three replicates were prepared as per design and subjected for

breakability test, cooking test and measuring organoleptic properties taste and aroma using 6 member sensory panel, giving scores between 1 to 10. The results obtained from the study are given in table 1.

Table 1 – Breakability, cooking time & organoleptic properties of the samples.

	Treatment Combinations	Breakability (g) (Mean value)	Cooking time (Min) (Mean value)	Organoleptic properties	
				Taste (Mean value)	Aroma (Mean value)
1	No leaf extract/ Air dried/ No Wheat flour	29.6	10	2.2	4.0
2	No leaf extract/ Oil fried/ 15% Wheat flour	73.3	08	4.7	4.8
3	Leaf extract/ Air dried/ 15% Wheat flour	40.5	10	3.1	4.2
4	Leaf extract/ Oil fried / No Wheat flour	99.3	05(6)	6.2	6.3

Since value of \bar{a}_1 is greater than the \bar{a}_0 ($51.4 > 76.7$) for breakability, strength of rice noodles strings will be increased with incorporation of Davul kurundu leaf extract. In the case of cooking time which also declined with incorporation of Davul Kurundu leaf extract ($\bar{a}_1 8 < \bar{a}_0 9$) into the rice noodles strings. Similarly organoleptic properties taste ($\bar{a}_1 6.2 < \bar{a}_0 3.7$) & aroma ($\bar{a}_1 5.2 < \bar{a}_0 4.0$) are also having higher value for \bar{a}_1 comparatively \bar{a}_0 .

Hence, there is a big advantage in the use of Davul Kurundu leaf extract in manufacturing rice base noodles as it prevents breakability of strings during production.

* harischandra.mh@slt.net.lk
8

Tel: 041-2224701-

139/B

Fish silage as replacement of fishmeal in tilapia feeds (*Oreochromis spp*)

S S K Madage and Y Sultanbawa*

Food Technology Division, Industrial Technology Institute, Baudhaloka Mawatha, Colombo 7

Fishmeal is the most expensive feed ingredient used in aqua feed. The objective of this study was to determine the effect of replacing fishmeal with tilapia silage incorporated with rice bran in the formulated diets of red tilapia (*Oreochromis mosambicus* X *Oreochromis niloticus* × *Oreochromis areus*). A feeding trial was conducted with red tilapia fingerlings ($2g \pm 0.35$) to evaluate the growth, feed conversion, and protein utilisation when fed with increasing levels of tilapia silage (0 g /Kg, 250 g /Kg, 500 g/ Kg and 750 g /Kg). Twenty fish were stocked in twelve, 1000 L fiberglass tanks, at 5% of body weight. At the end of the 12 week feeding trial, there were no significant ($P>0.05$) difference in the final mean weight ($31.64g \pm 2.92$, $36.35g \pm 2.11$, 28.05 ± 2.01 and 23.38 ± 1.72), weight gain ($29.53g \pm 3.12$, $24.24g \pm 2.1$, $25.8 g \pm 2.06$ and $21.62g \pm$

1.91), specific growth rate (3.22 ± 0.22 , 3.36 ± 0.08 , 3.04 ± 0.11 and 2.87 ± 0.25), feed conversion ratio (1.18 ± 0.09 , 1.07 ± 0.11 , 1.31 ± 0.12 and 1.35 ± 0.12) and protein efficiency ratio (2.78 ± 0.23 , 3.06 ± 0.32 , 2.37 ± 0.22 and 2.39 ± 0.24) among all treatments. There was no significant ($P > 0.05$) difference in organoleptic qualities of fish fed by the different diets. Results from the present study indicate that fishmeal content of red tilapia diet can be replaced with tilapia silage without adverse effect on the growth, feed conversion and carcass quality.

* yasmina@iti.lk

Tel: 011-2693807

140/B

Substitution of fishmeal with fish silage in broiler finisher diets

N D C Sirisena¹, N S B M Atapattu^{1*}, Y Sulthanbawa², R T Serasinghe¹ and S Madage²

¹ *Department of Animal Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya*

² *Industrial Technology Institute, Bauddhaloka Mawatha Colombo 7*

An experiment was conducted to study the effects of substitution of fishmeal (FM) with fish silage (FS) on growth performance, digestibility and carcass quality of broiler chickens. One-day-old ($n=80$) broiler chicks were fed with commercial starter ration up to 20 days. On day 20, chicks were randomly allocated into 20 pens (4 chicks/ pen) and fed with an experimental diet from 21-42 days. The dietary treatments were: commercial ration [T1], control ration (no fish silage added) [T2], 25% substitution of FM with FS [T3], 50% substitution of FM with FS [T4]. Commercial ration was in pelleted form while formulated rations were in mash form. FS was mixed with rice bran (RB) (1:2 w/w) and then dried at 60°C for one hour. Control ration was prepared by using normal RB and diets T3 and T4 were prepared by using dried RBFS mixture. The weight gain and feed conversion ratios were determined at weekly intervals. Birds were slaughtered on day 42. Ileal level dry matter and crude protein digestibility values were determined using Cr_2O_3 as an inert dietary marker. The meat quality was judged by a trained sensory panel.

Birds fed T1; showed significantly higher ($P < 0.05$) body weight, weight gain and carcass weight compared to other treatments on day 42. They consumed significantly higher ($P < 0.05$) amount of feed compared to the birds fed with other three diets. Feed conversion ratios were more or less similar ($P > 0.05$) across the four treatments. Both T3 and T4 diets showed significantly ($P < 0.05$) higher dry matter and crude protein digestibility compared to the T2. Fat free tibia ash percentage was similar ($P > 0.05$) for all the treatments. Sensory evaluation such as meat colour, odour, taste and texture were also not affected by the dietary treatments. The market price of one kilogram of T1 and calculated cost of T2, T3 and T4 diets were 42, 38, 35 and 33 rupees, respectively. Feeding costs per one kilogram of carcass were 109, 98, 104 and 89 for T1, T2, T3 and T4 ration, respectively. It was concluded that substitution of FS up to 50% does not adversely affect the growth performance and meat quality of broilers. Feed cost could be substantially reduced by substituting FM with FS. Further investigations are necessary to popularise the use of fish silage in poultry rations

* mahindaatapattu1@yahoo.com

Tel: 041-2292200

141/B

The effectiveness of heat treatment in reducing the microbial load in fish based herbal sausages

W A J S Perera¹ and Y Sultanbawa^{1*}

¹*Chemical and Microbiology Laboratory, Bauddhaloka mawatha, Colombo 7*

Five formulations of fish based herbal sausages were produced using parsley, mint, curry leaves, coriander and celery powders. The objective of the study was to determine the effectiveness of heat treatment in reducing the microbial load in fish based herbal sausages at 40 °C for 30 min. and at 90 °C for 15 min.

Five formulations of sausages were prepared separately. Half of each formulation was subjected to heat treatment and the other half was not heat-treated. Both heat-treated and non heat-treated sausages were packed, labeled and stored under freezer condition (-18 °C).

08 samples of each sausage formulation were analysed before and after heat treatment for Aerobic Plate Count, Yeast & Mould Count, Coliforms, Faecal coliforms, *E.coli*, *Staphylococcus aureus*, *Salmonella*, *Clostridium perfringens* and *Clostridium botulinum*. All analyses were done according to Sri Lanka Standard specifications.

Results before heat treatment, Aerobic Plate Count (2.3×10^5 - 8.6×10^6) and Yeast & Mould Count (2.1×10^2 - 4.0×10^2) were high in all five sausage formulations. Coliforms, Faecal coliforms, *E.coli* and *Staphylococcus aureus* were present in all samples. *Salmonella* was not detected in Mint and curry leaves sausage mixtures. None of the sausage mixtures contained *Clostridium perfringens* and *Clostridium botulinum*.

Results after heat treatment, Aerobic Plate Count (7.5×10^2 – 1.7×10^4) and Yeast & Mould Count (13 – 46) have reduced considerably. None of the samples contained Coliforms, Faecal coliforms, *E.coli*, *Staphylococcus aureus*, *Salmonella*, *Clostridium perfringens* and *Clostridium botulinum*.]

The above results indicate that the heat treatment was a very effective and an essential step in controlling food borne pathogens in sausage production.

* yasmina@iti.lk

Tel: 011-2693807

142/B

**The effect of growth stage and additives on the fermentation of CO - 3
(*Pennisetum purpurium* x *Pennisetum americanum*) grass**

D N Ranasinghe¹, Sujatha Premaratne^{1*}, G G C Premalal² and H M S S C H Thundeniya¹

¹*Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya*

²*Pasture and Fodder Division, Veterinary Research Institute, Gannoruwa*

The objective of the present study was to find out the effect of growth stage and additives on fermentation characteristics of CO-3 (*Pennisetum purpurium* x *Pennisetum americanum*) grass. An established stand of CO-3 was used. At first, the grasses were cut to a height of 12.5 cm above ground level and the re-growth was harvested at 2 stages, namely, 45 and 60 d. Grasses were chopped (1 kg for each) and ensiled alone (control) or with 5 % Rice bran (*Oryza sativa*) (RB), 5 % Poultry manure (PM) or 5% sugar cane (*Saccharum officinarum*) Molasses (M) in double lined polythene bags and sealed after expulsion of gases. The study consisted of eight treatments [2 Stages of cutting X with (Poultry manure, Rice bran or Molasses) or without additives (control) (4)] with five replicates. Silos were opened after 6 wks and the aroma, colour and texture of silages were observed. Proximate analyses were done using standard methods for fresh grass, silage and additives. The pH and volatile fatty acid content of silages were also measured. Data were statistically analysed using SAS package and means were compared using DMRT.

All silages were light green in colour and had a pleasant aroma. Control and the silage with PM had a moist texture. Inclusion of additives increased ($P<0.05$) the dry matter (DM) content of silage compared to the control. Silage with M had a higher ($P<0.05$) DM% (19.8%) than silage with RB (17.7%) or PM (16%). Addition of M reduced ($P<0.05$) the pH (3.7) of silage compared to other treatments (4.9, 6.0 and 5.7 for RB, PM and control respectively). Dry matter content of 60 d grass silage (17.4%) was much higher ($P<0.05$) compared to 45 d grass silage (16%) whereas crude protein content of 60 d silage (12%) was less ($P<0.05$) than that of 45 d silage (15%). However, stage of growth of grass did not have any significant effect on the pH of silage (4.9 and 5.3 for 60d and 45 d grass silage respectively). According to the results, inclusion of M or RB increased the DM and crude protein content of silage and reduced the pH of silage and thereby produced good quality silage. Therefore molasses or rice bran can be used as additives in making silage with CO -3 grass.

* suep@pdn.ac.lk

Tel: 081-2387179

143/B

Identification of pasture/forage varieties for water logged saline lands in Sri Lanka

G G C Premalal², Sujatha Premaratne^{1*} and H M S S C H Thundeniya¹

¹Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya

² Pasture and Fodder Division, Veterinary Research Institute, Gannoruwa

The main objective of the present study was to evaluate suitable varieties of pastures/forages for water logged saline lands in Sri Lanka. In addition, feeding value of these selected varieties was also evaluated. A plant house experiment was conducted using forages and soils collected from Kalutara, Ambalangoda, Matara and Tangalle areas. Following measurements were taken weekly: number of leaves per pot, number of shoots per pot, leaf area. Plants were harvested after eight weeks and dried samples were subjected to proximate analysis. Data were statistically analysed and means were separated using Duncan's New Multiple Range Test.

Eleocharis actangula had the highest ($P<0.05$) leaf area whereas *Sacciolepis interrupta* (*Beru*) had the highest ($P<0.05$) number of shoots and leaves during the first two weeks of growth. In contrast, *Panicum repens* had the highest ($P<0.05$) number of leaves and shoots after two weeks compared to other grasses. Dry matter yield of *Cynodon dactylon* was much higher compared to other grasses. *Eleocharis actangula* had the highest crude protein content while *Panicum psilopodium* had the lowest. Energy content was much higher ($P<0.05$) in *Panicum psilopodium* as compared with other grasses. According to the results, *Eleocharis actangula* can be considered as a grass performing well in saline lands due to high crude protein and energy content. However, animal feeding trials have to be conducted before recommendation.

* suep@pdn.ac.lk

Tel: 081-2387179

144/B

Mineral accumulation in deep litter of different poultry species

E B R W Edirisinghe, Sujatha Premaratne*, K Samarasinghe and K A Perera
Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya

A study was conducted to quantify N, P and important macro and micro mineral excretion of different poultry species in deep litter system as a function of time. Litter samples were taken at intervals of two weeks from selected pens of six different poultry species including grower chicken (GL), layer chicken (LL), broiler parents (BP), broiler litter disposed (BD), turkey (TL) and ducks (DL) using a soil auger, for a period of 4 months. In addition to these bedding materials, saw dust, paddy husk and feed given to these birds and fresh broiler droppings were also taken and used for laboratory analyses.

Dry matter, ash, N, P and K content of fresh saw dust and paddy husk were 53 and 90%, 1.2 and 17%, 0.27 and 0.79%, 0.6 and 0.13%, and 0.02 and 0.002% respectively. Chemical composition of feed varied with the type of feed. Nitrogen content of grower, layer and broiler feeds were 2.87%, 3.06% and 3.62% whereas P contents were 0.68%, 0.77% and 0.51% respectively. Dry matter, Ash, N, P and K content of different litters increased with time while those of disposed broiler litter decreased. This increase in N content was associated with accumulation of N in the litter. However, N accumulation during the last four weeks was somewhat less compared to previous week and this may be related to the accelerated NH_3 volatilisation due to the higher environmental temperature prevailed during the last four weeks. Calcium, Mg, Fe, Mn, Zn, Cu, and Cr contents also increased in all types of litters with time.

According to the results, it can be seen that intensive poultry management caused the accumulation of minerals including heavy metals in all the litters. Therefore, it is important to dispose the litter according to a manure management plan so that environmental pollution can be minimised.

* suep@pdn.ac.lk

Tel: 081-2387179

145/B

The effects of the physical form of feed and phytase supplementation on feed retention time in broilers

N S B M Atapattu* and N D C Sirisena

Department of Animal Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

Two experiments were conducted to determine the effects of feed physical forms and the dietary phytase supplementation on the feed retention time in the gastro-intestinal tract of broiler chicken. In the first experiment, 32-days old broiler chicks (n=24) were deprived of feed for 8 hours and then they were offered one of the four experimental diets. Dietary treatments were two physical forms (pellets or mash) given either in wet or dry form. Mash feeds were prepared by grinding pelleted feeds. Wet feeds were prepared by mixing feed with water at 1:1 ratio. Each treatment combination was tested on six birds giving a 2 * 2* 6 factorial arrangement. The time taken from the ingestion of feed to the expulsion of the first faecal pellet was considered as the time of digesta retention. In the second experiment, two mash form diets were formulated and prepared. One of the diets was supplemented with 1000 FTU of microbial phytase while the other diet contained no microbial phytase. As in the experiment one, both diets were given either in wet or dry form. This experiment was conducted on 40 days old birds. In the first experiment, pelleting or wetting did not significantly change the digesta retention time. However, the retention time of feed of wet mash was numerically lower compared to dry pellets. The digesta retention time varied from 162 minutes for wet mash to 182 minutes for dry pellets. The phytase supplementation also did not significantly affect the feed retention time. The mean digesta retention time increased from 173 minutes in the first experiment to 183 minutes in the second experiment. Elongation of the digestive tract during day 32 to 40 may have increased the retention time in the second experiment. It was concluded that pelleting, wetting or phytase supplementation of broiler diets have little effect on the retention time of digesta in the digestive tract. Retention time increases as birds grow due to the elongation of the digestive tract.

* mahindaatapattu1@yahoo.com

Tel: 041-2292200

146/B

Value addition of cow's milk based on the regional demand for milk products related to milk preservation

V Tharsinithevy^{1*} and K Premakumar

¹ *Vivekananda Road, Karaitivu 01*

² *Department of Agriculture, Eastern University, Chenkalady*

The study was carried out to examine the value addition of cow's milk based on the demand for milk products in the selected areas, in the Karaitivu divisional secretary division of Ampara and the whole Batticaloa district.

The demand study for milk products was carried out using preplanned questionnaires.

Milk preservation is a major problem faced by the farmers in these areas. Some of the milk collection centres found here were also far away from the farms. Hydrogen peroxide (H_2O_2 (aq)) was commonly used by the farmers to preserve milk for long period transportation. Therefore, the suitability of hydrogen peroxide treated cow's milk for the manufacture of value added milk products is much critical. To test the suitability, yoghurt and ice-cream were prepared from Hydrogen peroxide (H_2O_2 (aq)) treated cow's milk at the level of 477.14ppm and raw milk using standard manufacturing procedures. A consumer preference study was carried out on prepared samples with the raw milk products as control.

The study showed that a significant ($p < 0.05$) association existed between the demand for milk products and milking cows hold at house level, and preference of taste of milk products. The results also indicated a big demand for yoghurt and ice cream in both selected areas.

The selected level of Hydrogen peroxide (H_2O_2 (aq)) treatment to the milk drastically affects the overall sensory and organoleptic characters of both products.

* tharkaraitivu@yahoo.com

Tel: 067-2223583 (R)

147/B

Development of technology to produce a ready to serve carbonated soft drink using nutmeg (*Myristica fragrans*) rind extract

P D Liyanage*, S P Prematilake and E D K Edirisinghe
Research Station, Department of Export Agriculture, Matale

Nutmeg, *Myristica fragrans* Houtt., is a tropical evergreen large tree that produces two spices namely nutmeg seed or kernel, and mace or aril. Sri Lanka is the third supplier of nutmeg products. The rind or pericarp that amounts to about 70% of the fruit is usually thrown away and so, this is a by-product that is discarded during processing of nutmeg and mace from the matured fruits. It was expected to make a drink out of nutmeg rind extract for the market as a value added product and this will be beneficial to the country and the grower if the drink could be popularised as an herbal drink.

The product is a carbonated, sweetened, ready to serve soft beverage with food and medicinal value that is produced by using nutmeg rind extract for the purpose of adding the real nutmeg flavour and taste peculiar to the natural spice. Fully matured nutmeg fruits were harvested to produce commercial nutmeg and mace. The rind was taken to make nutmeg rind extraction. Thoroughly washed rinds were blended and squeezed to obtain the juice which is then added to the sugar syrup. The pre-mixture was added after that and the solution homogenised. The product was boiled for sterilisation and left for cooling. Permitted preservative was added and stirred. The total soluble solids (TSS) in the final product must be 13.5. The product was then cooled to 15°C and carbonated (1.5 gas volume/ min). Finally the product was filled in clean glass bottles and hermetically sealed with clean crown closures.

Nutmeg soft drink was subject to sensory evaluation tests by using a specific questionnaire. Overall taste of the nutmeg flavoured carbonated soft drink was tested by

a panel. 41% of panel members responded “like very much”, while 47 % of members indicated “like moderately”. The response for 12 % of panel members was 'like slightly' while none disliked the drink. Nutmeg rind which as a by product at processing can be used for making a very attractive soft drink instead of throwing away. The results of the taste panel indicated that an overall 88% of the people like the drink and therefore, a market demand can definitely be created among the public.

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* deshpd@yahoo.com

Tel: 066-2222822

SECTION C

301/C

Characteristic studies of dispersive materials with reference to slaking tests

K S Jeyabalamoorthy*

Slaking is a disintegration of unconfined soil or rock after exposure to the air and subsequent immersion in fluid. There is no external pressure assumed to act over soil or rock prior to immersion. Dispersive materials disintegrate without any weathering or any other external pressure when it is submerged into water. These problems can be encountered in many situations in the coal mining and irrigation project.

Certain clays exist in nature as dispersive clays and this cannot be differentiated from the ordinary clays by routine civil engineering test methods. There is an enormous difference in the fine grained soils in similar index properties. Dispersion occurs in water by a process of de-flocculation. This occurs when the inter particle forces of repulsion are greater than those of attraction, when particles get detached and go into suspension. These suspended particles are carried away by flow of water and finally they lead to failure of earth structure. Hence it is important to identify the dispersive soils.

Although significant numbers of research have been carried out to identify the dispersive soils in the last 35 years, not a single test has been able to identify the dispersive soils. At present, several research projects are in progress to find an easy and simple method to identify the dispersive materials. In this study, slaking test was used to investigate the dispersive character of materials. This method is very simple, easy and cheap. Boulder clay and kaolin materials were used for this investigation.

Test apparatus consists of an electronic balance, a 800 ml beaker containing deionised water, and a 10 mm square wire mesh specimen holder is suspended from a cantilever stand in to beaker by a thin wire which passes through a tiny opening in the middle of the cover so that the sample is immersed in the deionised water. Cover is placed on the top of the beaker to reduce evaporation. Similar apparatus was used by Moriwaki et al (1977) to study the piping failure of earth dam.

Initially, the dominant processes were absorption of water and release of air bubbles, when the specimen was immersed into slaking fluid. It takes few seconds to commence the process. This process is very quick when the material is very much dried. A specimen with higher initial water content could reach the necessary value of water content for the dispersion faster than dried specimen near the surface. Different initial moisture contents were used for both materials.

Four types of slaking behaviour were observed. (i) Swelling type of slaking (ii) dispersion slaking (iii) surface slaking (iv) body slaking. Percentage of dispersion with time for different moisture content of each material were analysed. This investigation concluded that it is possible to identify the condition under which materials disperse quickly and kaolin is more dispersive than boulder clay.

This report contains a method of testing and detailed investigations of dispersive character of boulder clay and kaolin.

Tel: 011-2591103

302/C

Flexural bond failure of pre-stressed concrete beams

I R A Weerasekera*

Department of Civil Engineering, University of Moratuwa, Moratuwa

In pretensioned prestressed concrete anchorage of prestressing steel in concrete is achieved by means of steel-concrete bond. This mechanism is two fold, consisting of transfer and flexural bond. The subject area of this study focuses on the latter. At the loading stage of a beam, it is extremely important to avoid a flexural bond failure. Our knowledge on flexural bond is more limited as compared to transfer bond. However, for the overall behaviour, both these bond influences need to be emphasised.

An experimental investigation has been carried out by fabrication and testing of 13 full-scale specimens to ascertain the influence of various parameters on bond characteristics. All the beams were designed to fail in bond, even though it is difficult to achieve such a failure mode. Experiments conducted for this study show that several factors influence the ultimate failure of these beams. Among them are, concrete strength, level of pre-stress in strand tendons, strand diameter or area, confinement of the tendon dictated by clear cover or half spacing and the nature of the load and its loading position of the beam. In 4 out of 13 beams tested, the failure modes were different from bond failure. The rest were either bond-flexure or bond-shear depending. However, the primary failure mode was bond. This shows the dangers involved in practices based on major design codes adopted in Sri Lanka. A premature bond failure undermines the flexural and shear capacities of pretensioned prestressed concrete beams which is a serious cause for alarm and concern.

The experimental results show that a bond failure is manifested by very little strand slip and should be monitored throughout the testing stage. Deflection measurements have been made at several stages of the test. Results indicate the prevalence of small deflections in the event of bond-shear failure and large deflections associated with bond-flexure failures. This means that some bond failures may be brittle as opposed to a ductile failure which we often desire to have. This shows the flaws associated with various design codes of practice as these do not provide adequate safeguards against such premature bond failures.

In conclusion, adequate steps should be taken during the design stage to maintain sufficient confinement and to avoid the use of low concrete strengths in the absence of experimental data to amend relevant codes of practice adopted in Sri Lanka. Enhancing the beneficial effects of such factors may act as a preventive measure for the time being.

* ruwan@civil.mrt.ac.lk

Tel: 011-2650567

303/C

Wave erosion on up stream slopes of earthen dams

E A C Ekanayake*

Department of Irrigation, P.O. Box 1138, Colombo

Slopes of earthen dams are mainly designed for stability. Slope deterioration will take place due to various reasons. Erosion is one cause. Therefore slope protections are

designed to minimise erosion. Erosion is mainly due to rain water and other factors like seepage forces, wave erosion etc. While rain water and seepage forces damage both upstream (U/S) and downstream (D/S) surfaces, wave erosion damages only the upstream surface.

Wave erosion has not been considered very much in designing rip rap protection in several dams. Due to this negligence, rip rap has been constructed only up to the reservoir full supply level. This paper discusses the damages caused by the non availability of rip rap protection up to the required elevation.

On D/S, slope protections are designed to overcome the erosion problems. Grass cover is common to protect the slope from rain water erosion. In high dams, horizontal berms of about 2 m. width are constructed at 10m elevations. On these berms, catch water drains are provided to collect rain water and then will be carried up to toe drain with suitable drainage methods to prevent the formation of gullies on the slope. Erosion due to seepage forces on D/S slope will be controlled by the means of filter drains, rock toe and toe drains etc.

On U/S, rip rap with bedding filter materials will protect the slope against all the causes i.e. rain water, seepage forces wave erosion etc.

During the monsoon period, most of the reservoirs are at full supply (FSL) level, or at high flood level (HFL). Therefore, mostly above FSL of the U/S slope is vulnerable for wave attack.

Once the wave hit the U/S slope, it will ride up along the slope up to a certain elevation. Due to wind blowing, the water surface tends to elevate a little at the upstream slope. This phenomenon is known as wind set up, and it is maximum if the dam is perpendicular to the wind direction and facing wind ward. If the water depth is high, wind set up is negligible and in shallow reservoirs wind set up is countable. Considering the above mentioned wave ride up, wind setup, wave height etc., free board for the dam is estimated.

Wave heights are calculated theoretically adopting several methods for the purpose of designing rip rap protection. Thumb rules and approximate methods give high wave heights and rigorous methods give lesser values. In some working reservoirs observed maximum values may be available during past cyclones.

Over estimation of wave height is favorable in designing free board and slope protections. Savings on reduction of free board and curtailing the rip rap cannot compensate the damages due to embankment failure.

Behavior of waves during winds or cyclones and the affected slope area can be predicted. When the water level is at maximum probable elevation such as FSL or HFS, the affected slope area can be marked on the **u/s** slope of the bund. The affected area has been found identical in this case study. To overcome this erosion problem, rip rap protection should be constructed up to the bund top level.

Such failure and remedial measures constructed are discussed in this paper.

* eacekanayake@yahoo.com

Tel: 011-2504677

304/C

Recognising the importance of thermal loading in the Sri Lankan context

I R A Weerasekera*

Department of Civil Engineering, University of Moratuwa, Moratuwa

Concrete bridges exposed to sun are subjected to complex thermal stresses, which vary with time. Although in a tropical climate, there are no large seasonal or daily variations in temperature, large amounts of heat exchanges take place due to solar radiation. This is the main source of heating of bridge decks in the Sri Lankan context. The resulting effect is a differential nonlinear temperature distribution depending largely on the shape of bridge cross section. The magnitude of stresses that are induced can be high and can cause cracking of bridge decks. In simply supported bridges longitudinal self-equilibrating stresses are produced within a cross section. In continuous bridges, there are additional continuity stresses which develop. The resulting effect is a combination of stresses where the principle of superposition is applicable. These stresses induced from thermal loading can be comparable to dead or live load stresses.

Concrete design codes provide very little guidance for thermal loading. Some codes give approximate temperature distributions for heating and cooling. These, however, are not applicable to Sri Lankan bridges. There are methods that could be utilised to ascertain temperature distributions and consequent stresses accurately. Most bridge designers have a false belief that thermal stresses are not very significant for a tropical country like Sri Lanka.

In the present investigation, an attempt has been made to evaluate temperature variation for bridge decks formed using different cross sections commonly used, employing the finite element approach as applied to a heat flow problem. A programme developed in North America based on this concept called FETAB is successfully employed. Corresponding thermal stresses are computed using a package known as CPF, also developed in North America. The comparison of results shows that temperature guidelines provided in the bridge code BS5400 are neither conservative nor meaningful in the Sri Lankan context. The results obtained using such approximate data could be very dangerous. Therefore, thermal effects cannot be disregarded in a robust design. Research conducted at Moratuwa also shows that the bridge beams used in the Industry are over designs so that serviceability problems may not arise from thermal loading. Therefore, the thermal stresses induced may not be trivial. However, techniques available show that accurate and comprehensive calculations can be made. These methods can lead to efficient designs, giving the designer confidence to produce economical bridge cross sections.

* ruwan@civil.mrt.ac.lk

305/C

Design and development of a power tiller operated fertilizer applicator for coconut cultivation

P L A G Alwis* and L W S Pemasiri
Faculty of Agriculture, University of Ruhuna , Kaburupitiya

Coconut palm is a perennial crop and spends its entire life span of 70 years or more rooted in one place. During this long period a palm removes a large quantity of nutrients and water through its bio-mass. If the soil is unable to supply the nutrients removed with the bio-mass, the palm will be starved of the relevant nutrients with subsequent decline in yield. Investigations carried out have shown that the majority of coconut soils in Sri Lanka are deficient in the major essential plant nutrients N P K. In certain areas, particularly in the wet zone Mg has also been found to be deficient. In the early stages fertilizers should be applied close to the palm on the weeded surface up to a distance of 1 foot from the base, and the soil turned over with mammoties or mammoty forks, As the palm grows older, the area round which fertilizer is applied should be gradually extended up to about 1.75 m from the bole.

Unfortunately, it is observed that consumption of fertilizers by the coconut sector is very low due to high charges and scarcity of labour.

The purpose of mechanisation in the coconut cultivation is to produce more from existing land. Machinery is a complementary input required to achieve higher land productivity. Additional benefits to the user may be associated with a reduction in drudgery of farm work greater leisure, or reduction of risk.

Use of manpower for the application of fertilizer is uneconomical due to high labour cost. Therefore, power tiller operated fertilizer applicator for coconut cultivation was designed and constructed. This machine is not only useful to broadcast fertilizer on the soil but also to mix it with the soil close to the palm on the weeded surface.

The designed machine consists of fertilizer distribution unit and rotary unit. The Maximum spreading width in meter and Machine discharge rate in gr/min were considered as criteria for comparison of merits and demerits. The results show that the Maximum spreading width and Machine discharges rate were 0.7m, and 150 - 230 gr/min, respectively. The cost of production of the designed power tiller operated fertilizer applicator was 10,000 rupees.

306/C

Serviceability analysis of slabs on grade

I R A Weerasekera*

Department of Civil Engineering, University of Moratuwa, Moratuwa

A slab on grade is defined as a concrete slab placed on earth, ground or some strata. These are encountered in construction as mass concrete, reinforced concrete or prestressed concrete depending on the practical situation. These find applications in pavement slabs found in footpaths, walk ways, airport runways, highways, basement floors and bottom slab of swimming pools. The basic characteristic of slabs on grade is that there are two different sets of environmental conditions at the top and bottom surfaces of the slab. These conditions vary from humid tropical situations to moisten cold weather or to dry extreme cold climates. The observed behaviour of some of these slabs is that they are fractured or cracked due to serviceability problems or construction defects. This study is aimed at investigating the former which is a time dependent phenomenon. The critical stages of these slabs can be assessed on short term or long term basis or both. The effects often treated are creep and shrinkage of concrete and relaxation of prestressing steel if relevant and temperature effects. In this study the latter is excluded from the main influencing parameters for serviceability behaviour.

Another important aspect experienced in slabs on grade is the differential variation of parameters through the thickness of the slab. This makes standard methods available in research literature not directly applicable. The procedure adopted recognises the main influences but requires a computer tool to conduct an efficient study. The analysis procedure involves evaluation of several integrals which are systematically coded using computer spreadsheets. The variables considered are relative humidity, thickness of the slab, age of concrete at loading, age of concrete at stress calculation, ambient temperature, type of cement and the amounts of both reinforcing and pre-stressing Steels. Therefore, a large number of analyses needed to be performed.

The results presented graphically describe the variations of final stresses as tensile or compressive with the information related to top and bottom fibres shown separately. In a given slab on grade combined loading (dead, imposed plus time dependant) could produce cracking of concrete. As the thickness of the slab increases, these effects become less significant. The results also show that most changes occur within the first 10 days but almost cease after about one year. A notable conclusion is that stress changes can be reduced if moisture at the bottom surface is retained by providing membrane sheets beneath rather than laying the concrete directly on ground.

* ruwan@civil.mrt.ac.lk

Tel: 011-2650567

307/C

Design and development of a power tiller operated sugarcane harvester

P L A G Alwis* and L W S Pemasiri
Faculty of Agriculture, University of Ruhuna, Kaburupitiya

Sugarcane is a tropical plant belonging to the family Gramineae. Its harvesting should be so timed that the cane has attained peak maturity and maximum yield level under the given growing conditions. The method of harvest should be such that maximum of the cane produced is harvested to the ground level and all extraneous matters such as tops, trash, roots etc. are excluded to the extent possible.

In Sri Lanka, harvesting is done manually using various types of hand knives. This method of harvesting does not only consume much time but also requires much skilled labourers. But nowadays labourers are becoming scarce and costly, particularly in the sugarcane cultivation areas. This is due to diversion of labour to other more remunerative work in industry, construction, business and diversion of labour to other crops.

In countries where sugarcane cultivation is highly mechanised, huge harvesters are employed. In these countries, sugarcane is grown on large plantation scales in large farms owned by either mills or big farmers. However, it is difficult to employ such machines in Sri Lanka due to various reasons such as, fragmented and small holdings with small and irregular fields, diverse cropping patterns followed, the cultivation practices which have been developed for manual harvest and poor farmers who cannot afford costly machines. Therefore power tiller operated whole stick harvester prototype was designed and constructed. The designed machine consists of reversible cutting device, power transmission unit with clutch mechanism and cane shifting device.

The maximum cutting width, machine capacity and traveling speed were considered as criteria for comparison of merits and demerits with existing manual method. The results show that the maximum cutting width, machine capacity and traveling speed were 1.2m, 0.8 ha/day and 0.75 km/hr respectively. The cost of production of the designed sugarcane harvester was 20,000 rupees.

Tel: 041-2292200

308/C

The effect of displacement induced loading on ancient stupas of different shapes

I R A Weerasekera*
Department of Civil Engineering, University of Moratuwa, Moratuwa

The ancient stupas are the oldest gravity structures in Sri Lanka. These stupas have been made of bricks in lime mortar. Huge granite solid rocks were also used for the foundation. The main components of a stupa are: a square platform (salapathalamaluwa), basal rings (pesa-valalu), a solid dome (garbhaya) a square chamber (hataraskotuwa), a cylindrical member (devatakotuwa), a conical member (kothkerella) and kotha at the top of the conical member. Generally according to its shape, these can be classified into six categories, but in this country there is evidence of four types of structures. These are bubble shaped (like a hemisphere), bell shaped (like a bell), paddy-heap shaped (like a heap of paddy) and a pot shaped (like an inverted

pot). Due to several decades of neglect of these stupas and enemy attacks, some remain to be in ruins. In some stupas, there was evidence of apparent fractures. But the rulers at that time had taken great efforts from time to time to restore them. Here all efforts to restore the structures have been made within a framework of environmentally friendly techniques and materials. Some of these monuments have changed in shape due to various rehabilitation processes including expansions at the base. Other efforts include plastering with new coatings to the outer surface.

Present finite element analysis recognises self weight of the dome and settlements at the base of the dome. Literature provided by the Jetavana Project Office describes the limited tests conducted on the materials on samples cut from ancient bricks, and hence it is assumed that the material used for other stupas have similar properties.

In this study, the four common domes are analysed for force and displacement induced loading. The element utilised is axi-symmetric solid (ASOLID) of SAP90. For each model 4-node quadrilateral and 3-node triangular elements have been utilised. Load case 1 is only the self weight of the dome where the base is fully restrained. Load case 2 is the loading due to the applied displacements at some points of the base. But in the actual situation, these two cases occur together. Element stresses are determined by using geometric centre of the finite element. Results reveal that actual vertical element stress has more influence on the fracture of these stupas. The analyses reveal that largest tensile stresses developed in the circumferential direction is maximum in the bubble shaped type. This is followed by the paddy-heaped, pot shaped and bell shaped.

* ruwan@civil.mrt.ac.lk

Tel: 011-2650567

309/C

Time dependent analysis of structural concrete continuous bridges produced using balanced cantilever method

I R A Weerasekera*

Department of Civil Engineering, University of Moratuwa, Moratuwa

The cantilever concept is used for the construction of balance cantilever bridges. The first segment on the pier is kept under fixed condition and the rest of the segments are attached to the first segment successively by post tensioning. In this type of bridge, time dependant analysis is important at the fabrication and all construction stages. An analysis procedure exhumed from literature, for time dependant analysis which is most comprehensive, systematic and succinct is followed in this study. The method recognises all the materials in a bridge section such as different concrete parts and different steel parts encountered during the entire life of the bridge in a unified manner. This approach is ideal for computer coding and adopts the matrix notation and algebra. The method is based on basic structural mechanics where flexural theory is extended to cover composite sections in which centroid is a variable due to time-dependant nature of the material properties (the modular ratios change with time). Hence the standard bending formula is not applicable. For the Principle of Superposition to be valid throughout the analysis, the concept of an arbitrarily defined reference point is introduced. This may be selected to suit the preference and convenience of the user.

The resulting equations follow a matrix procedure. The overall analysis is based on matrix displacement technique using axial strain at the reference point and curvature of the section as the basic unknowns. The subsequent changes arising from time dependant effects in the two unknowns are calculated in a similar manner. This rigorous procedure can handle any changes to statical conditions, material and geometrical properties. The analysis accounts for Creep, Shrinkage and Relaxation which are usually ignored by some designers. A companion computer programme developed in this study is adopted successfully for the design as there is a large number of analyses to perform in the design process. This tool can be conveniently used in continuous bridge designs to predict time-dependant stresses and deformations at the service stage.

A design example involving a bridge produced using the balanced cantilever construction technique is discussed. The results show that design checks are important to ascertain whether concrete cracks should be eliminated or controlled. The computer procedure developed and implemented is very powerful and fills several voids that existed in the serviceability design stage.

* ruwan@civil.mrt.ac.lk

Tel: 011-2650567

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Irrigation water management in Murapola Ela Scheme – Central Province

A L Dissanayake, N P Miguntanna, N S Miguntanna* and K P P Pathirana
Faculty of Engineering, University of Peradeniya, Peradeniya

A study was carried out to investigate the best use of irrigation water in the Murapola Ela scheme, situated in the Central Province, Sri Lanka. The headworks of the scheme is located across Gurugal Oya, which is a tributary of Mahaweli Ganga. The command area of the project is 800 ha. Nearly 1100 families are reportedly dependent on the scheme for their livelihood. A further 1500 families occupying highlands adjacent to the project area are also partially dependent on the scheme. When the scheme was developed in 1940's, the cultivation of the entire area of the scheme has been dependent on water diverted from the anicut. But at the beginning of 1980's, two reservoirs were constructed across tributaries of Gurugal Oya to meet water shortage during dry season. However, at present, water supplied from the reservoirs and the anicut was not sufficient to meet the demand. The cultivation has been abandoned in the tail end of the scheme due to water shortages caused by the sharp declination of the forest cover within the catchment. The objective of this study was to investigate the best use of irrigation water in the Murapola ela scheme giving much attention to the following aspects:

1. to introduce a better cropping pattern for Yala and Maha seasons to utilise the amount of water available at present more effectively. The criterion used in this analysis was mainly based on maximizing the cultivation area of the scheme with the intention of increasing the extent of paddy cultivation to at least 60%.

2. to propose a new reservoir to store more water during rainy season and there by, increase the irrigable area to cover the entire field canal system while allocating 80% of the total extent of the scheme for paddy cultivation.

To achieve these objectives, necessary field data were collected and analysed. Several reservoir simulations were carried out for the network of field canals and reservoirs with different cropping patterns. Initial analysis was performed with the existing scheme to adjust inflows to the reservoirs that were derived from rainfall data. In order to manage the amount of water available at present in a more effective manner, a suitable cropping pattern was found after several simulations. This cropping pattern includes 60% paddy and the rest with different types of vegetables, and the selection of these vegetables was based on a detailed survey carried out among farmers in the scheme. This study also reveals that an additional reservoir with a capacity of about 0.475 MCM is to be added to the system to cultivate the entire area of the scheme allocating 80% of the area for paddy cultivation, which is one of the prime requests made by the farmers in the scheme.

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* nsmiguntanna@yahoo.com

Tel: 011-2650472

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Optimum maintenance strategy for bridges using reliability approach

P B R Dissanayake and P A K Karunananda*

Department of Civil Engineering, University of Peradeniya, Peradeniya

This paper presents different aspects of development of maintenance strategy for bridges. It has been known that high expenditure in bridge maintenance is a burden for most countries in the world. In addition, most of bridge maintenance strategies are based on human visual inspections that have larger uncertainties. To solve this difficulty, there is a need to implement a probability based maintenance strategy for bridges that use both theoretical considerations and practical visual and human experiences.

Depending on the type of bridge, failure modes are proposed considering critical failure modes of the concerned bridge.

$$M_i = Z_{R_i} - Z_{S_i} \quad i = 1, 2, \dots, n$$

(1)

Where M_i is the safety margin for i^{th} mode of failure of the concerned bridge. Z_{R_i} is the strength variable and Z_{S_i} is the load variable. The reliability index (β_i) and failure probability (P_{f_i}) for i^{th} failure mode can be expressed as,

$$\beta_i = (\mu_{Z_{R_i}} - \mu_{Z_{S_i}}) / \sqrt{(\sigma_{Z_{R_i}}^2 + \sigma_{Z_{S_i}}^2)}$$

(2)

$$P_{f_i} = -\phi\left[\frac{(\mu_{Z_{Ri}} - \mu_{Z_{Si}})}{\sqrt{(\sigma_{Z_{Ri}} - \sigma_{Z_{Si}})}}\right]$$

(3)

According to Equation 3, for each failure mode ($i = 1, 2, \dots, n$), elementary reliability index and elementary failure probability can be calculated. Assuming all failure modes are combined with a series system, it is possible to calculate the system failure probability (P_F) from simple bound as shown in the Equation 4.

$$\text{Max}_{i=1,2}^n P_{f_i} \leq P_F \leq 1 - \prod_{i=1}^n (1 - P_{f_i})$$

(4)

Then, $\beta_S = -\phi^{-1}(P_F)$

(5)

As outlined above, for each type of bridge, it is possible to calculate the system reliability index (β_S) at different time. Overall bridge reliability index reduces with time. Once it reaches target reliability index, bridge maintenance can be carried out. By adopting as mentioned a maintenance strategy, unnecessary resources expenditure can be minimised and such a methodology is useful for a developing country like Sri Lanka.

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* mawanella1976@yahoo.com

Tel:

081-2393582

312/C

Design teaching and architectural design studio tradition: Critical pedagogy as an alternative to the conventional studio

Harsha Padmal Munasinghe*

Department of Architecture, University of Moratuwa, Moratuwa

Teaching design is construction and transfer of knowledge. In the schools of architecture, the most tested pedagogical practice is the design studio that is intertwined with embedded epistemology, and the social relationships develop in the studio. The power structure maintained in the studio and the hidden dynamics resulted by the struggle between the student and the designer-trained teacher, who often becomes the mentor, appear to play an essential role in architectural teaching. The current 'guild-culture training', in which the student is not freed from the biases of the mentor, integrates students to the profession through enculturation rather than education. The student as a result may fail to develop as an intellectual designer who sharpens his/her own way of creating architecture. We define our research problem in the lack of self-styled personal approaches to architectural design, and test the strength of critical educational theory to resurrect the mystique of architectural spaces. Our research aims at testing this hypothesis through design exercises, tutoring/teaching, and through

observation. We may contribute towards developing comprehensive pedagogical tools for architectural education to make the student able to perpetuate his/her mentors' intellectual and cultural biases and to turning the student into a *reflective practitioner*, who sets own norms or objectives to naturalise the hidden constraints in order to practice a more meaningful profession.

* harshamu@sltnet.lk

Tel: 011-2650301

313/C

Ethnic culture in the Sri Lankan construction industry

R Shiyamini* and R Rameezdeen

Department of Building Economics, University of Moratuwa, Moratuwa

One distinctive characteristics of the construction industry is the involvement of different groups of people with different cultures. Their values, attitudes, interests are diverse. In ensuring efficient and productive interaction of people, identification of cultural background of each individual plays a dominant role. It is therefore, important to appreciate and understand each participant's cultural differences/similarities. Using the four dimensions of a national culture established by Hofstede (1980), this paper aims to explore the ethnic cultural differences among project participants in the Sri Lankan construction industry. This study has focused on only two ethnic groups, namely Sinhalese and Tamils. The data for this study were obtained through structured questionnaire survey, based on the popular Value Survey Module, administered among Sinhalese and Tamil professionals in consultancy and contracting organisation of the industry. A total of 135 professionals were selected based on Quota Sampling method to take part in the survey. The respondents were limited to Engineers, Architects and Quantity Surveyors. In addition, few open ended interviews were conducted with selected experts in view of interpreting the results. The responses were analysed using Hofstede's cross cultural dimensions. Hofstede's has distilled cultural characteristics into 4 major groups: power distance; individualism-collectivism; uncertainty avoidance and masculinity-femininity.

From this research, it was identified that there is a significant difference between the cultures of these ethnic groups. It was found that the highest deviation between the ethnic groups is on the uncertainty avoidance index (UAI). Tamils have a very high uncertainty avoidance compared to Sinhalese indicating that Sinhalese are less threatened in ambiguous situations. The power distance dimension captured using the Power Distance Index (PDI), also shows a considerable difference between the two groups. It indicates that there is a huge gap between the superior and the subordinates in the Sinhalese culture. In the individualism-collectivism dimension, Sinhalese score a lesser value (32) compared to Tamils (68). Therefore, it can be stated that, Tamils are relatively more individualistic than Sinhalese. Computed value for masculinity and femininity, demonstrate that there is no significant difference between Sinhalese (value 53) and Tamils (value 54).

Since construction is teamwork, identification of ethnic culture and differences among groups is important for effective management of its workforce. This study provides a guide for managers to analyse cross-cultural influences of the two ethnic groups which

can lead to innovative business practices, faster and better learning within the organisation and sustainable source of competitive advantage.

* shiyalk@yahoo.co.uk
Ext.7204

Tel: 011-2650301

314/C

Principles of traditional technology that produced mural paintings

T D N Perera *

Department of Architecture, University of Moratuwa, Moratuwa

Accurate understanding of principles of traditional technology that used to produce mural paintings is the prerequisite in conservation of traditional mural paintings. This research was founded with an objective of exposing these principles by analysing existing paintings and a limited amount of literary records available. Two types of samples were used in this test. These were samples obtained from sites and simulated samples. Production processes of simulated samples were reformulated obtaining information from traditional Indian and Sri Lankan technical (*silpa*) texts and identifying constituent compounds by microchemical tests. Quantitative measurement of parameters of behavior was done with simulated samples. Resistance of processed compounds to oxidation, insect attacks and microbiological attacks were determined. Samples of paintings obtained from sites were placed under normal conditions and allowed natural aging to take place. The behavior of samples and actions occurring in them and response of samples to external actions were determined by physical tests, microchemical tests and microscopic observation. Samples were subjected to destructive chemical and physical testing after the end of this testing period. Physical nature of samples was examined under the microscope. Chemical constituents were identified using microchemical tests, IR and AAS. Porosity and permeability of layers to water transmission were also measured. Possible rate of evaporation of moisture was correlated with estimated rate of water absorption of paintings. Results indicated the use of microbiological, enzymatic and organo-metallic actions by traditional artists. This study revealed that the traditional techniques had been formulated using strictly followed principles based on the requirement of coordinated behavior of paintings with environment. Traditional technology contained strict guidelines that enabled preservation of paintings for long durations. Strict quantitative measurement had been followed throughout the production process. A greater level of coordination had also existed between production process and method of drawing. Following principles of traditional technology were identified according to obtained results: materials with highest chemical stability that do not interact themselves must be used in production of paintings; an adequate amount of microbiological, enzymatic and organo-metallic actions must be used during processing of material to generate antioxidant, insect-repellent and antiseptic properties in the medium; paintings must be produced to stand in equilibrium with their respective environments; adequate porosity must be provided in the ground to absorb and transmit available amount of water in the support and to evaporate at a rate allowed by environmental factors; permeability of paint layer must be controlled in relation to above factors; physical properties of produced paintings must support

provision of adequate amount of surface moisture to suppress thermal movement, and homogeneous layers must be ensured during production.

Acknowledgement: Financial assistance by the Ford Foundation, USA

* n88geo@yahoo.com
Ext.7122

Tel: 011-2650301

315/C

A study of multipliers in programmable logic devices

W A S Wijesinghe¹, M K Jayananda² and D U J Sonnadara^{2*}

¹ *Department of Electronics, Wayamba University of Sri Lanka, Kuliypitiya*

² *Department of Physics, University of Colombo, Colombo 3*

The hardware multiplier is a major component in many computational and DSP systems that are implemented in Field Programmable Gate Arrays (FPGA). Since there are no universally accepted methods, designers often need to construct their own multipliers for the application in hand. Although there are various methods to perform the multiplication operation in hardware, the selection of a suitable multiplier not only improves performance, but also saves valuable configurable logic resources. In this work, a comparison of resource utilisation and the execution speed of several different types of multipliers in programmable logic devices is presented.

Two target hardware devices, a high density Spartan 3 FPGA and a low density XC4005XL FPGA were used. Pipelined and non-pipelined versions of Binary, Carry Save Array (CSA) and Cellular multipliers as well as the multiplier in the VHDL library by default were evaluated. In the case of the Spartan 3, the default multiplier was an embedded one which did not use any of the logic resources available for applications. Since the XC4005XL chip has less configurable resources, only 4-bit and 8-bit multipliers were constructed while 4-bit, 8-bit and 18-bit multipliers were constructed for the Spartan 3 FPGA. It was found that the performance of the embedded multiplier available in the Spartan 3 was superior to all other multipliers. Next to the embedded multiplier, the CSA multiplier was found to be the best in terms of resource utilisation and speed. Further, the pipelined CSA multiplier performs approximately a factor of 2 faster than its non-pipelined version when a single stage pipeline is used. This speed could be further increased by inserting a few more pipelined stages.

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316/C

Development of an effective amateur radio voice communication network to be used during disaster situations

T D N Perera*

Department of Architecture, University of Moratuwa, Moratuwa

Every established landline and electromagnetic forms of communication come to a standstill during a disaster. This is a result of damage to landlines, switching centres, cell sites and power supplies. Only amateur radio stations are operational during such situations due to their independent operation, portability and requirement of low power. This research was conducted with the objective of finding the most relevant modulation technique that can be effectively used during disasters without doing extraneous modifications to the existing amateur radio network. Data was collected for this study from the amateur radio community in Sri Lanka. Measurements were done to detect parameters of the present system. Generated information was used to determine the relevant method. A reliable disaster communications system must be capable of providing means for effective and efficient communication with any two locations in the country at any given time without a break with at least four communication channels. TDD is the standard operational mode used in amateur radio transmissions. 2 m and 40 m bands are the main amateur radio bands used in inland communication. NBFM on 2 m and SSB on 40 m are the modes being used. Island-wide communication on 40 m is possible at certain intervals of a day depending on the season. Twenty four hour communication is possible on 2 m up to about 22 km distance. Long distance inland communication is being done using repeaters. Two repeaters installed in Yatiyanthota and Nuwaraeliya cover about 65 % of the total land area of the country. Local communications on 40 m band is highly susceptible to variations in ionosphere. It is impossible to rely on this band throughout the year. Resources available for 2 m band are also not sufficient due to inability to allocate more than a single channel at a time and impossibility to sufficiently cover the total land area of the country. It was understood from analysis done that the present system failed to provide reliable communications during disasters. Results confirmed that 2 m band is the most suitable band to perform reliable transmissions irrespective of the time of the day and season. Since only a single channel is available, AM, SSB and NBFM modes cannot be used to handle necessary density of traffic. Since TDMA needs centralised processing at the repeater site, its usage is non-relevant. CDMA is unusable due to the availability of only a narrow bandwidth of 50 kHz. Usage of FDMA with narrow digital channels is the only possibility. It is necessary to limit bit rate to 5 kHz s^{-1} . Quality of signal provided by this bit rate is sufficient for emergency communications. Since repeaters use non-linear amplifiers, only FSK and MSK are usable. Usage of FSK is ruled out where sharing of a narrow bandwidth is necessary for several channels. MSK is therefore the relevant mode. It is possible to allocate four (4) 12 kHz channels with a 2 kHz guard band for ISI free transmission on available 50 kHz bandwidth.

Acknowledgement: Assistance provided by The Radio Society of Sri Lanka

* n88geo@yahoo.com
Ext.7122

Tel: 011-2650301

317/C

A case study of executing social responsibility: Upgrading of a technical training centre

S K Seneviratne*

Department of Mechanical Engineering, University of Peradeniya, Peradeniya

The paper is based on the experience gathered in executing a project to upgrade the Light Engineering Training Centre, located in Aluwihare, Matale to a higher level certificate awarding institute. It was providing light engineering craft training for a batch of 20 youth. However, only a handful of those who enroll completed the programme and a fraction of that will continue in related areas of employment. In order to upgrade the centre, the Engineering Design Centre (EDC) of the Faculty of Engineering, University of Peradeniya was employed to provide the necessary consultancy work. This included, drafting of the intended upgrading programme and its implementation.

Based on a needs survey on the type of training and the availability of employment, the selected course was targeted to provide a training suitable for the 'die and mould making' industry. Based on the basic training required, the equipment and tools suitable for the target training were identified and course syllabi and course contents were drafted. At the same time, the teaching staff had to be trained and upgraded. They too had to be exposed to the modern equipment and tools that were to be made available at the centre.

The most important step was the selection of trainees. Through some publicity, 54 candidates were selected for the first batch, although the target was 60. After conducting the courses including practicals and industrial training, an evaluation of the trainees was done. Out of the 54 trainees of the first batch, 48 completed the course successfully. As many as 70% of the trainees had secured employment at the place of training itself.

This project has paved a way for satisfying the dire need of technically skilled personnel in a small way. The trainees have expressed their satisfaction about the programme as they have acquired skills that have a good market value. The parents of the trainees are quite happy that their children have been put on the right track by this programme. They have observed the positive changes in their children as they are behaving with responsibility and self-esteem. The response received from the industry is extremely satisfactory. They have expressed the highest regard for the trainees. This is well proven by the subsequent employment rate. Many have requested for future trainees in their organisations. In implementing this project, resources of several national level organisations were mustered. It should be noted here that all those who supported the execution of this project were ready to do much more than the call of duty and did their contribution as a social responsibility.

* sks@pdn.ac.lk

Tel: 081-2393601

318/C

**Investigation of cashew nut shell liquid (CNSL)
as potential colouring and finishing agent for textile substrates**

U G Samudrika* and N G H de Silva

Department of Textile and Clothing Technology, University of Moratuwa, Moratuwa

From time immemorial, man has been using bio-materials for his food needs, shelter and clothing. Even colours which make human beings attracted to, were originally extracted from biological and mineral sources. However, with the advent of the first synthetic dye in 1856, there began a quick decrease in the use of natural dyes which were more expensive and more cumbersome to use. Today almost all colours and finishes used in the 'textile industry' are synthetic man-made dyes and chemicals.

One of the major problems created by the Textile Industry is extensive environmental pollution. The production of synthetic dyes from petroleum based chemicals involves violent reactions as well, leading to the production of hazardous intermediates and various skin diseases such as cancer.

Presently there is a growing interest and development in the use of natural products for colouring as well as finishing of textiles. This tendency is growing fast since natural products generally exhibit better bio-degradability with higher environmental compatibility and lower levels of toxicity and allergic reactions.

This investigation of Cashew Nut Shell Liquid (CNSL) is an attempt to search for the possibility of obtaining bio-ingredients applicable to textiles for colour and crease resistant developments using bio-waste.

CNSL was solvent extracted using Hexane and used as the 'coupling component' to produce Naphthol type colours which have reasonable tinctorial values as shown by samples.

CNSL was also assessed for its crease resisting behaviour and reasonable results have been shown.

* samu@textile.mrt.ac.lk

Tel: 011-2640485

319/C

Analysis of sewage sludge and its suitability as land application

Chathuri Dilanika Geeganage^{1*}, Nilanthi Bandara¹ and K Mohotti²

¹ *Department of Forestry & Environmental Science, University of Sri Jayewardenepura, Gangodawila, Nugegoda*

² *Tea Research Institute of Sri Lanka, Talawakelle*

Disposal of sewage sludge on agricultural or forest lands has been shown to be an economical means of sludge disposal which reduces the amount of waste going to landfills and returns nutrients to the soil. The objective of this study was to evaluate selected chemical, biological and plant growth characteristics of sewage sludge generated from the central sewage treatment plant of the Biyagama Export Processing Zone (BEPZ) by comparing with that of composted municipal solid waste, bio compost,

and soil also with the standards set by SLSI to determine its suitability as land application.

In this study total N, P, Organic Carbon by, K and Heavy metals (Cd, Cr, Cu, Zn, Ni, Pb), pH, microbial activity, were determined to determine the possibility of using sewage sludge as a land application. To determine the suitability for plant growth, germination of *Phaseolus vulgaris* variety T.C., and their mean plant height, mean number of leaves emerged; fresh and dry shoot weight and root weight were analysed. The results were statistically analysed using one way ANOVA and Turkey's pair-wise comparison

Based on the results obtained, the pH level of sewage sludge is less than the lower limit of the standard range for organic manure and it shows no significant difference with other land application media which was analysed. Heavy metal content of the tested sewage sludge was within the standard values for organic manure set by the SLSI. According to the one way ANOVA with the exception of content of Ni, the contents of other heavy metals in sewage sludge are significantly higher than that of composted municipal solid waste, bio compost and soil. N content in the sewage sludge is less than the standard level, but compared to other land application media it shows no significant difference with municipal solid waste and soil. The contents of other nutrients such as, K, P and Organic Carbon are higher than that of the minimum required levels of the standards for organic manure. Microbial activity in the sewage sludge shows no significant difference with composted municipal solid waste. Analysis of results obtained for plant growth shows that the growth of plants is poor in sewage sludge compared to other land application media, and growth in sewage sludge was improved when sewage sludge was sterilised which indicates that there is a pathogenic effect in sewage sludge. Therefore, it can be concluded that heavy metals in the sewage sludge analysed in the study are within the standards for organic manures set by the SLSI, and except for K, N and P levels are lower than the Sri Lankan Standards. Therefore large amounts of sludge should be added in order to obtain the same effect as other organic fertilizer. If not, a source of nitrogen and phosphorous should be added. There is a good microbial population which can release nutrients fast enough to maintain rapid plant growth. The growth is poor in sewage sludge due to an undefined reason. This may be due to pathogens or harmful organics used by the industries in the zone.

Further studies should be carried out to investigate the cause of retardation of growth and to investigate further to determine whether there are any harmful micro organisms and harmful organic constituents in the sewage sludge. This would enable to identify a suitable disinfectant for disinfecting sewage sludge and thereby make it suitable for an appropriate land application. Further studies should be carried out to determine the appropriate sludge soil composition for land application. If sewage sludge is applied on land, regular monitoring should be done to ensure that in-house treatment of industrial waste water is properly done so that there is no risk of releasing toxics to sewage treatment plant.

The results are confined to sewage sludge analysed from common sewage treatment plant of BEPZ as composition can vary based on industry and type of activities handled by waste water treatment plant.

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Investigation of leaves and saw dust of jak tree as potential colouring agent for textile substrates

U G Samudrika* and N G H de Silva

Department of Textile and Clothing Technology, University of Moratuwa, Moratuwa

This focus of this research was the use of waste materials to produce a low cost natural dye. Jak trees are widely available throughout Sri Lanka. Timber trade is mainly situated in the Moratuwa area. Hence large quantities of sawdust are easily obtained. Ripe Jak leaves falling throughout the year were also an added advantage to conduct this project. As both natural materials are available in large quantities in Sri Lanka as well as in other countries, use of these can reduce the cost of materials. This kind of research can be developed to enter into the natural dye market, which is expanding. Saw dust is said to be termite proof and fairly resistant to fungi and bacteria, which gives additional advantage for dye preparation. There has been increasing interest in natural dyes all over the world especially in Europe, because of ecological, environmental and health problems related to the use of synthetic dyes. There is a need, therefore, to identify colour bearing natural substances for the future. The objective of this study was to develop a dye from leaves and saw dust of Jak tree (*Artocarpus Heterophyllus*) and to find the optimum condition for dyeing fabrics. An attempt was also made to minimise chemical usage, which makes this product low toxic. Dye extraction, dyeing and fastness testing were carried out to produce the dye.

The study concludes that the fabrics, which were dyed with the dye, produced from Jak leaves and saw dust have slightly low fastness for washing and light but it has considerably better rubbing fastness for both dry and wet. Further experiments need to be carried out using after treatments in order to improve the colour fastness to washing and light. Hence the fabrics dyed with above two dyes can be used for applications where, washing is not much needed and where frequent rubbing occurs.

* samu@textile.mrt.ac.lk

Tel: 011-2640485

SECTION D

401/D

Allelopathic activity studies of Sri Lankan seaweed extracts

S R Premaratne, M H Haroon and H R W Dharmaratne*
Natural Products Programme, Institute of Fundamental Studies, Kandy

Algae are known to produce an incredible diversity of secondary metabolites with a variety of biological activities. The focus of the present study is on seed germination inhibitory activity of seaweed extracts, with the hope of discovering new eco-friendly natural herbicides. Lettuce seed germination bioassay which is widely used in the detection of allelochemicals, throughout the world was carried out to examine 16 crude seaweed extracts for seed germination inhibitory activity. In this study, the normal lettuce seed germination assay was slightly modified to suit our needs. Out of 16 extracts tested, *Ulva fasciata*, *Caulerpa racemosa*, *Caulerpa sertularioides*, *Amphiroa anceps*, *Garcilaria hikkaduensis*, *Jania* spp. and *Cladophora* spp have shown statistically significant seed germination inhibitory activities, which might be due to the allelochemicals present in the seaweeds. Even though other extracts have not inhibited the lettuce seed germination at a significant level, reduced root lengths observed for all the extracts, except the methanol extract of *Caulerpa racemosa*, might increase the chance of desiccation in seedlings before establishment and delay growth. Interestingly, in the case of the methanol extract of *Caulerpa racemosa*, percentage seed germination enhancement and increased root length compared to the control (distilled water) was observed. Further studies are in progress with the hope of isolating natural products that are responsible for the above allelopathic effect of the seaweed extracts.

* hrwd@ifs.ac.lk

Tel: 081-2232002

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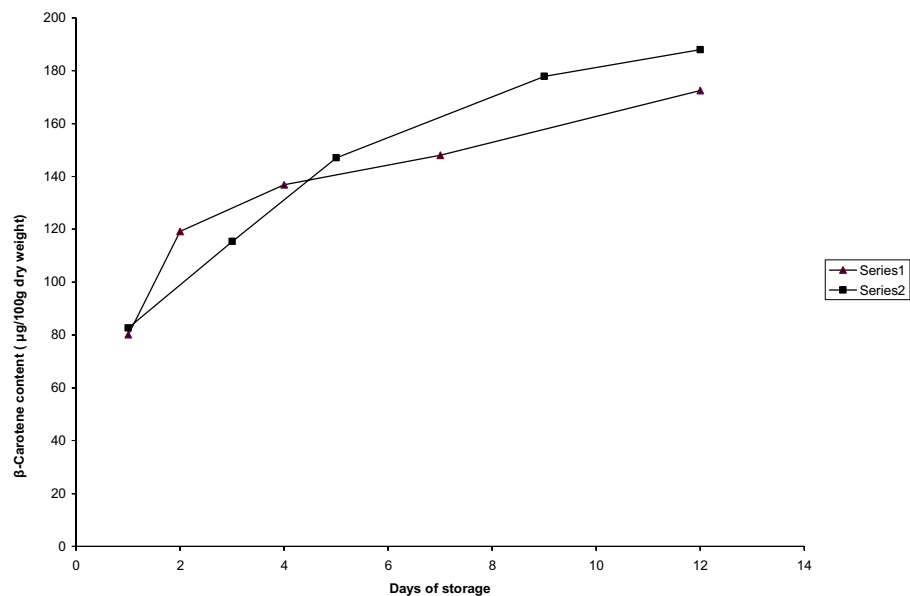
A study on post-harvest carotenogenesis of sweet potato

A M B Priyadarshani, E R Jansz* and H Peiris
Department of Biochemistry, University of Sri Jayewardenepura, Gangodawila, Nugegoda

In the context of alleviation of vitamin A deficiency, the importance of orange-yellow fleshed sweet potato has been demonstrated by many studies. Storing harvested intact tubers at room temperature can prolong the availability of sweet potato. In this study the effect of storage on post harvest carotenogenesis was studied. This is to find out if carotenoids are synthesised after harvest. The carotenoids content in orange-yellow fleshed sweet potato variety, "Gannoruwa white" during (a) the open and (b) Jute hessian (gunny) bag storage at ambient temperature for 12 days was determined on alternate days. Separation of the carotenoids was done by open column chromatography (OCC). Identification was based on scanning uv/visible spectrophotometry; comparison of visible absorption spectra with the published spectral information (λ_{max} and spectral fine structure), HPLC retention time and order of elution in OCC. Quantification was done by HPLC. β -Carotene and another unidentified carotenoid were detected from the studied sweet potato variety. Carotenogenesis occurred in both storage conditions with no significant difference in β -carotene content between the two conditions after 12 days of storage. During open storage, the β -carotene content increased from 80.1 $\mu\text{g}/100\text{g}$ after day 1 of harvest to 172.5 $\mu\text{g}/100\text{g}$ at day 12 (2.2 fold)

and in the Jute hessian bag storage, β -carotene content increased from 82.6 $\mu\text{g}/100\text{g}$ after day 1 of harvest to 188.0 $\mu\text{g}/100\text{g}$ at day 12 (2.3 fold). Both expressed on the basis of dry weight. The unidentified carotenoid showed the same trend of carotenogenesis as β -carotene (2.4 and 3.0 fold for open and Jute hessian bag, respectively). As long as moisture content is sufficient the enzymes synthesising carotenoids appear to perform normally. During post harvest storage, there was no appreciable loss of moisture that is no significant drying.

Figure 1: Changes in β -carotene content during storage in open and Jute hessian bag at ambient temperature



*Series 1- Open storage

*Series 2- Bag storage

Acknowledgement: Grant: Sri:07 of IPICS.

* erjansz@sjp.ac.lk

Tel: 011-2803578

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Some nutritional aspects of *Lasia spinosa* (kohila)

A G Shefaana, S Ekanayake* and E R Jansz
 Department of Biochemistry, Faculty of Medical Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda

A member of the family Araceae, the plant *Lasia spinosa* is a stout, spiny marshy plant with a creeping spiny rhizome. The tender leaves and rhizomes are used as a vegetable. The present study was carried out to determine the total antioxidant activity of *Lasia spinosa* and the contribution to antioxidant activity from the polyphenol fraction and ascorbic acid. In addition, the dietary fiber content was also determined. The antioxidant

activity of the samples was determined using 2,2'-azinobis (3-ethylbenzothiazonline-6 sulfonic acid) diammonium free radical cation salt (ABTS) assay with Trolox as the standard (antioxidant activity expressed as $\mu\text{mol/g}$ Trolox Equivalent Antioxidant Capacity (TEAC). Dietary fiber content was determined enzymatically. Rhizomes (n=6) of *Lasia spinosa* were collected from six different markets in the locality near the university.

According to results obtained from this study, *Lasia* rhizome proved to be a rich source of dietary fiber with 40% - 74% of total dietary fiber. The fiber fraction constituted of 36% - 60% and 4% - 17% of insoluble and soluble fiber respectively. The rhizome possessed an antioxidant activity of 144.0 – 957.0 $\mu\text{mol/g}$ TEAC on a wet weight basis with main contributions from polyphenols (39%) and ascorbic acid (43%). These results demonstrate the antioxidant potency of the *Lasia* rhizome which could be the basis for alleged health promoting potential. The high variation in the antioxidant activity in the samples could be due to biological variation, maturity and genetic and climatic effects. These antioxidants could act independently or synergistically with fiber to reduce the adverse effects of various diseases. The present study demonstrates that inclusion of 25-30 g of kohila would satisfy 6-10% of the recommended fiber requirement of an adult (25 g). In addition, this would contribute a considerable amount of antioxidant compounds to the diet. Thus kohila could serve as a good source of functional food with potential health benefits.

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* sagarika@slt.lk

Tel: 011-2803578

404/D

Biological control of bean rust of *Phaseolus vulgaris* by different rhizobacteria under greenhouse conditions

S Abeysinghe*

Department of Botany, Faculty of Science, University of Ruhuna, Matara

Bean rust caused by *Uromyces appendiculatus* Pers. is one of the major pathogens in bean (*Phaseolus vulgaris*) leads to considerable crop loss annually. In order to minimise the crop loss and application of fungicides alternative plant protection methods should be developed. Biological control is one of the options in this respect. Therefore, identification of biological control agents was attempted in this study. By using a root colonizing bioassay *in vitro*, five isolates of root colonizing bacteria were selected from the bacterial pool isolated from healthy bean rhizosphere. The bacterial isolates were identified as a *Serratia* spp., a *Bacillus* spp., and three isolates of *Pseudomonas* spp. When these isolates were used in pot experiments, induction of induced systemic resistance (ISR) against bean rust caused by *Uromyces appendiculatus* was observed with only two bacterial strains. A *Serratia* spp. and a *Pseudomonas* spp., among the root colonisers were significantly ($P < 0.05$) reduced the number of uredosporic pustules in leaves compared to non-bacterised controls in bean leaves indicated the potential of ISR mounting abilities of these strains. Non-root colonisers did not induce ISR against the

pathogen. These results indicate that root colonization is one of the important criteria to induce ISR.

* saman@bot.ruh.ac.lk

Tel: 041-2227024

405/D

Pseudomonas fluorescens* isolated from *Capsicum annuum* rhizosphere produces multiple antibiotics and exerts a broad spectrum of activity against different pathogenic fungi *in vitro

S Abeyasinghe*

Department of Botany, Faculty of Science, University of Ruhuna, Matara

An isolate of *Pseudomonas fluorescens* from *Capsicum annuum* rhizosphere showed strong antagonism towards various important soil borne pathogens in Sri Lanka. The crude extraction of 72 h culture supernatant strongly inhibited mycelial growth in Petri plate assay. The crude extract recorded the highest inhibition zone of 25 mm with 38% inhibition of mycelial growth against *Pythium* spp. over control. It had a significant effect on the hyphal morphology of *Pythium* spp., *Sclerotium rolfsii*, *Rhizoctonia solani*, *Fusarium oxysporum* f. sp. *cubense* and *Macrophomina phaseolina*. The hyphal tips of different isolates were also affected. Moreover, complete inhibition of sclerotia germination of *S. rolfsii* and *R. solani* was observed. TLC analysis indicated that the presence of probably two Phenazine compounds in the crude extract and these compounds might be the reason of fungal inhibition by the *P. fluorescens* isolate. Further investigation is underway to identify the antifungal compounds and potential use of the bacterial isolate as a biological agent.

* saman@bot.ruh.ac.lk

Tel: 041-2227024

406/D

Computer assisted semen analysis for cortisol antagonist induced sperm motility in *Anarhichas minor* (spotted wolfish)

S Kugathas*

Norwegian College of Fisheries Science, University of Tromsø, Norway

A major constraint in the culture of Spotted Wolfish (*Anarhichas minor*) is low sperm count and motility in captive conditions, where they are known to produce high plasma levels of cortisol. Synthetic cortisol antagonist (RU486) was tested to increase the motility of sperms in order to increase the fertilization rate. An experiment was conducted in completely randomised design with control (without RU486) and treatment (intramuscular injection of RU486 dissolved in propylene glycol via dorsal musculature), with 10 replicates. Control and treatment groups were held in rectangular tanks with

seawater (32-34 ‰ salinity) of 90 % O₂ saturation in the outlet water. Fish were kept at ambient temperature and natural photoperiod (Tromsø, Norway – 70 °N 19 °E), and were fed in excess with pellet food. At the end of the experiment, all fish were stripped and computer assisted semen analysis was performed to assess the influence of RU486 on sperm motility. Straight line velocity (VSL), average path velocity (VAP), beat cross frequency (BCF), curvilinear velocity (VCL) and percentage motility of sperm cells were the most sensitive indicators of movement. Increased plasma levels of RU486 significantly ($p < 0.05$) increased the BCF (8.5 ± 1.71 cycles/s), VCL (47.7 ± 4.6 $\mu\text{m/s}$), VSL (16.5 ± 4.40 $\mu\text{m/s}$), VAP (22.1 ± 5.15 $\mu\text{m/s}$) and the percentage motility (49.1 ± 6.75 %) in treated group compared to respective controls (4.5 ± 1.35 cycles/s, 39.8 ± 6.01 $\mu\text{m/s}$, 9.5 ± 1.58 $\mu\text{m/s}$, 16.6 ± 3.63 $\mu\text{m/s}$, and 40.9 ± 4.93 %). There were large differences between the VCL (~45 $\mu\text{m/s}$) and the VSL (~12 $\mu\text{m/s}$). This is in contrast to the smooth curve of the trajectory of sperm of most fish species in which the VSL and VCL are similar. Results of the present study indicate that RU486 significantly increases all aspects of sperm motility and could be used to increase the fertilization rate in wolfish.

Present address: Department of Zoology, University of Jaffna, Jaffna

* skthas6@yahoo.com
407/D

Tel: 077-6452467

Diuretic activity of high grown Sri Lankan dust grade No. 1 tea (*Camellia sinensis* L.) in rats

W D Ratnasooriya*, T S P Fernando and R A A R Ranatunga
Department of Zoology, University of Colombo, Colombo 3

The aim of this study was to evaluate the diuretic potential of Sri Lankan high grown dust grade No 1 black tea which is consumed widely by the tea drinkers worldwide. Different doses of hot black tea brew (BTB) of dust grade tea equivalent to 1.5, 3.0, 9.0 or 24 cups and green tea brew (GTB) (both Chinese and Japanese type) equivalent to 3 (180 $\mu\text{g/ml}$) cups were made and orally administered to previously starved (24 h) but subsequently hydrated (with 15 ml of isotonic saline) rats and their urinary output was monitored cumulatively at hourly intervals for 6h. The reference drug used was frusimide (13 mg/kg). The results showed that dust grade BTB induced significant ($p < 0.05$), moderate and dose-dependent diuresis (starting from 3 cups). This diuretic activity had a fairly rapid onset (within 2 h) and relatively short duration of action (1 h). BTB also significantly ($p < 0.05$) increased the overall urinary frequency. Further, the diuretic activity of dust grade BTB was less potent to GTBs (Chinese type by 34% and Japanese type by 47%) and frusimide (by 45%). Decaffeination of dust tea almost completely abolished the diuresis whereas the decaffeinated green tea inhibited diuresis partially. The diuresis of the dust tea brew was solely due to increased (by 55 %) urinary Na⁺ excretion (with no urinary K⁺ loss). Further, the chronic daily administration of the dust tea brew did not develop tolerance or induce toxicity (general, renal and hepatic). It is concluded that Sri Lankan high grown dust grade No 1 black tea is a natural, safe, orally active moderate diuretic with rapid onset and relatively short duration of action.

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* wdr@zoology.cmb.ac.lk
2583106

Tel: 011-

408/D

Antinociceptive effect and toxicological study of the aqueous inner stem bark extract of *Kokoona zeylanica* on rats

U E Illangakoon¹, W D Ratnasooriya^{2*} and S A Deraniyagala¹

¹ *Department of Chemistry, University of Colombo, Colombo 3*

² *Department of Zoology, University of Colombo, Colombo 3*

Kokoona zeylanica Thw. (family :celastraceae;Sinhala: Kokun) is an endemic plant used in traditional medicine of Sri Lanka for headache and snake bites. However, its antinociceptive activity has not been scientifically investigated so far. The aim of this study was to examine the antinociceptive potential, toxicity and phytochemistry of aqueous inner stem bark extract (ISBE) of *K. zeylanica*. Phytochemical screening of the ISBE showed the presence of alkaloids, flavonoids, tannins/polyphenols, steroids, terpenoids and saponins. Antinociceptive activity was investigated using rats in three test models of nociception (tail flick, hot plate and formaline tests). The results showed that the oral administration of ISBE at different dose (750, 1500, 2500 mg kg⁻¹) led to significant (P < 0.05) antinociceptive activity (when evaluated in hot plate and formaline tests but not in tail flick test). The 2500 mg kg⁻¹ dose had the highest antinociceptive activity compared to the control. The antinociceptive activity of ISBE had a rapid onset (within 1 h) and a fairly long duration of action (up to 5 h) with a peak effect at 1 h. The antinociceptive activity was dose dependent. In formalin test, the ISBE caused graded inhibition of both phases of formalin-induced pain. The impairment of the early and the late phases indicate that the ISBE is effective against acute nociceptive pain and continuous inflammatory pain respectively. Also the suppression of both phases indicates that the ISBE has peripherally mediated antinociceptive action as well. Further, the antinociceptive activity was not associated with harmful side-effects or toxicity even following subchronic administration and the extract was not cytotoxic towards brine shrimps lethality assay. Pretreatment with naloxone and atropine failed to block the antinociceptive activity. On the other hand, metochlopramide significantly (P < 0.05) curtailed the antinociceptive action time indicating that the antinociceptive action was mediated centrally at supraspinal level mainly via dopaminergic mechanisms. In addition, it is likely that antioxidant activity (by TBARs assay) and the mild sedative activity (determined by Hole board test) at high dose of the ISBE could have played an auxiliary role in inducing antinociception. Dopaminergic, antioxidant and sedative activities of ISBE could arise from its steroidal, phenolic and flavanoid constituents. It is concluded that ISBE of *K.zeylanica* has marked safe oral antinociceptive action.

* wdrrathna@webmail.cmb.ac.lk

Tel: 011-2503399

409/D

Antinociceptive activity of aqueous extract of the stem of *Vernonia zeylanica* (L.) Less. in rats

S K J S Peiris¹, W D Ratnasooriya² and S A Daraniyagala^{1*}

¹ Department of Chemistry, University of Colombo, Colombo 3

² Department of Zoology, University of Colombo, Colombo 3

Vernonia zeylanica (L.) Less. (Family: Asteraceae; Sinhala: Pupula; Tamil: Kuppilay) is an endemic shrub in Sri Lanka. In Ayurvedic medicine, this is recommended to be used in the treatment of fractures of bones. This suggests that it may have pain relieving properties. But, as yet this has not been scientifically tested. This study was carried out to investigate the antinociceptive potential of aqueous extract of the stem of *V. zeylanica*.

The water extract was prepared by refluxing macerated stem in distilled water for 2 days. Different doses of extract (AE) (750, 1000, 1500 mg/kg ; n=8/group) or vehicle (1ml distilled water) were orally administered to male rats and the analgesic potential evaluated using two models of nociception (hot plate and tail flick tests).

A considerable antinociceptive activity was evident in the hotplate test but not in tail flick test. The 1500 mg/kg dose had the highest activity (in terms of prolongation of hot plate reaction time) compared to the control. AE had a rapid onset of action (within 1h). AE showed no harmful side effects or toxicity following subchronic administration and when tested in brine shrimp lethality assay. The antinociceptive action was mediated centrally at supraspinal level. The AE also suppressed the number of paw lickings and the time spent on paw licking in the formalin test at both phases indicating that the AE also has peripherally mediated antinociceptive action. Pretreatment with nalaxone significantly reduced the reaction time induced by 1500 mg/kg of extract in the hot plate test indicating that the activity was mediated via opioid mechanisms.

In the hole board test number of crossings, rearings and head drippings were significantly reduced by the AE indicating sedative activity. Also AE had mild antioxidant activity (judged by TBARS method). The sedation and mild antioxidant activity of the AE could have played a supporting role in inducing antinociception.

Phytochemical studies and chemical analysis of the AE showed the presence of alkaloids, steroids, triterpenoids, flavonoids and polyphenolic constituents.

The AE induced inhibition of pain could arise from the presence of opioids and/or opioidomimetics (which could be alkaloid constituents) that were found in the AE, as well as from the presence of phenolic constituents and/or steroidal constituents which were shown to be present in the extract.

In conclusion, this study shows that the aqueous extract of *V. zeylanica* stem has orally safe antinociceptive action.

* SD@chem.cmb.ac.lk
2503367

Tel: 011-

410/D

The effect of Gramoxone (main ingredient gramoxone) on growth and survival of larvae of the endemic frog, *Polypedates cruciger*

M R Wijesinghe*, G Karyawasam and W D Ratnasooriya
Department of Zoology, University of Colombo, Colombo 3

Long-term (52-day) renewal experiments were conducted to assess the effects of gramoxone (with active ingredient paraquat), a widely used herbicide, on the growth and survival of larvae of the common hourglass frog, *Polypedates cruciger*. Two egg masses were collected and left to hatch under laboratory conditions. Hatchlings, corresponding to Gosner stage 20 (gill stage), were reared in glass tanks filled with tap water (20 per tank), exposed to 4, 10 and 40 ppb of gramoxone and monitored for eight weeks. Treatments and untreated controls were maintained in triplicate. Water was changed and pesticide concentrations were renewed every five days. Mortality was noted daily and body length measurements were taken at approximately weekly intervals. A significant positive dose-dependent trend was evident with exposure to higher doses resulting in greater levels of larval mortality (Pearson's correlation: $r = 0.99$, $p < 0.001$). Our observations also showed that long-term exposure to 40 ppb gramoxone caused a significant elevation in larval mortality (65 %) as compared to the control (8.33 %) (one-way ANOVA and post hoc Tukey test: $F_{3,8} = 19.67$, $p < 0.0001$). No significant reductions in survival were noted at doses of 4 and 10 ppb. Considering mortality levels at the different doses and using Regression Analysis the LD50 value was determined. After 52 days of repeated exposures, the tadpoles had a LD50 value of 32 ppb. Furthermore, survival rates in all treatments varied throughout the experiment with the highest mortality occurring between 11-21 days after exposure.

Despite the profound effects observed with mortality, gramoxone did not seem to affect the growth rates of the tadpoles. Although statistical analysis of the final body length measurements showed that there was significant differential growth among tadpoles across the various treatments (one-way ANOVA; $F = 10.46$, $p < 0.001$), the post hoc Tukey tests revealed that this difference existed only between the controls and the lowest dose of 4 ppb. Detailed examination of the results indicated that growth at the highest dose was impaired during the initial phase of the exposure but this trend was seen to reverse with the few survivors showing an abnormally high growth rate during the latter stages. Due to the adverse effects on mortality observed in this study, we conclude that gramoxone, at concentrations above 40 ppb, may pose a serious threat to the survival of natural populations of this endemic amphibian species in agricultural landscapes.

* mayuri@zoology.cmb.ac.lk
411/D

Tel: 011-2583106

An assessment on species richness of Ichthyofauna in the Thalangama lake

Thilina Surasinghe^{1&2*} and Enoka Kudavidanage³

¹ *Department of Zoology, University of Colombo, Colombo 3*

² *Department of Biological Sciences, Rajarata University, Mihintale*

³ *Department of Natural Resources, Sabaragamuwa University, Buttala*

The study was conducted over a period of four years to estimate the species richness of a suburban lake at Thalangama, in close proximity to Colombo. Weekly excursions were made to the study site. Fishes were caught using hand nets. The sampling locations were randomly selected. To randomly select the sampling locations, 1: 50000 grid map

of the lake area was used. Numbers were given to the grids and using a random number table, sampling grids were chosen. The sampling sites were selected that correspond to the grid number in the map. Sampling sites included the periphery of the lake, vegetated areas, open water and deep central areas of the lake. Records were also taken from catches of fishermen and visual observations, especially in the case of large-sized fish species. All fish species encountered were identified, recorded and released back. Twenty-seven species of freshwater fishes were encountered in this study, which consisted of five freshwater fish orders (Cypriniformes, Siluriformes, Cyprinodontiformes, Perciformes, and Channiformes) and 12 freshwater families (Channidae, Belontiidae, Anabantidae, Gobiidae, Cichlidae, Poeciliidae, Aplocheilidae, Heteropneustidae, Siluridae, Bagridae, Cyprinidae, Cobitidae). Five introduced species were recorded in this study. Among the 22 indigenous fish species, six were endemic. One endemic genus was also recorded in this research, *Malpulutta*. No significant variation in species richness or species composition of fish was observed over the four years. The species richness of the four consecutive years 2001, 2002, 2003 and 2004 were 27, 27, 26 and 26 respectively. Nevertheless, the relative abundance of two species, *Horadandia autukorali* and *Aplocheilus dayi* reached extreme high levels in October-December period in each year. The lake is subjected to pollution due to garbage dumping, eutrophication followed by soil erosion and inputs of agro-chemicals. Destruction of surrounding vegetation, invasion by introduced fauna and flora aggravated this situation. As a perfect habitat complex for suburban and urban wildlife, especially freshwater fish, the Thalangama Lake and its environment should be subjected to conservation and management strategies. In the process of conservation, the restoration and reclamation of vegetation of the lake vicinity, protection of the nearby marshes, and prevention of further pollution and removal of invasive species should be implemented.

* surasinghe@yahoo.com

Tel: 025-2266128

412/D

The effect of biocide exposure on the survival, growth and development of abnormalities in hour glass tree frog (ANURA: RANIDAE)

U A Jayawardena^{1*}, A N Navaratne², P H Amerasinghe³ and R S Rajakaruna¹

¹ Department of Zoology, University of Peradeniya, Peradeniya

² Department of Chemistry, University of Peradeniya, Peradeniya

³ International Water Management Institute, C/o ICRISAT, Patancheru-502324, Hyderabad, India

A number of environmental stressors, such as biocide contaminants, trematode infections and UV-B exposure, have been hypothesised as responsible for recent increase in limb abnormalities and severe range reduction in amphibians throughout the world. In this study, the effect of four commonly used biocides (two herbicides - glyphosate and 3, 4 DPA and two insecticides - chlopyrifos and dimethoate) on the survival, growth and development of abnormalities in the common hourglass tree frog, *Polypedates cruciger* were determined. The LD₅₀ values of the four biocides for *P. cruciger* were determined by exposing 5 days post-hatch tadpoles, to a concentration series of the respective chemicals. Survival was recorded weekly and growth and development were assessed at metamorphosis by measuring their snout-vent length, weight and the time required for forelimb emergence in 50% of the

tadpoles in a given treatment (TE_{50} value). Exposure of tadpoles to higher concentrations (>0.05 ppm) caused significant reduction in survival ($\chi^2 = 24.87$, $df = 3$, $p = 0.001$), while lower concentrations (<0.05 ppm) resulted in growth retardation and an elevated incidence of abnormalities, which were dose-dependant ($\chi^2 = 68.55$, $df = 3$, $p = 0.001$). Exposed tadpoles that took more time (80-147 days) to metamorphose were smaller than the tadpoles in the control group (36 days). The observed abnormalities mainly were lordosis (tail bending and vertebral column curvature) and lumps (almost everywhere on the body). The percentage abnormalities decreased with the age of the tadpole. However, growth retardation and abnormalities due to biocides makes them more susceptible to other environmental stressors. The study revealed that the all four biocides significantly affected the survival, growth and development of abnormalities on *P. cruciger*, which could possibly impose severe threats to natural populations. This study provides the first empirical evidence of the effect of biocides on the survival, growth and the development of abnormalities of a frog species, *P. cruciger* in Sri Lanka.

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* uthpala_jayawardhana@yahoo.com

Tel: 081-2394481

413/D

The first record of *Aneuretus simoni* Emery (Sri Lankan Relict ant) from Sinharaja forest and its relative abundance estimated by several sampling methods

K A M Perera, R K S Dias* and S Yamane
Department of Zoology, University of Kelaniya, Kelaniya

Aneuretus simoni Emery (Subfamily: Aneuretinae) has been recorded only from Sri Lanka. The relative abundance of *Aneuretus simoni* workers in Sinharaja forest, a world heritage site, was investigated from 14th to 17th February 2005 by honey baiting, litter sifting, soil sifting and pitfall trapping along a 100 m transect laid in each of the ten sites under dry weather conditions. Honey baits were kept at 4 m intervals and were collected after an hour. Some morphospecies and their numbers observed in honey baits were recorded in the field and the rest were preserved in 85% ethanol. Litter sifting (10) and soil sifting (20) were carried out at 10 m and 5 m intervals, respectively. Honey baited pitfall traps (10) were fixed in the evening at each of three sites to collect ants at night. Air temperature (21°C – 27.5°C), soil temperature (21°C – 25°C), mean litter depth (2.1 cm – 6.1 cm) and soil humidity (29.2% - 35.8%) of each site were also measured.

Worker ants belonging to seven subfamilies, Amblyoponinae, Aneuretinae, Cerapachyinae Dolichoderinae, Formicinae, Myrmicinae and Ponerinae and thirty two morphospecies of worker ants were observed. *Aphaenogaster* sp. 1 (38.6%) was dominant whereas *Technomyrmex bicolor* Emery (11.6%), *Pheidole* sp. (11%), *Paratrechina* sp.1 (10%), *Tetramorium* sp. 2 (5.2%), *Aphaenogaster* sp. 2 (4%), *Lophomyrmex* sp. (3.5%), *Pheidologeton* sp. 1 (2.5%), *Tetramorium bicarinatum* Mayr (2%), *Hypoponera* sp. 1 (1.8%), *Pheidologeton* sp. 2 (1.5%), *Myrmecaria* sp. (1%), and *Aneuretus simoni* Emery (1%) were observed in lower proportions. Each of the other

morphospecies contributed less than 1% to the ant community in this forest and the rare ants *Amblyopone* sp., *Harpegnathos* sp. and *Vollenhovea* sp. were also observed.

Significantly lower number of *A. simoni* workers than that of all other worker ants ($\chi^2 = 1529$, $p < 0.05$) was observed in Sinharaja forest. This species was recorded from 50% of the study sites in 2% (Site - B), 1 % (D), 1.5 % (E), 7.5 % (F) and 1 % (I) proportions. The relative abundance of *A. simoni* workers was 12 % (N = total number of worker ants = 106), 3% (N = 88) and 0.3 % (N = 1742) in litter, Soil and honey baits, respectively. *Aneuretus simoni* was not observed in pitfall traps. Although *A. simoni* has been recorded from several habitats earlier, this is the first record of this species from Sinharaja forest.

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* rksdias@kln.ac.lk

Tel: 011-2914479

414/D

**Influence of rain fall and sand grain size on the distribution
of crustacean macro-fauna in the North Western coast of Sri Lanka**

S Kugathas* and Y Sivatharshan
Department of Zoology, University of Jaffna, Jaffna

A monthly survey was performed over a period of one year from October 2003 to September 2004 in a sandy and in a muddy coastal area in Mannar Island to see the influence of rainfall and sand grain size on the distribution of macro crustaceans. In both study areas, six sampling sites were selected and vertical transects (with 0.5 x 0.5 m² quadrant in 1.5 m uniform interval) were laid with 100 m distance along the shore. To ensure the constant sampling of the same areas during sampling, permanent marks were set in the study site. Random sampling was also performed and the samples were identified with the help of invertebrate keys and references. Wherever appropriate student t-test was done to compare the differences. Shore crabs, *Gammarus* sp *Balanus* sp. and *Lepas* were recorded. In muddy shore abundance of all four species was high when compared to sandy shore. Mean numbers of crabs (6.08±1.13) and *Gammarus* (188.58 ±11.2) per m² are significantly high in muddy shore compared to that of sandy shore (3.18± 0.63, 146.69 ±12.00). Distribution of Crabs and *Gammarus* positively correlated with rain fall, but not with temperature or humidity while the distribution of *Balanus* and *Lepas* shows no relationship with any of the climatic factors. In sandy shore, there was no correlation between climatic factors and the distribution of crustaceans. It is concluded that increasing sand grain size decreases the abundance of all reported crustaceans while rain fall influences the distribution of some crustaceans in muddy shore but not in sandy shore

* kugathas@jfn.ac.lk

Tel: 077-6452467

415/D

**Vocalisations of the *Urocissa ornata* (Sri Lanka blue magpie)
in the Sinharaja world heritage site**

C P Ratnayke^{1*}, E Goodale² and S W Kotagama^{1*}

¹ Department of Zoology, University of Colombo, Colombo 3

² Evolutionary & Organismic Biology, University of Massachusetts, Amherst, MA 01003, USA

We studied the vocalisations of the Sri Lanka Blue Magpie (*Urocissa ornata*), a threatened restricted range species to Sri Lanka, to investigate possible functions within the social organisation of the species during breeding and non-breeding seasons and its use of vocal mimicry. Behavioral observations and recordings were made of three groups of individually marked birds and in three additional localities in Sinharaja world heritage site during the intensive study of behavior and ecology of the species.

The magpie produced 15 distinct vocal displays as well as specialised reproductive and developmental vocalisations. We recognised 6 vocal displays (“Cracks”, “Tings”, “Cricks”, “Up only”, “Gargle” and “Whiny-L”) were nonspecific and given in several circumstances: territorial, mixed species flock encounters, alarm, alarm & mobbing, contact, forging, and flight. The remaining vocal displays had specific context: “Whiny-H”(alarm & mobbing), “cuck”(contact), “sub song” (foraging), mimicry (alarm), “Up down” (alarm). The magpie vocalisations have a “combinatorial” property that consists of different acoustic elements combined with different sequence and produced vocal signals with different functions. The “crick” had combinatorial and transition characteristics and grade into “cracks” and “tings”. “Crack” call type was the most used vocal display and consisted of various structural and temporal variations, which were produced in different contexts. The “Gargle” display had the greatest structural variation and possibly found individual stereotypy, which was important to recognise individuals. Specific reproductive calls produced before egg laying or during the incubation period with courtship display. “Begging” calls frequently produced by the nestlings, fledglings, first year juveniles and adult female bird during the incubation period. Low amplitude non-alarm mimicry was found mostly in “sub-song” often produced by first year or second year juvenile birds perched on a branch while forging within group. The loud alarm mimicry of *Accipitar* hawk calls and giant squirrel, which were produced both adult and juvenile birds. This tropical magpie’s vocalisations were compared to other magpie species and it is suggested that imitation of predators may be a universal signal among several species of the same avifauna, as Greater Racket-tailed Drongo (*Dicrurus paradiseus*) mimic the same *Accipitar* hawk calls in the same area.

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* chamipra@yahoo.com

Tel: 011-5342609

416/D

**Characterisation and differentiation of local mustard
(*Brassica juncea* L.) germplasm in Sri Lanka**

W S R Wimalasuriya¹, S R Weerakoon^{1*}, S Somarathna¹ and M C M Iqbal²

¹ Department of Botany, The Open University, Nawala, Nugegoda

² Institute of Fundamental Studies, Kandy

Mustard (*Brassica juncea* L.), a member of the genus *Brassica* of the family Brassicaceae, is an important spice. It has been grown in the Indian subcontinent for hundreds of years as an oil seed crop. However, in Sri Lanka, mustard is grown comparatively in lesser extent compared to other crops and is widely used as a condiment as well as oil for cooking purposes and in Ayurvedic medicines.

It has been reported that there are about 60 mustard accessions available in Sri Lanka. However, the genetic diversity and the relationships among these mustard accessions were yet to be studied and documented. The objective of the present study was to assess the genetic divergence of locally available genotypes of *B. juncea* using numerical analyses of agro-morphological characters, for identification of genetically diverse and agronomically superior accessions of mustard which may generate putative transgressive segregates on hybridisation. The study included thirty (30) mustard accessions available locally and on which thirty five agronomic characters were measured and recorded.

Morphological data were analysed using different multivariate statistical procedures: Cluster analyses, Principle Component Analyses (PCA) and Discriminant Function Analyses (DFA). In cluster analysis, five clusters of mustard accessions were recognised at 60% dissimilarity level (60% phenon level). The PCA extracted eleven components explaining a cumulative variance of 69% of the total variance in the dataset and variance of 31% was not explained by PCA. Therefore, DFA was carried out on the dataset to characterise and differentiate the mustard accessions and to compare the DFA results with PCA. The scatter plots produced by plotting DFA 1 versus DFA 2 indicated that there were three distinct groups of mustard accessions. Comparison of PCA and DFA revealed that there was a difference in the grouping patterns of mustard accessions yield under different statistical procedures. The results revealed that morphological characters seem to be inadequate in tracing the morphological variation in the mustard accessions and other sources of information such as biochemical and molecular markers are of importance in characterisation of mustard accessions.

* srwee@ou.ac.lk
Ext. 383

Tel: 011-2853777

417/D

Morphological diversity of new coconut phenotypes identified from Unawatuna and neighbouring villages in the southern province

G K Ekanayake^{1*}, C K Bandaranayake¹, P N Dassanayake² and J M D T Everard¹

¹ *Coconut Research Institute, Lunuwila*

² *University of Sri Jayawardenepura, Gangodawila, Nugegoda*

Genetic improvement was recognised as an important strategy for increasing coconut productivity and thereby the production to meet increasing demands of various industries. Identification of true genetic diversity in populations is a strong prerequisite for a properly directed coconut breeding programme. Various morphological and molecular descriptor analyses of coconut have revealed a narrow genetic base in country's germplasm collection conserved *ex-situ* in field gene banks. Recent discovery of a 'coconut diversity hotspot' in the southern province, confined to Unawatuna and adjoining villages prompted this study, to assess morphological descriptor states of four new phenotypes; Ran pol, Juwan, Murusi and Bothal thembili identified from this region. Thirteen inflorescence and 27 fruit descriptors were recorded over a period of one year in above phenotypes along with four well known coconut phenotypes; Sri Lanka tall, Dwarf green, King coconut and San Ramon. High female-flower-bearing capacity with a large number of spikelets carrying female flowers, long central axis of inflorescence in Juwan, and exceedingly high weights of all components of the fruit in Ran pol were noteworthy observations made during the assessment. Principal Component Analysis (PCA) performed on data revealed number of female flowers, spikelets with female flowers, length of central axis, peduncle thickness, peduncle length, number of male flowers and all components of fruit as good indicators of diversity. The morphological differences observed in floral and fruit structures are encouraging. Clustering of phenotypes clearly reflect the traditional grouping; tall-like and dwarf-like coconuts. The true genetic variation of new coconut phenotypes would be further extensively elucidated by DNA assessments planned in future.

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* gkekanayake@yahoo.com

Tel: 031-2255583

418/D

Relationship between the lithological characteristics and the coastal erosion trends along the Southern and Southwest coastal zone of Sri Lanka

A K Wickramasooriya*

Faculty of Applied Sciences, South Eastern University of Sri Lanka, Sammanthurai

Coastal zone of Sri Lanka, which is defined in the Coast Conservation Act No 57 of 1981 shows a great importance as it is rich in natural resources and is the most economically

productive area in the country. However, it has been experiencing numerous environmental and socioeconomic problems. Coastal erosion is one major issue affecting various coastal segments in the study area. This is more significant along the Southwest and Southern coasts. Many natural influences like climatic changes, wave energy, tidal effects etc. as well as human activities are responsible for this impact. There are places which were eroded more than 50 meters within last two to three decades. However, in some places, it is noted that even though the existing environmental and climatic conditions are very similar, there are different trends of coastal erosion. It was observed that this is mainly due to the variation of available surface materials and their physical characteristics like fracture intensity, porosity etc. Therefore, the nature of the available surface materials is one of the major factors that determine the rate of coastal erosion in the study area. Mainly there are eight different types of surface materials that can be identified along the South and Southwest coastal zone of Sri Lanka. They are hard rocks, moderately weathered rocks, weathered overburden, limestone, beach rock, laterite, coastal deposits and protection structures. They were ranked according to their influence on coastal erosion and according to their physical characteristics like porosity, fracture intensity etc, another ranking system was introduced. After analysing these ranking systems using spatial technology i.e. Geographical Information Systems (GIS), the study area was divided into different costal segments based on resistance to coastal erosion.

* awickramasooriya@yahoo.com

Tel: 067-2260073

419/D

Importance of interactions among endophytes for plant growth

W M M S Bandara and G Seneviratne*
Institute of Fundamental Studies, Kandy

Plants profit extensively by harboring endophytic microbes. They promote plant growth and confer enhanced resistance to various pathogens by producing antibiotics. However, the way the interactions among endophytes influence the plant productivity has not been studied. Present study experimentally showed that endophytes isolated from rice plants produced 2 types of cultures: biofilms (bacteria attached to mycelia) and mixed cultures with no such attachments. Organic acid production as measured by pH in cultures with biofilms was higher than that of fungi alone, bacteria alone or mixed cultures. The acid production of individual microbes was marginally increased when they were in biofilms or mixed cultures. The Indoleacetic Acid Like Substances (IAAS) production of biofilms was higher than that of mixed cultures, fungi or bacteria. Bacteria and fungi produced higher quantities of IAAS than mixed cultures. In mixed cultures, the IAAS production of individual microbes was hampered considerably. There was a clear negative relationship between IAAS and pH of the biofilms, indicating that IAAS was the main contributor to the acid production. However, such a relationship was not observed in mixed cultures. Microbial acid production is important for suppressing plant pathogens. Thus the biofilm formation in endophytic environment seems to be a very important factor for healthy and improved plant growth. However, it is unlikely that an interaction among endophytes takes place naturally in the endophytic environment, due to physical barriers of plant tissues. Further, critical cell density dependant quorum

sensing that leads to biofilm formation may not occur in the endophytic environment as there is a limited space. As such *in vitro* production and application of beneficial biofilmed inocula of endophytes are important for improved plant production in any agro-ecosystem.

* gaminis@ifs.ac.lk

Tel: 081-2232002

420/D

Assessment of rates of soil carbon sequestration by litter decomposition of Yagirala forest reserve & Horton plains natural forest in low country wet zone and montane zone of Sri Lanka

L A M C Amarasekara^{1*} and D M S H K Ranasinghe¹

¹ *University of Sri Jayewardenepura, Gangodawila, Nugegoda*

An assessment of rates of soil carbon sequestration by litter decomposition was carried out in 2 forest types; Yagirala Forest Reserve (FR) in the low country wet zone & Horton plains Natural Forest (NF) in Montane zone of Sri Lanka.

Yagirala Natural Forest Reserve was located between 6°21' to 6°26' North altitude and 80°6' to 80°11' east longitude in the lowland wet climatic zone in Sri Lanka. Horton Plains Natural Forest was located between 6° 47'- 6° 50' north latitude and 80° 46'- 80° 51' east longitude in mid country of Sri Lanka.

Three transects with three plots (100m distance) were established for each forest. Annual litter fall was estimated from 36 litter traps located in Yagirala Natural Forest and 9 litter traps in Horton Plains. Litter decomposition rates were estimated by mesh bag technique. The experiment was conducted in Yagirala forest reserve from August, 2005 to May, 2006 for a period of 8 months and in Horton plains NF December 2005 to May, 2006 for a period of 5 months.

According to the results, the rate of litter fall in the Yagirala FR was 7.72 tons/ha year compared with 3.13 tons/ha year in Horton Plains Natural Forest. The values for carbon sequestration for the Yagirala Forest Reserve were 2.87 tons ha⁻¹year⁻¹ while the Horton Plains NF recorded 0.57 tons ha⁻¹year⁻¹.

According to the results, it is clear that Yagirala Forest Reserve situated in the low country wet zone recorded higher carbon sequestration rates compared with Horton Plains Natural Forest situated in the montane zone of the country.

Key words : Annual Maximum Litter Decomposition Percentage, Carbon sequestration, Litter fall rates

* matheesha.amarasekara@gmail.com

Tel: 077-7626305

421/D

Leaf anatomy of some canopy, sub canopy and understorey seedlings grown under different light regimes in the Sinharaja forest

W M L M Weerasinghe* and B M P Singhakumara

Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Gangodawila, Nugegoda

Light is especially crucial during the seedling stage of rain forest trees. Therefore, it is necessary to know the nature of the responses of the seedlings in different light environments in order to carry out most of the silvicultural practices in forest management. The anatomical characteristics at leaf level are important in the silvicultural practices since these characteristics play a major role in reducing water loss and increasing photosynthesis. In this regard, study of the leaf structure of endemic tree species in most abundant light environments in the lowland rain forests is very important.

This study examined the anatomy of some seedling leaves belonging to canopy, sub canopy and understorey species which have been grown in controlled light environments for two years near the field station of Sinharaja forest reserve. There were seventeen species. (10 canopy, 4 sub canopy and 3 understorey species) belonging to families; Dipterocarpaceae, Clusiaceae and Melastomataceae. The controlled light environments were having the light environments of partial sun (R: FR ratio 1.05, PPFD $800 \mu\text{molm}^{-2}\text{s}^{-1}$) and partial shade (R: FR ratio 0.97, PPFD $350 \mu\text{molm}^{-2}\text{s}^{-1}$). Each light level had three replicate shade houses. The leaf anatomy attributes considered were: thickness of leaf blade, upper epidermis, palisade mesophyll, lower epidermis and cuticle layer.

Results showed significant difference of the leaf anatomical attributes in most of the species in two light environments. Within canopy species, except for *Shorea trapezifolia* and *S. congestiflora*, in other 8 canopy species, considered leaf anatomical attributes have increased in partial sun. For all sub canopy and understorey species, all considered anatomical attributes have increased with light intensity, although there were no significant difference of some of the attributes in two light environments. Results elucidate that the considered anatomical attributes can be used in determining the shade tolerance of a species. Most of the species show better performance in partial sun.

* unisj@sjp.ac.lk

Tel: 011-2802695

422/D

A review of application of economic instruments in industrial pollution control in Sri Lanka

I D Weliwita* and U A D P Gunawardena

Department of Forestry and Environmental Sciences, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda

Industrial pollution is a negative externality that arises since the impacts of pollution control are not part of the industry's decision making process. Negative externalities include health impacts, direct and indirect impacts on productivity, effects on ecosystems and aesthetic effects. Economic instruments are often preferred over the conventional command and control approaches in controlling pollution. However, application of economic instruments in Sri Lanka is minimal leading to increasing levels of pollution in

air water and land resources. The objective of this study was to review the application of economic instruments in Sri Lanka and to review the use and availability of economic values in guiding the design of economic instruments.

The review was based on two surveys. The first survey was on the available applications of economic instruments for different types of pollutants in Sri Lanka with a view to recognising the potential application in other areas, potential advantages over the conventional approaches and economic efficiency issues. A second survey was carried out on economic damage cost estimations of pollution in Sri Lanka and their usefulness in guiding economically efficient economic instruments for the industrial sector.

Survey of existing instruments of pollution control revealed that financial assistance for cleaner production technologies (Rs 3 to 5 million per industry), common waste water treatment plant (with a cost of Rs 8.5 billion) and relocation of industries in industrial estates (22 estates in 13 districts) are the prominent interventions from the government and there has been no market based instruments in operation. Damage cost estimations have been very scarce thus limiting their application in optimal instrument levels. The applicability and feasibility of load based charge system (with a tariff based on Chemical Oxygen Demand of the industry) has been tested for industries that are to be connected to the common treatment plant for Moratuwa-Rathmalana and Jaela-Ekala industrial areas. The potential for further application of economic instruments was also evident from the literature.

* unisj@sjp.ac.lk

Tel: 011-2802695

423/D

Effects of the tsunami on metal concentrations in water and sediments of Rekawa lagoon

H B Asanthi^{1*} and P R T Cumarantunga²

¹ *Department of Limnology, Faculty of Fisheries and Marine Sciences and Technology, University of Ruhuna, Matara*

² *Department of Fisheries & Aquaculture, Faculty of Fisheries and Marine Sciences and Technology, University of Ruhuna, Matara*

Megathrust earthquake with a moment magnitude of 9.3, which occurred close to west coast of the Indonesian island, Sumatra, on 26th December 2004, affected the Sri Lankan coastal districts. It first hit the eastern coastline, shortly after 8.00 am and then swept along the southern and south-western shores of Sri Lanka within the next 90 minutes. In certain areas, tsunami waters were reported to be black and carrying a thick muddy sludge. In the Hambanthota (south-eastern coastal town), water was reported to be of slimy texture. Initial inference is that, marine sediments may have deposited in coastal water bodies and on land. Rekawa lagoon has an area of 2.50 km² and supported the fishery, which provides fish for the consumers in the vicinity of the lagoon. Lagoon was partially damaged and the ecological and economic loss due to tsunami is quite obvious. Present study was an attempt to determine whether the tsunami has affected the metal concentrations in water and sediments of Rekawa lagoon. Samples of water and sediments were collected from the lagoon after tsunami in February 2005 and they were compared with samples collected on three occasions since January 2004 from the same sites. Metal concentrations in all samples were determined by ICP-MS (VG

Plasma Quad PQ2 Turbo Plus). Concentrations of As, Sr, Zn and U in water varied significantly with the sampling occasions and there was a significant difference in the concentrations of above metals in water samples collected before and after the tsunami ($P < 0.05$). Sr and U concentrations in water were significantly different after the tsunami from other three occasions. Mean metal concentrations in sediments, especially of metals such as Mn, Co, Zn and Ba were significantly different after the tsunami from other three occasions ($P < 0.05$). Concentration of As in sediment samples that were collected after the tsunami exceeded the low effect range (ERL) recommended by Australian National Oceanic and Atmospheric Administration (NOAA, 1999). Since As is a toxic metalloid, serious attention should be given to this matter.

* asanthi@fish.ruh.ac.lk

Tel: 041-2227026

424/D

Preliminary studies on mangroves vegetation in three coastal villages in Batticaloa district, Sri Lanka

P Manoharan*

Department of Botany, Faculty of Science, Eastern University, Chenkalady

Villages of Pillayardi, Sathurukkonadan and Tannamunai are located in lagoon associated coastal areas in Batticaloa district, Sri Lanka. Mangroves and its associated species have been dominated for years in the villages. Mangrove vegetation is divided by a main road A15 thus forming thin and stretched land near the shore with vast vegetation in the inland areas. A preliminary study was carried out to determine the distribution, status of mangroves and associated species and its ecosystem in the three villages. There are six true mangroves and seventeen mangroves associated species which were identified between December 2005 and May 2006. Most of the mangrove and its associated species are reported near the shore site. A few *Sonneratia caseolaris* trees are found to grow taller than other species and are found only along the lagoon shoreline. Dominant species is *Excoecaria agallocha* and found in both shoreline and inland areas. A few *Rhizophora apiculata* were observed either along the coastal site or in between *Excoecaria agallocha* patches near the shore. *Avicennia marina* was found within the inland site, but found to be away from coastal water points and trunk road. More *Lumnitzera racemosa* were recorded in an inland site compared with the shoreline site. *Suaeda maritima* was found only in the inland site along with grasses. Such species zonation in between sites suggests the ability of the species to stand and tolerate the salinity during their life span. Most of the mangrove associated species such as *Acanthus ilicifolius*, *Acrostichum aureum* and *Typha angustifolia* were found in the shoreline area. A major part of the inland area is being cultivated with paddy.

Species recorded on either side of the road are more vulnerable to deforestation due to the present situations. However, a gradual regeneration is evident from the pruned mangrove and thus could sustain the mangrove ecosystem. Aforestation with *Rhizophora* sp. and *Terminalia arjuna* along either sides of road. Bird migration begins in August and ends by May. But, noise caused by vehicular movement along the trunk road possibly affects bird's occupation of this wetland.

* prikok@yahoo.com

Tel: 065-2240757

425/D

Accumulation pattern of some selected heavy metals in some edible fish species from Bolgoda lagoon

Pathmalal M Manage^{1*} and Samiddhi D Wijethilaka¹

Department of Zoology, University of Sri Jayewardenepura, Gangodawila, Nugegoda

Heavy metals exist naturally at background levels in the environment but they can also be introduced into the aquatic environment from anthropogenic activities. Once released to the environment, these metals transfer via food chains by bioaccumulation and bioconcentration to fish, which leads to severe health hazards on humans and other piscivorous animals when they are consumed.

Therefore, the present study was carried out to determine the levels of Lead (Pb), Cadmium (Cd), Chromium (Cr), Zinc (Zn), Nickel (Ni), and Copper (Cu) of some selected edible finfishes, (*Ambassis commersoni* - Katilla), *Netuma thalassinus* - Anguluwa), *Mugil cephalus* - Godaya); shellfishes, *Metapenaeus dobsoni* - Malissa), *M. ensis* - Korallissa) and plankton from two sampling stations of Horethuduwa and Panadura estuary in Bolgoda Lagoon, from September 2005 to February 2006, by means of Flame Atomic Absorption Spectroscopy (FAAS).

The highest mean concentrations of Zn ($2.8923 \pm 0.488 \mu\text{g/g}$), Pb ($0.1110 \pm 0.053 \mu\text{g/g}$), Ni ($0.0620 \pm 0.034 \mu\text{g/g}$) in *N. thalassinus*, Cu ($0.0226 \pm 0.009 \mu\text{g/g}$) in *M. ensis* and Cd ($0.0225 \pm 0.002 \mu\text{g/g}$) in *M. cephalus* were recorded from Horethuduwa. The Cr levels ($0.0307 \pm 0.004 \mu\text{g/g}$) in *N. thalassinus* from Panadura Estuary were greatest among other species analysed. The detected highest metal concentrations remained well within the acceptable limits of CEA (Zn <5.0mg/kg, Pb <1.0mg/kg, Cd < 2.0mg/kg, Cr < 1.0mg/kg, Ni < 5.0mg/kg, Cu <3.0mg/kg). Therefore, the present detected heavy metal levels may not seriously effect on health hazards by consuming *A. commersoni*, *N. thalassinus*, and *M. cephalus*, *M. dobsoni* and *M. ensis* from Bolgoda Lagoon. Though, exposure to daily low doses of the mentioned heavy metals may lead to chronic toxicity. The highest bioaccumulation factors (BAF) for Cd (200.00), Cr (140.00), and Cu (186.67) were detected in plankton from Horethuduwa where as highest BAFs for Pb (25.00) and Ni (17.21) were recorded in plankton from Panadura Estuary and Zn (263.75) in *N. thalassinus* from Horetuduwa. Almost all the metals show low bioaccumulation factors except for Zn in *N. thalassinus*. The bioaccumulation factor for Pb was less than 1 for all fish species showing a diminution in higher tropic levels where as BAF of Pb was grater than 1 for plankton showing a definite biomagnification. Thus, the findings of the present study highly recommend the importance of regular monitoring of heavy metals in fishes and biota from Bolgoda Lagoon since all other metals tested other than Pb and Ni (except in *N. thalassinus*) show bioaccumulation.

* path@sjp.ac.lk

426/D

Heavy metal levels in two species of food fish, *Etroplus suratensis* (Koraliya) and *Ambassis commersoni* (Katilla) inhabiting Negombo lagoon, Sri Lanka

P Indrajith¹, K A S Pathiratne^{2*} and A Pathiratne³

^{1,2} Department of Chemistry, University of Kelaniya, Kelaniya

³ Department of Zoology, University of Kelaniya, Kelaniya

Negombo lagoon which is used by the local community mainly for fishery is becoming polluted with chemicals from various sources. The present study was carried out to assess the total levels of eight metals viz. Pb, Cu, Hg, Cd, Cr, Mn, Zn and Ni in the muscle, liver and gills of two species of food fish, *Etroplus suratensis* and *Ambassis commersoni* inhabiting the lagoon. Fish samples were collected from seven locations of the lagoon and the levels of Hg in the tissues were analysed by cold vapour atomic absorption spectrometry. The other metals were analysed by graphite furnace atomic absorption spectrometry. Total metal levels in muscle tissue (in $\mu\text{g kg}^{-1}$ wet weight) of the two species showed a wide range: Pb 11-81; Cu 23 -374; Hg 32-329; Cd 2-48; Cr 22 - 283; Mn 54-506; Zn 28 -3002; Ni 14-310; in *E. suratensis* (n=150); Pb 4-61; Cu 6-251; Hg 41-258; Cd 1 - 30; Cr 7-241; Mn 9-321; Zn 65-2561; Ni 6-211; in *A. commersoni* (n = 95). Accumulation of most metals in the tissues of these two species followed the increasing order, muscle<gills<liver. Of the different metal levels detected in the tissues of the two fish species, only the level of Cd in liver tissue of *E. suratensis* (6%) and *A. commersoni* (12%) exceeded the level specified for human consumption by European Union. No significant differences in metal accumulation levels were found between the two species of fish examined in the gill and liver tissues. Mean levels of Zn and Hg in the muscle tissue of *A. commersoni* were two fold higher than that of *E. suratensis* (P<0.001). Bioaccumulation factors of the metals in the muscle tissues of the fish in relation to water ranged from 5 to 171 for *E. suratensis* and from 8 to 142 for *A. commersoni*. The levels of metals in the muscle tissue of both fish species were positively correlated (P<0.001) with the body weight or body length of the fish. Based on the levels of Hg, Pb, and Cd in fish, edible muscle of both fish species collected from the lagoon was found to be safe for human consumption. However, consumption of bigger size fish may pose a health risk to the consumers as there were strong positive correlations between body weight /body length and metal levels in muscle tissues of both species of fish.

¹ Present address: SGS Lanka laboratory Services, 141/7, Vauxhall Street, Colombo 2

* kaspathi@kln.ac.lk

Tel: 011-2914486

427/D

Lipid profile of marine and fresh water fish consumed by Sri Lankans

J J Gunasekara and S Wimalasena*
Department of Chemistry, University of Kelaniya, Kelaniya

Percentage moisture and lipid in the edible flesh and the lipid profile of the oil of seven commercially important commonly consumed marine and fresh water fish namely *Scomberomorus commerson* (Sinh. Thora), *Neothunnus macropterus* (Sinh. Kelawella), *Stoleophorus indicus* (Sinh. Hendella), *Scomberomorus guttatus* (Sinh. Anjeelawa), *Sphyraena jello* (Sinh. Jeelawa), *Etroplus suratensis* (Sinh. Irikoraliya) and *Oreochromis mossambicus* (Sinh. Tilapia) were determined. Comparison of the composition of the oil of different varieties of fish as well as that between marine and fresh water fish is reported in the present study. For each species 48 fish samples purchased from fish markets in Pettah, Negambo, Gampaha and Moratuwa during periods of March - May (2005), June - August (2005), September - November (2005), December (2005) - February (2006) were analysed. Moisture content of the edible flesh was determined using Dean and Starke apparatus with toluene as the solvent. The lipid from the fish was extracted using CHCl_3 : CH_3OH (1:1) and methylated using boron trifluoride - methanol. 39 fatty acids were identified in the methylated fish oil by glc analysis using methyl esters of fatty acids and methylated cod liver oil whose peaks have been identified by standards in a previous study.

Moisture and lipid content per 100 g of edible flesh ranged from 64.9 – 72.4 g and 4.49 – 0.57 g respectively. Except for *S. indicus* all other marine fish species analysed contained a high content of lipid compared to fresh water fish. In all fish samples analysed total monounsaturated fatty acids (MUFA)(13.57 – 26.01%) was low compared to saturated (SFA)(37.40 – 47.73%) and polyunsaturated (PUFA)(29.02 - 43.56%). The content of palmitic acid (C16:0), oleic acid {C18:1(n-9)}, docosohexaenoic acid (DHA){C22:6(n-3)}, eicosapentaenoic acid (EPA){C20:5(n-3)}, arachidonic acid {C20:4(n-6)}, linoleic acid C18:2(n-6), γ -linolenic acid C18:3(n-6), α - linolenic acid C18:3(n-3) and the n-3/n-6 were 24.32 -28.69%, 3.78 - 12.34%, 5.43 - 21.08 %, 1.14 – 8.60%, 2.28 – 4.41%, 0.40 – 5.31%, 0.22 -2.78%, 0.19 – 0.50% and 1.23 – 4.81% respectively. Concentrations of EPA, DHA, n-3/n-6 and the percentages of EPA and DHA in PUFA in fresh water fish was very much lower than those in marine fish showing that they contain more n-6 acids. The results were subjected to two way ANOVA and significant difference in the values was observed for site, period of collection and the interaction of the two.

The results of the present study reveals that of the fish species analysed the oils of *N. macropterus* and *S. indicus* are the two best sources of oil that could contribute to the beneficial health effects for they had the highest % of PUFA, lowest % of SFA and highest % sum of DHA and EPA.

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* sukumalw@yahoo.com

Tel: 011-2914486

428/D

A study on mosquito larvaecidal and hyper haemolytic compounds of palmyrah flour

A A P Keerthi, E R Jansz* and S Ekanayake

Department of Biochemistry, FMS, University of Sri Jayewardenepura, Gangodawila, Nugegoda

The presence of several bioactive principles in palmyrah (*Borassus flabellifer* L.) flour is documented. In the present study attempts were made to identify the effects of palmyrah flour extractives on different mosquito larvae at different larval stages. The methanol extractive of palmyrah flour indicated activity against dengue mosquito (*Aedes albopictus* and *Aedes aegypti*) larvae with a LD₅₀ value of 0.06 to 0.076 mg/ml depending on larval molting stage. Larvaecidal activity was due to formation of a physical barrier on the surface of water by compounds in the methanol extract. These high froth-forming compounds lowered the surface tension of the water and were identified to be saponins. The lethality was dependent on the length of the breathing siphons. The *Aedes* mosquito larvae with short breathing siphons were unable to penetrate the physical barrier formed by the flour extractive. However, *Culex quinquefasciatus*, with long breathing siphons was not effected. The existence of a saponin, which exhibited high haemolytic activity on human red blood cells, was observed during these studies. The applicability of the extract as a mosquito control agent in natural water bodies is limited due to high toxicity to other gill and lung fish (*Poecilia reticulata* (Guppy) and *Micoglanis iheringis*, (Antenna catfish)). The compounds act on the breathing surfaces, lungs, gills of fish and results in death. However, the compound can be used as a dengue in-house mosquito controlling method successfully as the dengue mosquito breeds in house holds and garden containers. Ultra structural differences or clastrogenic effects were not observed using transition electron microscopy in the larvae. Bioassay guided fractionation and MicroTOF mass spectrometry led to the identification of the structure of active compound as β -sitosterol – Glc – Rha – Rha.

The compound with high haemolytic compound obtained was identified as a flabelliferin with six carbohydrate units attached to β -sitosterol. Mass spectrum resulted peaks at M⁺/Z 1534.8015, 1307.6594, 1161.6041, 869.4889, 723.4309, 577.3737 and 415.3202. According to the mass spectrum and earlier data we postulate the attachment of a simple fatty acid to the flabelliferin.

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* erjansz@sjp.ac.lk

Tel: 011-2803578

429/D

Mosquito larvicidal toxin production of *Hirsutella thompsonii* in different broth mediums and incubation times

R Samarasekera^{1*}, I S Weerasinghe², D A S Siriwardhana¹ and M L Peiris¹

¹ Herbal Technology Division, Industrial Technology Institute, Bauddhaloka Mawatha, Colombo 7

² Department of Ebtomology, Medical Research Institute, Colombo 8

Mosquito control is a major priority to minimise the infections and transmission of mosquito-borne diseases in the tropical region including Sri Lanka. Increased public

concern regarding the potential adverse environmental effects of chemical insecticides has prompted the search of alternative methods for mosquito control. Biological control has been considered as an alternative to conventional chemical control methods as a means of mosquito control. Acaricidal activity of *Hirsutella thompsonii* have been previously reported against coconut and citrus mites and considered as promising biological control agent. Our recent studies have indicated that Sri Lankan isolates of *H. thompsonii* exhibited an effective mosquito larvicidal activity against laboratory reared *Anopheles tessellatus*, *Aedes aegypti* and *Culex quinquefasciatus*. The objective of the present study is to investigate the different liquid culture mediums and incubation times on production of mosquito larvicidal activity of *H. thompsonii*.

A suspension of infected mites was prepared, pour plated and incubated to obtain discrete colonies of *H. thompsonii*. Fungal colonies were identified by phase contrast microscope by examining the mycelia and conidiophores. *H. thompsonii* was grown in broth mediums, Czapek-Dox broth (CZ) and Glucose-Yeast extract (GY) at different incubation times of 7, 11 and 15 days to obtain crude broth extract, mycelium and spores. Mosquito larvicidal bioassay for *Cx. quinquefasciatus* followed the WHO standard protocol and LC₅₀ values were obtained by probit analysis using SPSS software package.

The mycelia, crude broth and spore amount production by *H. thompsonii* in GY and CZ culture media differed significantly and were depend on the incubation time. Mosquito larvicidal activity also varied with the culture medium and the incubation time. *Hirsutella thompsonii* gained its highest yield of spores, mycelium and the crude broth in CZ medium after 11 days shaking at 26 °C. The highest larvicidal activity against *Cx. quinquefasciatus* has been shown in CZ medium for crude broth (LC₅₀ = 35.347 ppm) and mycelium (LC₅₀ = 81.110 ppm) after 11 days shaking. For spores the highest larvicidal activity against *Cx. quinquefasciatus* (LC₅₀ = 9.76 x 10² spores/mL) has been shown in GY medium.

This study indicated that Sri Lankan isolate of *H. thompsonii* exhibited mosquito larvicidal properties and highest production of toxins was achieved in CZ medium after 11 days incubation time.

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* radhika@iti.lk
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Tel: 011-693807 Ext.

430/D

***Bacillus thuringiensis* and *Bacillus sphaericus* active against larvae of vector mosquitoes**

R Samarasekera^{1*}, I S Weerasinghe², M L Peiris¹ and D A S Siriwardhana¹

¹ Herbal Technology Division, Industrial Technology Institute, Bauddhaloka Mawatha, Colombo 7

² Department of Ebtomology, Medical Research Institute, Colombo 8

Bacillus thuringiensis var. israelensis (Bt) and *Bacillus sphaericus (Bs)* have been identified as the most efficient and widely used bacterial agents for mosquito control. They synthesise large quantities of insecticidal crystal proteins and are toxic against a wide range of insect species. The objectives of the present study are to isolate and identify Sri Lankan strains of *Bt* and *Bs* and to investigate mosquito larvicidal activity of those isolates grown on solid and broth mediums against *Culex quinquefasciatus* and *Aedes aegypti*.

Soil samples were collected from different climatic zones in Sri Lanka to isolate *Bt* and *Bs*. Two hundred and three isolated *Bacillus* species were screened for mosquito larvicidal activity against *Cx. quinquefasciatus* and *Ae. aegypti* and thirteen of them showed activity. Physical and bio-chemical testes were used in identification tests. *Bacillus thuringiensis* colonies were specifically identified by the presence of parasporal crystals under phase-contrast microscope. Single colonies of *Bt* and *Bs* isolates and ATCC and WHO standards were grown in Luria broth and final whole cultures were lyophilized to obtain the primary powders. *Bt* and *Bs* isolates and standards were also grown in aerobic liquid fermentation using molasses as the fermentation medium. Mosquito larvicidal bioassay for *Cx. quinquefasciatus* and *Ae. aegypti* followed the WHO standard protocol and relative toxicities, LC₅₀ were calculated using a probit analysis software package.

Twelve mosquito larvicidal *Bt* isolates and one *Bs* isolate were isolated from Sri Lankan natural habitats. The maximum biomass production with higher larvicidal activity against *Cx. quinquefasciatus* and *Ae. aegypti* was observed for liquid fermented cultures of *Bacillus*. Of the fermenter grown cultures, *Bt* SB125 showed the more activity against *Cx. quinquefasciatus* (LC₅₀ 0.02354 ppm) and *Ae. Aegypti* (LC₅₀ 0.02551 ppm), an activity comparable with the ATCC standards, *Bti*, *Btk* and *Bs* and WHO standards *Bt* H-14 and *Bs*-2362. Also *Bt* isolates, SB59, SB67, SB142, SB155, SB160, and SB172 and *Bs* isolate SB63 showed potential activity against *Cx. quinquefasciatus* and SB67, SB59, SB107, SB160, SB165, SB172 and SB63 against *Ae. Aegypti*.

This study showed that the *Bt* isolates, SB59, SB67, SB107, SB125, SB142, SB155, SB160, SB165 and SB172 and *Bs* isolate, SB63 could be used as useful biocontrol agents against the local vector mosquito larvae.

Acknowledgement: Financial Assistance by NSF grant no RG/2004/C/05.

* radhika@iti.lk

Tel: 011-693807 Ext.

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431/D

Quantitative assessment of essential elements in acute and chronic wound tissues

Iranga Rodrigo¹, Janitha A Liyanage^{1*} and Mandika Wijeratne²

¹Department of Chemistry, University of Kelaniya, Kelaniya

²Department of Surgery, Faculty of Medicine, University of Colombo, Colombo 8

Wounds are likely to have existed ever since man existed. Non-healing wounds reduce the quality of life for individuals and are a significant burden upon the financial resources of the healthcare economy of the country. Wound healing is an enormously complicated

process and the actual scientific mechanisms and events that take place during healing are far more complexed and dynamic than might be imagined. Essential elements, especially trace elements are believed to be pivotally important to the wound healing process. Their involvement in tissue regeneration and repair appears to be wide-ranging and the deficiencies have been reported to impair the healing process.

Thus an assessment of trace element levels in wound tissues could be beneficial for trace element based wound healing. This preliminary study was an attempt to assess whether there is any link between trace element concentrations of wound tissues and blood of patients in Sri Lanka hospitals.

Blood samples and tissue samples from 50 acute wounds and 58 chronic ulcers were analyzed for concentrations of Fe, Zn, Cu, Mn, Ca, Sn, Cr, Cd and Pb using atomic absorption spectrophotometry. All the data were tested for normality by Ryan-Joiner normality test ($\alpha = 0.05$) and one-way ANOVA was done for the normally distributed data.

Results showed that blood contains significantly higher amount of Fe than wound tissues and greatly varies with the patient. Ca is somewhat stable in blood and wound tissues contain more Ca when comparing to the blood for both acute and chronic wounds. Zn concentration is higher in blood than in wound tissues except for few cases. Concentrations of Cu in wound tissues are relatively lower than that of blood of the same patient. Mn is more or less stable and contains very low levels in the wound tissue and blood contains more Mn when comparing to wound tissues. Sn, Cd, Cr and Pd were not detected by graphite furnace atomic absorption spectrophotometry.

The metal content in acute and chronic wound tissues showed that the wound tissues always contain higher amount of calcium than blood of the same patient and other element levels are lower than blood in most patients.

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* janitha@kln.ac.lk

Tel: 011-2914486

SECTION E₁

501/E₁

**The effect of organo-chalcogen donor molecule BEDT-TTF
on the efficiency enhancement of the polymer sensitised solar cell**

N de Silva and G K R Senadeera*
Institute of Fundamental Studies, Kandy

Over the past decade, there has been a considerable progress achieved in the dye sensitised mesoporous TiO₂ solar cells employing liquid electrolytes. These devices show excellent power conversion efficiencies (up to 11%) due to the broad absorption spectrum of dyes based on ruthenium bipyridyl complexes. However, due to the long term unavailability of noble metals such as ruthenium and their high production cost, the use of conjugated polymers in such cells has generated a tremendous interest as these materials can be used simultaneously as sensitiser and a possible replacement for the liquid electrolytes. Among these conjugated polymers, poly [2-methoxy-5-(2V-ethyl) hexoxy-1,4-phenylenevinylene] (MEH-PPV) has attracted much attention due to its solubility in common organic solvents. However in the photo-voltaic cells using pure conjugated polymers, the energy conversion efficiencies are too low (typically of 10⁻³ to 10⁻¹ %) for practical applications, because these materials suffer from low charge mobility and short exciton diffusion lengths. Further, the transport of charge carriers from the organic film to the inorganic electrode is one of the most commonly observed problems associated with organic materials. In many cases improvement in carrier transport is obtained by introducing a buffer layer which adjusts the electronic behaviour of the adjacent materials. Keeping these in mind, we investigated the effect of organo-chalcogen donor molecule, bisethylenedithio-tetrathiafulvalene (BEDT-TTF or ET), which became the building block of organic superconductors, in the performances of polymer sensitised (MEH-PPV) solar cells. Photoresponses of the cells were compared under air mass 1.5 (100 mW 100 cm⁻²) before and after the addition of ET. Significant enhancement in photocurrent was observed for the TiO₂/MEH-PPV cells when MEH-PPV was blended with 2% (wt) ET. The FTO/TiO₂/MEH-PPV cell gives the open circuit voltage (V_{oc}) of 0.60 V, the short circuit current density (J_{sc}) of 0.95 mA cm⁻², and the fill factor (FF) of 0.62. In comparison, the FTO/TiO₂/MEH-PPV-2% ET cell shows a V_{oc} of 0.56 mV, a J_{sc} of 1.66 mA cm⁻², a FF of 0.64 and white light conversion efficiency (η) of 0.6 % that is ten fold to that of the cells without ET. It is observed that the photo current for cell with ET tends to decrease with the increase of the amount of ET.

* rsen@ifs.ac.lk

Tel: 081-2232002

502/E₁

Polymer sensitised quasi solid-state photovoltaic cells

J M R C Fernando and G K R Senadeera*
Institute of Fundamental studies, Kandy

Ruthenium based dye-sensitised solar cells (DSCs) have been reported to have high energy conversion efficiencies reaching 10% and are one of the promising candidates for next-generation solar cells. Apart from expensive ruthenium dyes, DSCs contain redox species (I⁻/I₃⁻) and volatile organic solvents such as acetonitrile. Because of their high volatilities, solvent losses occur during long-term operations, which decrease DSC performances. On the other hand, due to the high cost and the long-term unavailability of the ruthenium dyes, many research efforts have focused on improving this system by developing new sensitisers. In this context, conducting polymers (CPs) are a versatile

replacement for both the liquid electrolyte and the dye, since they can be synthesised to suit a wide range of technological purposes and are generally inexpensive. Keeping these in mind, substituted thiophene sensitised, nanocrystalline TiO₂-based quasi solid-state solar cells were fabricated either by using poly(3-thiophene acetic acid) (P3TAA) or a co-polymer; poly(3-thiophene acetic acid)–poly(hexyl thiophene) (P3TAA-PHT) polymers and copper iodide (CuI) as a hole conducting material together with the ionic liquid 1-ethyl-3-methylimidazolium bis (trifluoromethylsulfonyl) amide and lithium bis (trifluoromethanesulfone) imide as additives for charge transport promotion. Dramatic enhancements in the cell performances were observed with the additives in CuI. While the cell sensitised with P3TAA generated a short-circuit photocurrent of $\sim 1.45 \text{ mA cm}^{-2}$, an open-circuit photovoltage of $\sim 345 \text{ mV}$ with a total power conversion efficiency of $\sim 0.3 \%$ under simulated full sunlight of 100 mW cm^{-2} (Air Mass 1.5) the cell sensitised with copolymer P3TAA-PHT delivered $\sim 0.25\%$ efficiency under the same conditions with $\sim 1.23 \text{ mA cm}^{-2}$ as photocurrent and $\sim 371 \text{ mV}$ as photovoltage.

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* rsen@ifs.ac.lk

Tel: 081-2232002

503/E₁

Fractal properties of long sparks

D I Amarasinghe and D U J Sonnadara*
Department of Physics, University of Colombo, Colombo 3

Two methods have been utilised to study the fractal nature of long laboratory sparks. The first method based on a statistical technique uses the variation in angle between consecutive steps to deduce the fractal nature in segments. The second method is based on the sandbox technique to calculate the fractal dimension of long sparks.

The variation in step size was found to be exponential. The direction change followed a Gaussian distribution with a standard deviation of 12.1° . The average tortuosity of laboratory sparks was found to be $10.5^\circ \pm 0.6^\circ$. This is about 1° smaller than the values reported for fixed segment length. Thus, the tortuosity values reported in literature for natural and triggered lightning flashes may be a slight over estimate of the actual tortuosity.

The average fractal dimension of laboratory sparks was found to be 1.71 ± 0.14 . This value agrees with the commonly accepted 1.7 value for complex laboratory discharges. Surprisingly, the fractal dimension showed a dependency on the magnitude of the applied voltage. This is due to the brightness variations in the sparks caused by channel currents. Thus the fractal dimension not only depends on the channel complexity but also on the channel thickness. This feature can be extended to calculate the currents in natural lightning channels. However, this is a disadvantage when calculating the parameters such as channel tortuosity through fractal methods.

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* upul@phys.cmb.ac.lk

Tel: 011-2584777

504/E₁

Stochastic modelling of dielectric breakdown

D I Amarasinghe and D U J Sonnadara*

Department of Physics, University of Colombo, Colombo 3

Using a 2D stochastic dielectric breakdown model, patterns of lightning discharges and surface discharges were studied. The model based on a Laplacian growth, develops the breakdown process stepwise, choosing one lattice point at a time out of all possible lattice points. The probability of lattice points being chosen was weighted according to the cell potentials. The potential ' ϕ ' at each cell was calculated by solving the discrete Laplace equation subjected to the boundary conditions using the finite difference method. The simulated tree patterns were analysed using fractal techniques.

The fractal dimension of the simulated tree patterns varied depending on the cell configuration chosen for the breakdown. Fractal dimensions of the three possible cell configurations for the simulated lightning were 1.57 ± 0.02 , 1.43 ± 0.02 and 1.50 ± 0.02 . The inclusion of the cells in the diagonals with reference to the growth site produced less branched trees with smaller fractal dimensions. The production of branches depended highly on ' η ', which is the exponent of the probability distribution. When η is equal to 1, a highly complex tree pattern with many branches was observed. The 'sparse' nature of the breakdown pattern reduced rapidly with increasing exponent and produced patterns which were closer to the experimental observations. The most time consuming part of the simulation was the solving of Laplace equation for each new growth site. The model can be easily extended to study the tree growth in 3D.

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* upul@phys.cmb.ac.lk

Tel: 011-2584777

505/E₁

Lie group analysis of nonlinear ordinary differential equations

A G Johnpillai*

Department of Mathematics, Eastern University, Chenkalady

In this paper, the Lie group theoretical method of integration of second and third-order nonlinear ordinary differential equations (NLODEs) is presented. Point transformations that form a continuous Lie group of transformations or Lie point symmetries which leave the equations form invariant are studied.

The infinitesimal generator $X = \xi(x, y)\partial_x + \eta(x, y)\partial_y$ of an n^{th} -order NLODE, $y^{(n)} = H(x, y, \dots, y^{(n-1)})$, $n \geq 1$, is a Lie point symmetry generator if

$$X^{[n]}(y^{(n)} - H) \Big|_{y^{(n)} - H = 0} = 0,$$

where, $X^{[n]}$ is the n^{th} -prolongation of X .

The knowledge of the Lie point symmetries admitted by the equations combined with the notion of solvability of the Lie algebra is used in the integration process. The consecutive reduction of the order of the equations is done by the ideals of the Lie algebra.

For the second-order NLODE, an exact solution was obtained and the third-order equation was integrated by quadratures.

* agjohnpillai@esn.ac.lk

Tel: 065-2240753

506/E₁

Symmetry analysis of a variable coefficient nonlinear diffusion equation

A G Johnpillai*

Department of Mathematics, Eastern University, Chenkalady

The focus of this paper is the variable coefficient nonlinear diffusion equation of the form $u_t = (x^\mu u^{-4/3} u_x)_x$ which has various applications in mathematical physics. Point transformations that form a continuous Lie group of transformations or Lie point symmetries which leave the equation form invariant were then studied.

The generator $X = \xi^1(t, x, u)\partial_t + \xi^2(t, x, u)\partial_x + \eta(t, x, u)\partial_u$ is a Lie point symmetry of the equation if

$$X^{[2]} \left\{ u_t - \mu x^{\mu-1} u^n u_x - n x^\mu u^{n-1} u_x^2 - x^\mu u^n u_{xx} \right\} \Big|_{u_t - (x^\mu u^{-4/3} u_x)_x = 0} = 0,$$

where, $X^{[2]}$ is a second-prolongation of X . This is the determining equation of the Lie point symmetries of the equation under consideration.

Lie point symmetries admitted by this equation are used to reduce the number of independent variables in the equation by one called symmetry reduction and this has led to obtain group-invariant solutions that do not appear in the literature.

* agjohnpillai@esn.ac.lk

Tel: 065-2240753

507/E₁

Aggregation control of Langmuir Blodgett (LB) films of di octadecyl Merocyanine via applying a potential

N P Liyanawaduge^{1*} and C A N Fernando²

¹ *Industrial Meteorology Laboratory, Industrial Technology Institute, Colombo 7*

² *Department of Physics, University of Ruhuna, Matara*

Possible ways to enhance the photocurrent via preventing the formation of aggregates were investigated. Di octadecyl Merocyanine (C_{18} -Mero- C_{18}) molecules were deposited on conductive glass plate by LB technique. A constant voltage was applied to glass plate using conventional potentiostatic method with three-electrode configuration during the deposition. Absorption spectra of deposited layers were obtained and absorption spectra consist of the three peaks at 510nm (dimers) 540 (monomers) and 580nm (J-aggregates). In the Negative biasing condition dimers and J- aggregates are more abundant than monomers. In the positive biasing condition monomers are more abundant than dimers and J- aggregates.

AFM pictures of deposited dye layers by LB technique show that in the positive biasing condition, the surface of the dye film is 2D where as in the negative biasing condition it is 3D due to formation of J-aggregates.

A photocurrent enhancement can be seen in the photo electrochemical cell when formation of J- aggregates is controlled by applying positive voltage during the LB film is formation.

* prasanna@iti.lk

Tel: 011-2691516

508/E₁

Enhancement of absorption properties of interlocked dye films of di octadecyl Merocyanine with octadecyl Rhodamine prepared by Langmuir and Blodgett (LB) technique

N P Liyanawaduge^{1*} and C A N Fernando²

¹ *Industrial Meteorology Laboratory, Industrial Technology Institute, Colombo 7*

² *Department of Physics, University of Ruhuna, Matara*

The possibility to control the J- aggregates formed during film formation by LB technique by interlocking was investigated.

Compressing the dye layer on air-water interface causes reduction of surface area of the dye layer. The surface area corresponding to various values of surface pressure can be represented graphically, called surface pressure area isotherm.

Surface pressure area Isotherms of di octadecyl Merocyanine (C_{18} -Mero- C_{18}), octadecyl Rhodamine (R- C_{18}) and their 1:1 mixture confirmed the interlocking of octadecyl Rhodamine dye between two hydrocarbon chains of di octadecyl Merocyanine molecules. Interlocking minimise the formation of J-aggregates.

The absorption properties of the films will improve considerably when two dyes are interlocked to each other.

* prasanna@iti.lk

Tel: 011-2691516

509/E₁

Observations of H α line profiles in Be stars using 45 cm cassegrain telescope at the Arthur C Clarke Institute

Saraj Gunasekera^{1*}, Janaka Adassuriya¹, Indika Medagangoda¹, Jayathu Fernando¹
and

K P S C Jayaratne²

¹Arthur C Clarke Institute for Modern Technologies, Katubedda, Moratuwa

² Department of Physics, University of Colombo, Colombo 3

H α line profiles of 13 Be stars ($m_v \leq 6.9$) were observed using 45 cm Cassegrain telescope at the Arthur C Clarke Institute, Sri Lanka during the period of August 2005 to March 2006. The dispersing element of 1200 lines/mm reflective grating was used in the first order with spectral resolution $R = \lambda/\Delta\lambda = 22000$ to obtain high resolution spectra of Be stars. Data reduction was carried out using IRAF (Image Reduction & Analysis Facility).

The profile HR5941 is previously observed by R. Hanuschik (1986), Dachs & W. Hummel (1992) and Banerjee (2000). All these observations showed the $V/R < 1$ but the present study shows $V/R > 1$ (2.12), a drastic change in V/R ratio. i.e. the violet and red peak intensities are reversed. This cyclic variation of V/R ratio is ascribed to slow apsidal motion of the gas in the elliptical ring.

The observation made by R. Hanuschik (1986), Dachs & W. Hummel (1992) showed HR 6118 has a triple peak profile and according to Banerjee (2000) this is a wine – bottle type profile. Present observations show this profile has a symmetric Gaussian profile. The low $V_{\text{ sini}}$ (140 km/s) implies this should be a pole-on star and our profile clearly shows this fact. Observed HR2284 profile is a winebottle-type profile (Hummel 1994) which is caused by the non-coherent scattering broadening (NSB) of the optical thickness of H-alpha line radiation. We used a peak reconstruction line profile derivative method described by W. Hummel & M. Vrancken (1995) and developed a software code to detect the hidden peaks on wine bottle type line profiles. This method was applied to the spectra HR 2284, HR 6712 to find the peak separations.

We also found a good correlation (0.8) between FWHM and $V_{\text{ sini}}$ (D.P.K. Banerjee 2000). This can be explained by the Keplerian motion of the gas in the ring and the kinematic broadening is the major factor to the profile width. Projected velocity $v_{\text{ sini}}$ and the Keplerian velocity of the disk increase with the stellar rotation velocity v , thereby increasing the width of the profile. The strong correlation (0.96) between the I_p/I_c and the equivalent width of the profile clearly agrees with the definition of the equivalent width.

* saraj@accmt.ac.lk

Tel: 011-2651566

510/E₁

A simple and low cost device for saving cooking gas

E M Ranatunga and W G D Dharmaratna*

Department of Physics, University of Ruhuna, Matara

With ever increasing fuel prices, it is an urgent need to invent energy saving devices for practical applications especially for developing countries like ours that heavily depend on imported fuel. An attempt was made to invent a simple gas saving device for cooking

pans with round bottoms. The main objective is to reduce the energy loss to the surroundings due to convection, radiation and conduction.

A device is constructed to cover the gap between the burner and the wall of the cooking pan so that the maximum energy is transferred from the heated air to the pan. The device consists of a cylindrical aluminum foil around the pan with an air space between the pot and the foil, a glass wool around the foil as an insulating layer, partially covered bottom layer of insulating material with aluminum foil at the top and an insulating top. The efficiency of the device is compared with that of the bare pan by measuring the time taken to boil a fixed amount of water while keeping the other conditions the same. The variation of the temperature of water with time is measured using a temperature censer connected to a computer through a data acquisition unit.

The preliminary result indicates that the device reduces the gas consumption by ~20%. The study is in progress for further improvements and for the determination of optimal values for all parameters for pots of different shapes. However, it is already clear that the simple device invented here can be manufactured locally at low cost for practical applications.

* dharm@phy.ruh.ac.lk
Ext.4305
511/E₁

Tel: 041-2227022

Some effects in classical proton hydrogen atom collisions that originate due to dimensional restrictions

G Bandarage* and H S S Peiris

Department of Chemistry, The Open University of Sri Lanka, Nawala, Nugegoda

Thermal reactions are due to atomic and molecular collisions. Hence, a theoretical study of product formation in atomic collision processes constitutes a first step in understanding the detailed dynamics of chemical reactions. Quite often the simplest of such systems, viz. *bare nucleus-hydrogen atom* (three body) collisions, are studied in developing concepts associated with such processes and in testing new approximate theories. Such collisions lead to three types of outcomes, viz. excitation, charge transfer and ionization.

In the recent past, attention has been focused in studying the said collision system using classical mechanics. In Classical Trajectory Monte Carlo method the quantum nature of the electron dynamics is incorporated by running a large number of trajectories. Trajectories are generated by numerically integrating the relevant Hamilton's equations from a large internuclear separation, R_{in} , which is negative, to a large positive internuclear separation and then the outcome is determined. The dynamics of particles during the collision process can be studied in phase space. Such a study provides intriguing insights to the product formation process. In this context, it is useful to examine such collisions in reduced dimensions, viz. in one and two dimensions, in detail and the effects that originate due to such reduction in dimensions.

We have studied $H^+ + H(1s)$ collisions in one and two dimensions in detail in the internuclear velocity range $v = 1.09 \times 10^6 \text{ ms}^{-1}$ (0.5 a.u.) to $v = 6.56 \times 10^6 \text{ ms}^{-1}$ (3.0 a.u.).

In the case of two dimensions, the impact parameter was kept at zero so that the nuclear motion is the same in both cases. The probabilities of all three types of outcomes oscillate as a function of R_{in} . These oscillations are counter intuitive and are an inherent feature of the collision process. They are not due to limitations in statistics. Consistently, the probability of ionisation is higher in the case of collisions in two dimensions compared to its counterpart in one dimension. Probability of excitation and charge transfer as a function of nuclear velocity, shows more structure in one dimension than in two dimensions. The difference in amplitudes of oscillations in the probability of excitation and charge transfer in one and two dimensions is more prominent than that with ionisation.

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* gband@ou.ac.lk

Tel: 011-2822738

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**Analysis and evaluation of econometric time series models:
Dynamic transfer function approach**

T M J A Cooray*

Department of Mathematics, University of Moratuwa, Moratuwa

This paper illustrates how to apply a set of response variables and a set of explanatory variables by using systems of equations of regression models as well as the same set of variables model led by Dynamic Transfer Function (DTF) model, in order to compare degrees of accuracy and inter-relation between such variables. A macro econometric forecasting system employed by the Accounting and Statistics of Annul Bulletin published by the Central Bank of Sri Lanka was studied. We shall use this study to illustrate the problems with the inclusion of contemporaneous input variables in the identification of a transfer function model and their effects on the forecasting performance of the model. The methods used in this study have been developed by the author. The data from the period 1991-2004 have been used in this study.

* cooray@math.mrt.ac.lk

Tel: 011-2651123

513/E₁

The impact of economic growth intervention on electricity demand of Sri Lanka

T M J A Cooray*

Department of Mathematics, University of Moratuwa, Moratuwa

This paper presents an estimate of electricity demand of Sri Lanka using the well known econometric model, developed by Yang (2000) and Structural time series modeling method (STSM). We find that current as well as past changes in electricity demand have a significant impact on the change in real Gross Domestic Product (GDP) and electricity price in Sri Lanka. Due to the increase in electricity demand, the preferred specifications differ somewhat and there is quite a wide range in the long-run price and income elasticities. There is also a wide range of estimates of the speed with which consumers would adjust to any disequilibrium. Furthermore, the estimated effect of the underlying electricity demand increases over time. Thus, on one hand, it is encouraging that the Sri Lanka electricity authorities can have some faith in the model used for forecasting, which, for a small electricity generation system like Sri Lanka's represents a considerable difference. Hence, the chosen econometric work does have a considerable impact of the policy decisions in the Sri Lankan electricity supply industry. This study, therefore, explores this issue by investigating how different time-series estimation methods perform in terms of modeling past electricity demand, estimating the key income and price elasticities, and hence forecasting future electricity consumption in the context of the Sri Lankan electricity supply industry. This allows for a different forecast electricity demand using these different econometric techniques to be compared indicating that the policy decisions might vary according to the chosen econometric method.

* cooray@math.mrt.ac.lk

Tel: 011-2651123

514/E₁

White Noise in a stock market model

U N B Dissanayake^{1*} and C H Baduraliya²

¹ *Department of Mathematics, University of Peradeniya, Peradeniya*

² *Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka, Buttala*

Market is a place where buyers and sellers meet for day-to-day transactions and for long-term transactions. Stock market is a place where shares are sold and bought and it is a special kind of a financial market where market share price is determined at every moment. Share price index measures share price fluctuations on a daily basis. It is a well-known scenario that sudden disturbances in the society have a great impact on the price of goods and stocks in financial markets. The aim of this study was to investigate the effect of White Noise on the time path of the price function of linear stock market models via a Wiener process (inclusion of random disturbances in the form of differentials).

Under the assumption that the growth rate of the stock price $P(t)$ at time t is a linear superposition of a time independent parameter μ and the speed of the Wiener-process $W(t)$ with a time dependent White Noise Multiplier $\sigma(t)$, the governing equation of the stock market model takes the form,

$$\frac{1}{P} \frac{dP}{dt} = \mu + \sigma \frac{dW}{dt}, \text{ where } P(0) = P_0 > 0 \text{ and } t \in [0, T].$$

This is a Stochastic- Initial Value Problem (S-IVP) and using chain rule in stochastic calculus the following stochastic differential form can be established, where $\sigma \in C[0, T]$:

$$d(\log_e P) = (\mu - \frac{1}{2} \sigma^2) dt + \sigma dW$$

Solving this we get the time path of the price function $P(t)$. Upper bounds for expectation $E[P(t)]$ and variance $V[P(t)]$ are obtained using well-known CBS and GRB inequalities. That is, we have established the following results:

$$(i) P(t) = P_0 \exp[\mu t - \frac{1}{2} \int_0^t \sigma^2 ds + \int_0^t \sigma dW].$$

This shows that White Noise has a significant impact on the time path of the Price function.

$$(ii) E(P(t)) = P_0 \exp[\int_0^t \mu(s) ds] = P_0 e^{\mu t} \leq P_0 e^{\mu T}.$$

Thus the expectation of the time path of the price function is free from the white noise.

$$(iii) V(P(t)) \leq \|P^2\|_2 \|\sigma^2\|_2 \exp\left(\int_0^t \mu^2 ds\right) = \|P^2\|_2 \|\sigma^2\|_2 e^{\mu^2 T}.$$

Moreover this can be utilised to detect the strength of the White Noise $\|\sigma\|_s$ of the market model over a time period $[0, T]$.

* dissa12@yahoo.com

Tel: 081-2389134

515/E₁

A study on factors affecting the formation of cataract

D R T Jayasundara* and M R Sooriyarachchi
Department of Statistics, University of Colombo, Colombo 3

With the objective of determining the factors contributing to cataract formation, an unmatched, clinic based, case-control study was designed, in which cases are respondents having cataract and controls are those who do not have cataract. A total of 197 cases and 190 controls were taken. Initially, univariate analysis was used to select a small set of possibly significant variables from among the large number of variables.

Then binary logistic regression modeling was used to determine the factors affecting cataract formation and to quantify this effect.

After adjusting for confounding effects age, injury and drug, the risk factors minor indoor smoke, and ventilation near wood stove were found to be significantly associated with the development of cataract on eyes. Apart from the main effects, interactions of age and minor sources of indoor smoke like coils, joss sticks, age and duration cooked using wood for years, age and hypertension and drug and duration cooked using wood for years are also significantly associated with the formation of cataract.

These findings highlight that smoke affects the formation of cataract. The exposure to biomass smoke (i.e. smoke which comes from wood stoves), smoke from minor sources of indoor smoke like mosquito coils and joss sticks are high risk factors for getting cataract. In addition, the risk of having cataract for elderly people exposed to mosquito coil smoke throughout the night daily is high. Also elderly people with hypertension or involved in cooking for more than 20 years using wood as a fuel are more likely to develop cataract.

Diabetics exposed to smoke from coils and joss sticks are at a high risk of developing cataract. Ultimately, it can be said that other than the already discovered risk factors of cataract, like age, family history, medical problems such as diabetes, injury to the eye, medications especially steroids, long-term unprotected exposure to sunlight, previous eye surgery, the exposure to biomass smoke and mosquito coil smoke can also make an impact on cataract formation. According to the observed data, there is no evidence however to conclude that cigarettes smoke increases the risk of cataract.

* ravindij@yahoo.com

Tel: 011-2590111

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Factors affecting the prevalence of lung cancer and the survival of lung cancer patients

R V Jayatillake* and M R Sooriyarachchi
Department of Statistics, University of Colombo, Colombo 3

The study focuses on lung cancer, which is one of the common cancers found among Sri Lankans as well as one of the leading causes of death in the island. The data for the statistical analysis is from a survey conducted among 256 cancer patients who were treated at National Cancer Hospital in Maharagama from April to August 2004. Among them, 128 were diagnosed with lung cancer and these were taken to be cases while other 128 were diagnosed with other types of cancer and these were taken to be controls.

The primary objective of this case control study was to identify significant factors that cause lung cancer. In order to achieve this objective, a binary logistic model was fitted taking lung cancer or other types of cancer as the response. From the analysis, the important factors that cause lung cancer were found to be exposure to contaminated air at work place as well as general exposure to air contaminants ranging from fine particles

to hazardous chemicals. In addition, smoking cigarettes, which combines the nature of exposure, number of cigarettes smoked and the number of years smoked is one of the most important causes of cancer. Furthermore, exposure to domestic smoke such as mosquito coils was also found to be a factor that affects lung cancer.

The secondary objective of the analysis was to identify the factors that contribute to the survival of the lung cancer patients. To achieve this objective, Cox proportional hazard model was fitted to the data. With respect to the results given by the model, the most significant factor that increases the risk of death is the age of the patients. As age increases, the hazard of death increases very significantly. The smoking habit is also an adverse factor for the survival of the patients. With respect to a smoker, increase in the number of years smoked and the number of cigarettes smoked per day, make the risk of death also increase. In addition, with respect to a patient who is not exposed to any other domestic smoke, the exposure to mosquito coils increases the hazard of death as the number of hours the patient is exposed to increases. Furthermore, a male patient has lower survival probability than a female.

* rasikavj@yahoo.com

Tel: 011-2590111

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**A computational study of the electric field strength of radio transmissions
in selected areas of the Rathnapura district**

W K I L Wanniarachchi and C P Abayaratne*

Department of Physics, University of Sri Jayewardenepura, Gangodawila, Nugegoda

Radio wave signals in many areas of the Rathnapura district were observed to be weak. This is due to the presence of mountains between transmitters and reception points which obstructs completely or weakens the signals reaching the receiver. In this study, an attempt was made to identify the shadow areas where no waves were received and to compute signal strengths where a significant signal was received from a given transmitter in a selected area of the Rathnapura district.

Shadow areas were identified when obstructions such as mountains were present in the line of sight path between the transmitter and the receiver. In areas where radio signals were present, the interference between the direct wave, its ground reflection and knife edge diffraction from the tallest obstacle in the line of sight path was taken as the total electric field.

A good agreement was seen in the computed shadow areas and the areas where no radio signals were observed in the field strength measurements carried out by the Sri Lanka Broadcasting Corporation in 1997 for the Yatiyanthota and Radella transmissions. Where measurable signals were present, the measured and computed signal strengths were different. This was possible since atmospheric absorption, reflections from mountains among other effects were not considered in the computations. This type of computational studies is useful in planning and operation of radio communication systems in order to optimise radio coverage and cost.

Present Address: ¹ Division of Science and Technology, Uva Wellassa University, Badulla.

* cmapala@sjp.ac.lk
Ext.368
518/E₁

Tel: 011-2802695

A computational study of the interference effects of a single radio frequency transmitted from two different locations

W K I L Wanniarachchi and C P Abayaratne*
Department of Physics, University of Sri Jayewardenepura, Gangodawila, Nugegoda

Some radio service providers transmit two radio waves of the same frequency in an attempt to provide a better service to receptors in areas where regions shadowed by mountains are deprived of sufficiently strong signals. An example is provided by the two Sri FM transmission stations located at Rathnapura and Deniyaya targeting the Rathnapura, Elapatha, Pelmadulla and Nivithigala divisions in the Rathnapura district. However, it is known that reception throughout this area is not sufficiently strong. In this study, we investigate the reason for poor reception in many places in the area by computing the field strengths throughout the area.

According to our computations which considered the interference of six waves, namely the direct wave, the ground reflection and the diffraction from the tallest obstacle in the line of sight path for each of the two stations, it was revealed that destructive interference of the waves from the two stations resulted in weak signals in many parts of the region studied, despite the expectation of enhancing the reception. Unavailability of measured data prevented us from comparing measured and computed data which is a drawback. However, this type of study would be useful in designing radio communication links.

Present Address: ¹ Division of Science and Technology, Uva Wellassa University, Badulla.

* cmapala@sjp.ac.lk
Ext.368

Tel: 011-2802695

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Topographically informed high resolution temperature estimates for Sri Lanka

P M J Chandimala*, M Siriwardhana and L Zubair
Foundation for Environment Climate and Technology, C/o Maintenance Office, Mahaweli Authority, Digana Village, Rajawella, Kandy

Spatial mapping of climate data is conventionally done by spatial interpolation on station data. In the case of temperature, simple spatial interpolation techniques fail in capturing regional variations resulting from rapid elevation change in-between the stations in Sri Lanka. We used lapse rate theory to bring in the elevation dependency into the interpolation. Elevation data at 1-km resolution was used in the interpolation. Station temperature climatologies were projected on to a grid of 1km at an imaginary sea level datum using the environmental lapse rate Γ . The environmental lapse rate for each

month was estimated from the monthly mean temperature and elevation of 37 stations. Thereafter, an inverse distance weighing method was used for the interpolation at the sea level datum. Then the temperature at every grid point was projected to take account of the topography. This permitted in producing more fine scale temperature estimation at 1 km² in place of original density of 1726 km²/station. This procedure was used to construct annual and monthly spatial climatologies of minimum, maximum and mean temperature for Sri Lanka. The new interpolation method provided realistic values for temperature particularly in the mountainous areas.

* janakic@sltnet.lk
520/E₁

Tel : 081-4922992

Business intelligence via enterprise resource planning: A case study of apparel brand identification industry

R K R Prasanna*
University of Moratuwa, Moratuwa

It has been a major challenge and an aggravating issue among Apparel Brand Identification Manufacturers to lose brand buyer's confidence due to delivery of non conformity products with wrong specification. It is evident that the main cause for this was not using a properly integrated information system to manage and control their processes. Presently most of them use manually coordinated systems for their operations.

In view of the above background, an attempt was made to develop two major base modules analysed and designed as key areas of an Enterprise Resource Planning (ERP) application suitable for Apparel Brand Identification Industry. They are Sample Manufacturing Process Management and Management Information System.

By developing a Sample Manufacturing Process module, it was intended to achieve the objectives such as eliminating information duplication in Sample Manufacturing Process, avoid re-sampling of previously done samples, thereby reducing delays and costs, avoid unnecessary delays in locating sample information when doing its bulk production, improve Sample Manufacturing lead time by increasing information integrity and avoid producing non-conformity bulk production by maintaining correct sample information. Secondly, with a Management Information System module, the researcher's main aim was to gain objectives such as improving monitoring and controlling of organisational performances, reducing time in preparing management reports with non-integrated information, improving the accuracy of management information by avoiding data duplication, reallocation of human efforts on other productive area such as strategic planning, operational management and controlling, etc.

By achieving these objectives with proposed modules, author's ultimate goal was to elaborate the flavor of having proper Enterprise Resource Planning application as a tool for improving Apparel Brand Identification Manufacturer's overall challenge of delivering non-conformity products.

* raj@mot.mrt.ac.lk

Tel : 011-2650365

521/E₁

An investigation on the application of ICT in the education sector in Sri Lanka

R K R Prasanna*

University of Moratuwa, Moratuwa

Today Information and Communication Technology (ICT) has become pervasive in most organisations and affects every aspect of organisational performance. It has become a major driving force of most of the organisations. As in other fields, in the sector of education too, the significance of ICT use in modern day teaching and learning is indisputable. The use of information and communication technologies (ICTs) in and for education is rapidly expanding in many countries, and is now seen worldwide as both a necessity and an opportunity. The Dakar Framework for Action (April 2000) identified the use of new information and communication technologies as one of the main strategies for achieving the EFA (Education for All) goals. But, developing an ICT-equipped learning environment is a complex undertaking that is still in its infancy in most developing countries. There is no doubt that the effective use of ICTs is hampered by low accessibility, low connectivity, and lack of training and high infrastructure costs. To face this set of challenges, preparation of an ICT strategy to go in parallel with the learning and teaching, marketing and administration strategies has become one of the key responsibilities of the management of any education institute or an equivalent.

In this context, it will be a vital factor to know how educational institutes are faring in terms of applying ICT for their learning and teaching activities. With this objective, an investigation into the present and past level of ICT usage in the education sector in Sri Lanka was carried out.

This paper, while elaborating the present achievements and usage related to Information Technology (IT), Information Systems (IS) and Internet Capacity and the strategic relevance of ICT in the education sector in Sri Lanka, an attempt was made to evaluate the information intensity carried by the products and their value chain and finally the growth of the IT and Internet application over the years in selected organisations and the education sector in general.

* raj@mot.mrt.ac.lk

Tel: 011-2650365

522/E₁

Automatic music composition based on the emergent systems paradigm

N I Senaratna and D N Ranasinghe*

University of Colombo School of Computing, Colombo 3

Academics in both the music and Computer Science fields have been very keen to learn exactly how human composers compose music. Automatic Music Composition (AMC) has, hence, become a field of much significance and interest. Many scientists have pursued the AMC in an effort to come up with a human-free, real-time music composing system. Also, due to its evident commercial potential, industrialists in the cellular phone and video game industry have been keenly monitoring developments in this area. There

have been several attempts at AMC using novel AI related techniques. Out of these, “Emergent Computing” techniques have shown much potential. This is principally because it is possible to draw close parallels between “emergence” and human composing technique. Nonetheless, attempts so far have been hampered by several problems. This is probably because most emergent AMC systems tend to use a single technique - a single, centralised emergent system that attempts generating all the material required.

This paper attempts to solve these problems by replacing the traditional single technique approach with TIES - A Tree of Interacting Emergent Systems. TIES is a tree-like macro-structure made up of several interacting emergent systems. It is a context-independent framework and is applicable to many applications, including AMC.

In our work, the hierarchy of TIES consisted of natural algorithms mapped to the conventional layers of music generation. For example, motifs, rhythms and dynamic generation use iterated function system calls (or fractals), whereas chord generation was done by cellular automata. Phrase generation was by genetic algorithms. The lowest levels of the hierarchy fed their outputs to the next higher level natural algorithm. As such the higher level metaconstructs reflected the emergent properties of the interacting lower level natural algorithms.

AMCTIES has been evaluated by experts in the musical field. They are confident about the musical merits of its output, and rate its computational ability favourably. Music produced by AMCTIES was found to be expressive, naturally structured and interesting.

* dnr@ucsc.cmb.ac.lk

Tel: 011-2591064

523/E₁

Plasticized and plasticizer-free, Nano- composite polymer electrolytes for rechargeable Li –ion batteries

M A K L Dissanayake^{1*}, H M J C Pitawala² and K Vignarooban²

¹ *Postgraduate Institute of Science, University of Peradeniya, Peradeniya*

² *Department of Physics, University of Peradeniya, Peradeniya*

One of the major drawbacks in PEO - LiX polymer electrolytes is the low ionic conductivity at ambient temperatures. The most promising methods to overcome this problem are the incorporation of ceramic fillers, as was first suggested by Weston and Steele (1982) and the incorporation of organic plasticizers to the polymer electrolytes. However, the incorporation of plasticizers alone will yield polymer electrolytes with poor mechanical properties. In our recent work, we studied the dependence of ionic conductivity on different types of ceramic fillers and also the effect of incorporation of plasticizer and ceramic filler together in PEO LiTf polymer electrolytes. In this work, we have studied thermal and electrical properties of the polymer electrolyte PEO₉ LiTf + 15 wt% filler, incorporating four different types of ceramic fillers TiO₂, Al₂O₃, ZrO₂ and BaTiO₃. We have also studied thermal and electrical properties of PEO₉ LiTf EC : Al₂O₃ polymer electrolyte incorporating Ethylene carbonate (EC) as the plasticizer. In the first system, the presence of the first three ceramic fillers with dielectric constants 435, 20 and 12.5 enhanced the ionic conductivity substantially. However BaTiO₃ filler

having a relatively very high dielectric constant (3000) compared to other three ceramic fillers has resulted in a drop in conductivity. Presence of 15 wt% TiO₂ exhibited the maximum enhancement in conductivity ($\sigma_{RT} = 4.2 \times 10^{-4} \text{ S cm}^{-1}$). The observed conductivity enhancement has been attributed to Lewis acid-base type surface interactions of ionic species with O/ OH groups on the filler surface. In the second system, it was observed that the addition of plasticizer (EC) to the PEO₉LiTf + 15 wt% Al₂O₃ electrolyte up to a concentration of 50 wt. %, showed a maximum conductivity enhancement [$\sigma_{RT} = 1.5 \times 10^{-4} \text{ S cm}^{-1}$]. It is suggested that the conductivity is enhanced mainly by two mechanisms. The plasticizer (EC) would directly contribute by reducing the crystallinity and increasing the amorphous phase content of the polymer electrolytes. The ceramic filler (Al₂O₃) would contribute to conductivity enhancement by creating additional sites to migrating ionic species through transient bonding with O/OH groups in the filler surface. The decrease of T_g values of plasticized composite polymer electrolyte systems seen in the DSC thermograms points towards the improved segmental flexibility of polymer chains giving rise to increased mobility of conducting ions.

* director@pgis.lk

Tel: 081-2387218

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Thermal and electrical properties of PEO₉LiTf + x wt% TiO₂ + (15 – x) wt% Al₂O₃ nano-composite polymer electrolyte membranes

M A K L Dissanayake^{1*} and K Vignarooban²

¹ Postgraduate Institute of Science, University of Peradeniya, Peradeniya

² Department of Physics, University of Peradeniya, Peradeniya

Nano-composite polymer electrolytes are receiving attention as potential candidates to be used as electrolyte membranes in Lithium polymer batteries and other devices. However, a survey of literature reveals that, a systematic study on the effect of a mixture of two ceramic fillers incorporated in PEO₉ LiTf polymer electrolyte is lacking. In this work, we have studied thermal and electrical properties of the nano-composite polymer electrolyte PEO₉ LiTf + x wt% TiO₂ + (15 – x) wt% Al₂O₃ (x = 0, 2.5, 5, 7.5, 10, 12.5, 15) incorporating TiO₂ of grain size 200 nm and Al₂O₃ of grain size 150 mesh (pore size 5.8 nm). The electrolyte incorporating the mixture (10 wt% TiO₂ + 5 wt% Al₂O₃) showed higher conductivities compared to the one with 15 wt% Al₂O₃ at temperatures above 27 ° C. Maximum enhancement in conductivity was obtained with 15 wt% TiO₂ addition. The observed conductivity enhancement has been attributed to Lewis acid-base type surface interactions of ionic species with O/ OH groups on the filler surface. However, all other electrolyte samples with mixed- fillers showed lower conductivities than the one incorporating 15 wt% Al₂O₃. Some samples with different mixed filler compositions even exhibited a drop in conductivity below that of the filler free electrolyte possibly due to the blocking effect.

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Synthesis and electrical characterisation of $\text{Li}(\text{Ni}_{1/3}\text{Co}_{1/3}\text{Mn}_{1/3})\text{O}_2$

P B Samarasingha* and H W M A C Wijayasinghe
Institute of Fundamental Studies, Kandy

From an overall perspective Li-ion batteries undoubtedly represent the most promising energy storage system, and certain aspects of its principles of operation deserve particular attention. The performance of a battery is mainly related to the intrinsic property of the materials that form the positive and negative electrodes and the electrolyte. LiCoO_2 has most widely been used as the cathode material of Li-ion battery, however, the high cost of this material is a main obstacle for developing it as a cheaper and reliable portable power source. $\text{Li}(\text{Ni}_{1/3}\text{Co}_{1/3}\text{Mn}_{1/3})\text{O}_2$ has recently been investigated as a potential candidate for cathode material in secondary lithium batteries. With better cycling performance and stability at high potential windows, it is expected to perform better than the commercialised LiCoO_2 . This paper presents a study of synthesis and electrical characterization of $\text{Li}(\text{Ni}_{1/3}\text{Co}_{1/3}\text{Mn}_{1/3})\text{O}_2$ material synthesised by Pechini method, which is a low cost technique but can result in powders with high purity, homogeneity and particle morphology that are highly desired for Li-ion battery cathodes.

$\text{Li}(\text{Ni}_{1/3}\text{Co}_{1/3}\text{Mn}_{1/3})\text{O}_2$ powders were synthesised by the Pechini method, with various ethylene glycol to citric acid (EG:CA) ratios of the organic precursor solutions, to investigate the affect of EG:CA ratio on the synthesised powder. The calcination studies were performed by calcining at 800 -1000 °C in order to find the optimum calcination temperature and phase analysis were performed by XRD. Under electrical characterisations, the a.c. impedance, Seebeck and d.c. electrical conductivity (four probe method) analysis of sintered pellets were carried out.

The phase analysis revealed the formation of only the $\text{Li}(\text{Ni}_{1/3}\text{Co}_{1/3}\text{Mn}_{1/3})\text{O}_2$ phase of R3m structure in all the materials synthesised under different EG:CA ratios and calcination temperatures between 800-1000 °C, though the previous studies based on other synthesis techniques reported the lowest possible synthesis temperature as 900 °C. The electrical conductivity at 25 °C is about 1×10^{-4} S/cm and 2×10^{-3} S/cm at 200 °C, which are comparable with those reported from other studies where different synthesis techniques were employed. In an electrochemical performance study performed using the material calcined at 1000 °C, the cathode showed good reversible cycling behavior between 3.0 and 4.5 V and the discharge capacity observed is 175 mAh/g at room temperature, which is considerably higher than that reported for LiCoO_2 (138 mAh/g). Altogether, this study shows the ability of preparing $\text{Li}(\text{Ni}_{1/3}\text{Co}_{1/3}\text{Mn}_{1/3})\text{O}_2$ material by Pechini method, with appropriate electrochemical properties suitable for Li-ion battery cathode application.

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Synthesis and electrical characterisation of LiCoO₂, LiFeO₂ and NiO binary compositions

H W M A C Wijayasinghe*
Institute of Fundamental Studies, Kandy

From the viewpoint of cost and efficiency, semi-conductive oxide ceramics are the best practical electrode materials for number of electrochemical energy conversion devices, specially for fuel cells and batteries. This work is based on synthesising and electrically characterising binary oxide ceramics of LiFeO₂, LiCoO₂ and NiO, which are regarded as promising candidates for the cathode of the Molten Carbonate Fuel Cell (MCFC) and the Lithium Ion Battery (LIB). A number of new compositions under NiO-LiFeO₂, LiFeO₂-LiCoO₂ and LiCoO₂-NiO binary systems have been investigated. The feasibility of two wet-chemical techniques, the glycine-nitrate method and the Pechini method, was investigated in order to obtain powder with characteristics appropriate for cathode fabrication. Scanning Electron Microscopy was employed to investigate the powder morphology. The phase analysis on the materials was carried out with X-ray diffraction and the d.c. conductivity measurements were performed by the four-probe method from room temperature to 800 °C.

The powder prepared by Pechini method shows better characteristics of having rather spherical shaped agglomerated sub-micron size particles. The phase analysis reveals the existence of solid solution of *Fm3m* structure in LiFeO₂-NiO rich compositions. Increase of the LiCoO₂ content in the composition results in the formation of *R3m* layered structure of LiCoO₂. The electrical conductivity of the LiFeO₂-NiO and LiFeO₂-LiCoO₂ compositions lay between those of the end materials. However, a completely different behaviour is seen in LiCoO₂-NiO System, where the conductivity increases drastically to a maximum with the increase of LiCoO₂ content. These binary materials, specially the compositions up to 80 mole% of LiCoO₂, show promising characteristics for the MCFC cathode application, having adequate electrical conductivity (well above 1 S/cm at the operating temperature of 650°C). The LiCo_{0.2}Ni_{0.8}O₂ composition shows an electrical conductivity of about 0.01 S/cm at 25 °C in air, while it is about 0.001 S/cm of LiCo_{0.8}Ni_{0.2}O₂ composition. This significant room temperature conductivity together with the formation of LiCoO₂ type layered structure in these binary materials reveal their potentiality them for LIB cathode application.

* athula@ifs.ac.lk
527/E₁

Tel: 081-2232002

Electrochemical synthesis and characterisation of poly(3,4-ethylene dioxathiophene)/Dodecyl benzene sulfonate films in aqueous media

U L Zainudeen, M J M Jafeen and M A Careem*
Department of Physics, University of Peradeniya, Peradeniya

Conducting polymers (CPs) such as polypyrrole (PPy), poly-N-methyl pyrrole (PNMP) and polyaniline (PANI) have been studied extensively by our group for a long period of time. It has been found that properties of these CPs depend significantly on the method of polymerization and on the conditions used during the synthesis. We report here our current studies on another CP, poly(3,4-ethylenedioxythiophene) (PEDOT) in

conjunction with PPy in different configurations. Our ultimate goal is to explore the possibility of using bilayer or multilayer of these two polymers in artificial muscles.

PEDOT and PPy, each containing dodecyl benzenesulfonate (DBS) anions as immobile dopant species, were synthesised galvanostatically and characterised using cyclic voltammetry, absorption spectroscopy and electrochemical quartz crystal microbalance (EQCM) techniques. During the synthesis, PEDOT(DBS) films form at a higher potential than that of PPy(DBS) films. Cyclic voltammograms (CVs) of a PEDOT(DBS) film and a PPy(DBS) film under same cycling conditions are different in shape and size. While the CV of the PPy(DBS) film exhibits strong and well defined reduction and oxidation peaks, the PEDOT(DBS) has a capacitive-like current and two pairs of barely distinguishable redox peaks. For the PEDOT(DBS) film, the electrode mass change is small compared to that of the PPy(DBS) film during both cathodic and anodic parts of the cycle.

The two polymer films show slightly different optical absorption behaviour. In the reduced state, while the PEDOT(DBS) film has the main peak at 2.1 eV, the PPy(DBS) film has it at 3.0 eV. These peaks which can be assigned to $\pi-\pi^*$ electronic transitions correspond to the band gaps of the polymers. Thus, the PEDOT(DBS) film appears to have lower band gap compared to that of the PPy(DBS) film.

* mac@pdn.ac.lk

Tel: 081-2394599

528/E₁

An iron removal plant for drinking water

N A Zainudeen and L R A K Bandara*

Department of Physics, Faculty of Science, University of Peradeniya, Peradeniya

Water contains many impurities in dissolved and solid form. These impurities should be in their permissible level to satisfy the drinking water standards. In a large number of areas in Sri Lanka, the ground water, shallow as well as deep, contain a considerable amount of dissolved iron in the form of Fe^{2+} . It is important to have an iron removal system in areas where the iron content is in excess, in order to reduce the iron content in water to an acceptable level. There is a large number of methods and processes to remove iron compounds from water at commercial and large scale water treatment which are usually expensive to have at domestic level. In this study, the design of an iron removal plant using simple articles available at domestic level is described. In this case, the iron removing mechanism includes the basic principle of converting the existing form of iron (Fe^{2+}) to precipitating form of iron (Fe^{3+}).

The investigated raw water samples were obtained from Kiribathkumbura area in Kandy District. Kaolin mineral and naturally occurring red earth are used as a natural filter and polystyrene is used as an artificial filter medium. Cascade type aerator was designed in order to get maximum oxygen contact to the raw water before different treatments.

According to WHO standards, the permissible level for iron in drinking water is 0.3 mg/l and the maximum measured value of iron content of the raw water from the above area was 1.1 mg/l. By adding Kaolin with the concentration with 5 g/l to the raw water 60% of reduction of iron content was observed. Adding red earth with same concentration, as a

natural filter media, only 26% of reduction of iron content in raw water samples was observed.

The possibility of further reduction of iron content by using a static magnetic field was also tested. For Kaolin added water samples, with the presence of the static magnetic field, the maximum total reduction of the iron content was 71.8%. Also it has shown that iron removal using artificial filter medium is very effective for water quality improvement. For example, when polystyrene was used as an artificial filter medium, for the treated water, the maximum total reduction of the iron content was 76%.

Using the apparatus setup, we have proposed that an iron removal plant can be constructed at domestic level. Iron removal using artificial filter media is very effective for water quality improvement. Our study and the data presented provide the essential framework to modify the filtering systems that are currently being used.

* kalingab@pdn.ac.lk

Tel: 081-2394585

529/E₁

ENSO influences on the mean temperature in Sri Lanka

M Siriwardhana*, P M J Chandimala¹ and L Zubair¹

Foundation for Environment, Climate and Technology, c/o Maintenance Office, Mahaweli Authority of Sri Lanka, Digana Village, Rajawella

The inter-annual and seasonal variations of mean temperature affect crop production, public health, water and natural resources. Even though the range of temperature in Sri Lanka is modest, small variations can have serious ecological implications such as its influence on dengue and malaria transmission. The El Nino-Southern Oscillation (ENSO) is a primary mode of climate variability over South Asia. In this paper, the relationship between Sri Lankan mean temperature and ENSO and its decadal variation is quantified based on composite and correlation analysis. A mean temperature data index was constructed by averaging data from 18 well distributed stations of the Department of Meteorology for the twentieth century. The ENSO index of NINO3.4 data which is the mean of sea surface temperature in the equatorial eastern Pacific Ocean was used for the analysis. ENSO phases were identified as El Nino ($NINO3.4 > 0.5$), Neutral ($-0.5 < NINO3.4 < +0.5$) and La Nina ($-0.5 > NINO3.4$).

A composite analysis of mean temperature shows that Sri Lanka has an annual mean temperature of 25.91, 25.73 and 25.63 °C during El Nino, Neutral and La Nina respectively. Overall, El Nino leads to slightly warmer conditions in all the months except May and October. These are the two months from which the South-West and the North-East monsoon seasons are in transition. The significant relationships between ENSO and temperature are brought out by undertaking the analysis for seasons that are variants of the conventionally monsoonal seasons (December-February, March-April, May-September and October-November). On average, the temperature during the El Nino phase is higher by 0.425 (November-February), 0.4 (March-April) and 0.225 °C (June-September) than during the La Nina phase. The correlations of ENSO indices with mean temperature are statistically significant for November-February, March-April and June-September seasons have largely remained so in the twentieth century.

530/E₁

**Deposition of Pt and Au quantum dots on TiO₂ nanoparticles:
A study of ballistic electron transport with dye-sensitisation**

L S G Liyanage¹ and V P S Perera^{1,2 *}

¹ *Department of Physics, Open University of Sri Lanka, Nawala*

² *Institute of Fundamental Studies, Kandy*

Metallic and metal oxide semiconductor nanoparticles have become an area of growing interest and importance in many fields. Particles in nano range (< 100 nm) have different properties than that of the bulk materials. For example, the conduction band, which is present in bulk metals, is absent in nano metallic particles, where instead they have discrete energy states. Further, the band gap energy depends on the particle size of the semiconductor. So that, when metallic and semiconductor nanoparticles are made to be in contact, they have unique optical, electronic and chemical properties.

Depletion region similar to a bulk semiconductor in contact with a metal does not exist when a metallic quantum dots are deposited on a semiconductor nano-particle because of their small dimensionality. However electrons transfer from low work function material to the higher work function material to establish an equilibrium energy state. In this study, we have deposited quantum dots of Pt and Au on TiO₂ nanoparticles by mixing TiO₂ powder (Diggusa P-25) in a measured volume of ultra diluted solutions of gold chloride hydrate and chloroplatinic acid and sintering at 500 °C in a furnace where quantum dots of Au and Pt deposited respectively on TiO₂ nano-particles.

It is important to note that the metallic composition in TiO₂//Pt or TiO₂/Au matrix is very low. However, with the increment of metallic composition in the matrix, the conductivity seems to decrease because conduction electrons in TiO₂ transfer to the metal particles increasing the resistivity since the work function of Pt and Au are lower than the work function of TiO₂. The resistivity depends on the number of metallic quantum dots on TiO₂ nano-particles as well as the size. These metallic quantum dots deposited on TiO₂ nanoparticles were examined with diffusion reflectance spectroscopy and flat band potential was determined with Mott-Schottky measurements. With the increment of Pt in the matrix, band gap seems to shrink while the flat band potential moves towards more negative values, which is consistent with the variation of resistivity.

Secondly, we have studied the transport of electrons in TiO₂/Pt matrix by employing this material in a dye-sensitised solar cell. Generally the excited level of the dye is well above the conduction band of the semiconductor so that electrons are injected as hot carriers to the semiconductor and it has been previously shown that those electrons travel ballistically through thin gold films deposited on TiO₂ films. When the composition of TiO₂/Pt matrix varied, we found an optimum cell with highest photocurrent. At this optimal level, it is supposed to form minibands between the Pt quantum dots and TiO₂ nano-particles in which electrons could travel without any phonon interaction so that the process is dissipativeless. Therefore, the photocurrent of the cells increases due to suppression of recombination. Study of quantum level effects with this type of simple techniques is encouraged to promote research in nano-technology, which is an emerging field in science.

Acknowledgement: Financial assistance by the NSF research grant RG/2004/P/03

* vpper@ou.ac.lk

Tel: 011-2853777 Ext.445

531/E₁

The effect of Cu_{2-x}O quantum particles on TiO₂ films of dye-sensitised solar cells

M K I Senevirathna¹, L S G Liyanage² and V P S Perera^{1,2*}

¹ *Institute of Fundamental Studies, Kandy*

² *Department of Physics, The Open University of Sri Lanka, Nawala, Nugegoda*

Dye-sensitized photo electrochemical solar cells are gaining much attention as an alternative to the silicon based solar cells because of their low cost and high efficiency. The dye-sensitized solid-state solar cell of the structure [n-type semiconductor/Dye/ p-type semiconductor] has been introduced since the former cell suffers from some technological problems due to the presence of liquid electrolyte. Although solid state solar cells have been fabricated with many hole collectors, highest efficiency has been reported with the semiconductors, p-CuI and p-CuSCN, where Cu is one of the constitute in both the materials. CuI is widely used to fabricate dye-sensitized solid-state solar cells because it could be dip coated dissolving in many organic solvents. Since CuI is a volatile material, liberation of iodine at high temperature and expose to UV radiation is reported. Therefore this is a serious problem in dye-sensitized solid state solar cells based on CuI. Prolong illumination for several days completely deteriorate these cells due to the above reasons. But the effect of liberated copper in the photodecomposition of CuI is not intensively studied, which we addressed in the current report.

Since the liberated Cu in photodecomposition of CuI is very small, we purposely grew Cu_{2-x}O quantum size particles on TiO₂ in our investigations to study its effects. Quantum particles of Cu_{2-x}O were deposited on titanium dioxide particles by mixing TiO₂ (P-25) powder with Cu(NO₃)₂ solution with a known concentration and sintering at 500 °C. Sintering at 500 °C converts almost all of the Cu(NO₃)₂ adsorb on the surface of TiO₂ particles to copper oxide (Cu_{2-x}O). These samples (TiO₂/Cu_{2-x}O) were examined with diffusion reflectance spectroscopy and band edge positions of the samples were determined with Mott-Schottky measurements.

The colour of the samples varied with the Cu percentage added. The samples prepared with very low concentration of Cu appeared in pale yellow colour and it turned into black increasing the copper concentration. When those samples were examined with diffusion reflectance spectroscopy, apparent absorption in the visible region could be observed. However, it also clearly indicated that the absorption onset of TiO₂ red shifted incorporating copper to TiO₂. This band gap variation was further studied with the Mott-Schottky measurements. It gave clear evidence that band edge of TiO₂/Cu_{2-x}O shifts towards more negative values in the energy scale incorporating more copper to the samples.

Therefore, we finally conclude that if Cu that produced in photodecomposition of CuI move on to the TiO₂ films of the dye-sensitized solid state cell, it would affect to lower the photovoltage of the solar cell because photovoltage of a dye-sensitized solar cell is determined by the band edge position of the semiconductor material. Since the Cu_{2-x}O that deposit on TiO₂ electrode in decomposition of CuI is very much small, we could not quantitatively detect it with the available facilities.

Acknowledgement: Financial assistance by the NSF research grant RG/2004/P/03

* vpper@ou.ac.lk
Ext.445

Tel: 011-2853777

532/E₁

Clay polymer nanocomposites: Investigation of their mechanical properties for industrial and technological applications

Q Y Soundararajah¹, B S B Karunaratne^{1*} and R M G Rajapakse²

¹ Department of Physics, University of Peradeniya, Peradeniya

² Department of Chemistry, University of Peradeniya, Peradeniya

This study aims at investigating the Mechanical property enhancement of clay polymer nanocomposites. The bentonite clay was used to be intercalated with polyaniline to prepare the intercalated montmorillonite polyaniline nanocomposites (MMT-PANI). The MMT clay was ion exchanged with H⁺ and dried at 120 °C. The H⁺ present in the clay was then exchanged with anilinium ions. The anilinium ions present within the intergalleries were polymerised by a chemical oxidation route using S₂O₈²⁻. The resultant slurry was dried under room temperature for 3 to 4 days. The green coloured polyaniline form known as the emeraldine salt containing MMT composite (EMS – MMT) was resulted. Various compositions with different clay contents were prepared with a constant polymer concentration. X-ray diffraction spectra were obtained for raw MMT clay, H⁺ treated MMT and for the EMS-MMT series. Rectangular bars were pressed uniaxially at 4 M Pa for making the test samples and were vacuum dried at 120⁰ C and 150⁰ C for two hours prior to the testing. The mechanical properties were investigated using a mechanical testing machine in the ceramic laboratory. Four-point bending was used to investigate the modulus of rupture (MOR) and Young's modulus (Y). The fracture toughness (K_{1C}) was found using single edge notch beam.

The EMS-MMT series showed a drastic increase in the MOR and Young's modulus at rather low filler content. This result clearly indicates that the ability of dispersed silicate layers that increase the MOR and Young's modulus of EMS-MMT nanocomposites can be directly related to the average length of the layers, hence to the aspect ratio of the dispersed nanoparticles. The MOR may strongly depend on the nature of the interactions between the matrix and the filler. The increase is due to the presence of polar and ionic interactions between the polymer and silicate layers. The increase in the fracture toughness was achieved due to increased interfacial areas and improved bond characteristics of the EMS-MMT nanocomposites. The results indicate that the mechanical properties enhanced even at low clay loadings more than the neat materials. Further work is necessary to investigate the other property enhancement.

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* bsbk@pdn.ac.lk

Tel: 081-2394598

533/E₁

Phosphate bonded clay bricks

H D N S Fernando and B S B Karunaratne*

Department of Physics, University of Peradeniya, Peradeniya

The broad aim of this project is to fabricate chemically hardened clay bricks for building industry using suitable minerals commonly available in Sri Lanka. Conventional clay bricks are fired at temperatures 800 °C-1000 °C depending on the composition of the clay. The major cost of clay bricks is due to the firewood utilisation in the firing process and hence the cost can be brought down by reducing the firing temperature. Manufacturing of clay bodies with strong bonding at low temperatures using inexpensive chemicals and minerals is a suitable approach in reducing the high demand for firewood in the brick industry. This will in turn help prevent deforestation. Due to the high production cost of phosphate bonded clay bodies, they were not commonly used.

It is expected that the addition of phosphoric acid forms a self reinforced microstructure with Fe³⁺ ions present in soil. Since red soil has relatively high amount of Fe³⁺ ions, commonly available red soil was used as the starting material whereas phosphoric acid (3M/1M solutions), Eppawala apatite mineral (EAM) and Eppawala rock phosphate fertilizer (ERP) were used as additives. Phosphoric acid, EAM with phosphoric acid added small size brick samples were prepared and fired at 300 °C for one hour. ERP added samples were fired at 500 °C for one hour. The important physical properties such as compressive strength, modulus of rupture and water absorption of these brick samples were investigated. These properties were compared with those of conventional bricks made with the same soil fired at 800 °C. It was observed that the properties of phosphoric acid added bricks and both apatite and phosphoric acid added bricks were superior to those of conventional bricks fired at 800 °C. On the other hand, the ERP added bricks fired at 300 °C did not show any promising improvement. However, better performance of these bricks was observed when fired at 500 °C. Iron oxide (Fe₂O₃) present in the raw material was identified using the X-Ray Diffraction (XRD) analysis. Scanning Electron Microscopy (SEM) of phosphoric acid (3M) added fired brick samples showed that there were needle type elongated grains formed in the microstructure. Subsequent EDAX analysis revealed that these needle type grains were mainly composed of iron rich phosphate compositions. Formation of needle type elongated grains of iron phosphates may act as a self reinforcement and hence leading to increase the strength by crack branching, crack bridging and fiber pullout.

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* bsbk@pdn.ac.lk

Tel: 081-2394598

SECTION E₂

601/E₂

Identification and quantification of carotenoids of Wel kohila leaves (*Syngonium angustatum*)

P W N M Colombagama¹, U G Chandrika^{2*}, K K D S Ranaweera³

¹ Department of Food Science and Technology¹, Sabaragamuwa University of Sri Lanka, Buttala

² Department of Biochemistry, University of Sri Jayewardenepura, Gangodawila, Nugegoda

³ Department of Food Science and Technology, University of Sri Jayewardenepura, Gangodawila, Nugegoda

Vitamin A deficiency is one of the major health problems prevailing in Sri Lanka. Although, it has been reported that consumption of green leafy vegetables rich in provitamin A can adequately contribute to its Recommended Daily Allowance (RDA), people have neglected to consume most of the potentially wholesome leafy vegetables due to many reasons. The underutilisation of these potential vegetables may result in their long-term extinction from the biodiversity on one hand and in worsening the nutritional status of the local communities on the other hand.

A survey was conducted to assess the popularity of under utilisable leafy vegetables in a selected area (Piliyandala MOH area) and this study, as a model, can be carried out in other areas. Forty five individuals selected randomly were interviewed. According to the statistical analysis, 95.5% of the families interviewed were found to consume immature Manioc (*Manihot esculenta* Crantz) leaves and 93% consume Kurignan (*Gymnema lactiferum*) leaves and 89% consumed Wel kohila (*Syngonium angustatum*) leaves. Recent studies show that manioc leaves sufficiently contribute to the RDA. This work is a part of the main project focused on preparing a database on the carotenoid composition of commonly consumed Sri Lankan green leafy vegetables. Therefore, the

objective of the present study is to identify and quantify carotenoids of selected under usable leafy vegetable, Wel kohila (*Syngonium angustatum*) by the above preliminary survey.

Isolation, identification and quantification of carotenoids were carried out according to Rodriguez-Amaya (1999), which involved extraction of carotenoids, partitioning them to petroleum ether, separation of carotenoids by open column chromatography (OCC), identification of carotenoids by using ultra violet visible absorption spectra (λ_{\max} and spectral fine structure), order of elution of OCC and chemical tests. According to the results obtained, high pro-vitamin A activities of β -carotene ($25.6 \pm 4.5 \mu\text{g/g}$ (FW)), and Lutein ($4.1 \pm 0.8 \mu\text{g/g}$ (FW)), which is essential in reducing risk of cancer and macular degeneration were found in Wel kohila leaves. It was revealed that α -carotene ($5.6 \pm 4.2 \mu\text{g/g}$ (FW)) is also found in Wel kohila leaves, even though the presence of α -carotene among leafy vegetables has not been reported. Further studies should be carried out to find out percentage of contribution to RDA.

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* chandri@sjp.ac.lk

Tel: 011-2803578

602/E₂

Chemical investigation of the properties of four traditional Sri Lankan oils

Kapila N Seneviratne*, B M Jayawardena, R T Kotuwegedara and R P K Manoj
Department of Chemistry, University of Kelaniya, Kelaniya

Traditional Sri Lankan oils extracted from the seeds of *Calophyllum inophyllum* (Domba), *Madhuca nerifolia* (Mee), *Canarium zeylanicum* (Kekuna), and *Ricinus calamus* (Endaru) are currently used only for medicinal purposes. The analysis of their fatty acid composition and the quality parameters is important in order to evaluate their potential as edible oils and as ingredients for beauty care products.

Fatty acid compositions of medicinal oils prepared by pressing the seeds of above plants were determined by Gas Liquid Chromatography (GLC). Acid value (AV), iodine value (IV), saponification value (SV) and peroxide value (PV) were determined by the standard methods. The results are given in Table 1.

Table 1. Fatty acid compositions and quality parameters of medicinal oils

	Domba	Mee	Kekuna	Endaru
Saturated fatty acids (%)	35.4 ± 0.1	43.8 ± 0.1	15.4 ± 0.1	24.0 ± 0.1
Oleic acid (%) (C 18:1)	39.4 ± 0.1	46.5 ± 0.1	16.2 ± 0.1	35.5 ± 0.1
Linoleic acid (%) (C 18:2)	25.0 ± 0.1	9.6 ± 0.1	49.3 ± 0.3	38.6 ± 0.1
Linolenic acid (%) (C 18: 3)	0.2 ± 0.1	0.1 ± 0.0	19.1 ± 0.1	1.9 ± 0.1
AV (mg of KOH/g)	2.1 ± 0.1	3.1 ± 0.1	1.2 ± 0.1	2.3 ± 0.1
IV (g of I ₂ /100g)	80.0 ± 0.6	52.0 ± 0.5	95 ± 1	101 ± 1
SV (mg of KOH/g)	219 ± 1	69 ± 1	185 ± 1	181 ± 1
PV absorbance at 500 nm	0.37 ± 0.04	0.41 ± 0.01	0.15 ± 0.02	0.50 ± 0.05

Each data point represents the mean of five replicates ± S.E

Quality parameters for the locally prepared medicinal oils were established in the current research. Fatty acid compositions and the tested quality parameters of local domba and endaru oils are within the ranges of the reported values. However, the trace amounts of eicosanoic acid reported for domba oil was not observed in the tested samples. Not much chemical information about mee and kekuna oils has been reported. High linoleic and linolenic acid compositions in kekuna oil suggest that this oil is an excellent source of essential fatty acids. High unsaturated fatty acid contents of all the tested oils indicate that these oils should be excellent ingredients for beauty care products.

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* kapilas@kln.ac.lk

Tel: 011-2914486

603/E₂

Phenolic content and antioxidant activity of virgin coconut oil and other coconut oils

Kapila N Seneviratne* and C D Hapuarachchi
Department of Chemistry, University of Kelaniya, Kelaniya

Virgin coconut oil (VCO) has become a very popular vegetable oil in the world market recently. However, the major method of the extraction of commercial coconut oil (CCO) in the Asian region is by pressing copra. Due to the unaffordably high prices, Sri Lankan consumers are unable to use VCO in their regular diet. Even though several beneficial health properties, including antioxidant activity have been advertised for VCO, scientific data about the beneficial effects of VCO are still insufficient. In the present study, total phenol contents and the antioxidant activity of the phenolic extracts of VCO were compared with those of CCO and traditional coconut oil (TCO), prepared by boiling coconut milk.

Phenolic fractions of coconut oils were separated by the liquid-liquid extraction using methanol/water (80:20 v/v) and the total phenol contents were determined by the Folin-Denis method. Antioxidant activities of the phenolic extracts of coconut oils were determined by measuring the extent of the reduction of potassium ferricyanide by the phenolic extracts.

The highest reported total phenol content for CCO and TCO are 91 ± 11 and 618 ± 46 mg/kg respectively. The total phenol content of VCO was 78 ± 1 mg/kg and the discarded liquid during the cold extraction of VCO contained 133 ± 5 mg/kg of phenolic substances. The results indicate that the lowest total phenol content is present in VCO and a considerable amount of phenolic substances is not incorporated into coconut oil in the preparation of VCO as indicated by high phenol content in the discarded liquid. The reducing powers of the phenolic extracts of VCO, CCO and TCO were $160 \pm 5\%$, $209 \pm 6\%$, and $553 \pm 5\%$ respectively. Even though the antioxidant activity of VCO is highly advertised, the above results indicate that CCO and TCO show better antioxidant properties compared to VCO. Lower phenol contents have also been reported for virgin olive oil compared to other types of olive oils and the antioxidant activity has been shown to depend on the phenol content of olive oil. The above findings indicate similar trends for coconut oil.

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* kapilas@kln.ac.lk

Tel: 011-2914486

604/E₂

New Benzopyran from *Acronychia pedunculata* and its biopesticide activity on *Aedes aegypti*

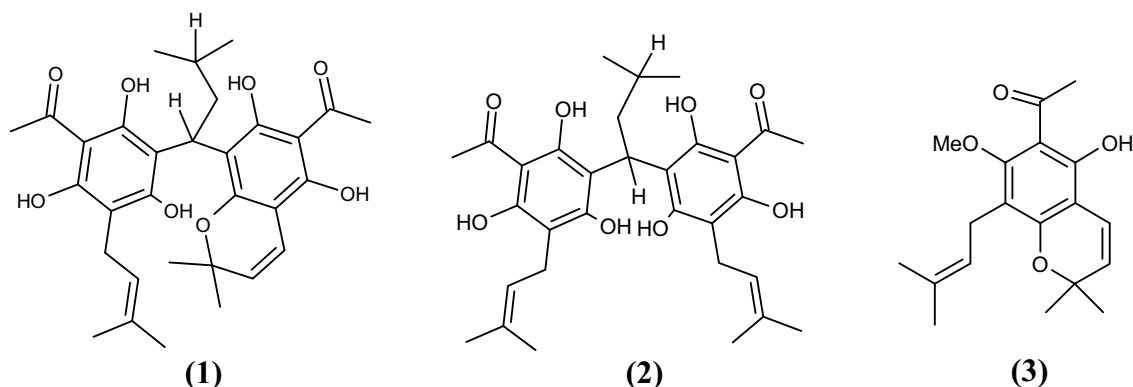
Yasodha Ahilan and Vijaya Kumar*
Department of Chemistry, University of Peradeniya, Peradeniya

We have previously reported the isolation of a new benzofuran, 7-acetyl-4,6-dihydroxy-2-(1-methylethyl)-5-(3-methyl-2-butenyl)benzofuran along with acrovestone, demethylacrovestone and demethylacronylin from the dichloromethane extract of *Acronychia pedunculata* fruits. Further study has revealed the presence of a novel benzopyran derivative (**1**) and the sesquiterpenoid, clovan-2,9-diol in the extract, the

structures of which were established using NMR spectra and comparison of spectral data with those reported for related compounds.

NMR data revealed the presence of two phenyl rings, two acetyl groups, an isopentenyl side chain, a gem-dimethyl substituted chromene ring and five hydroxyl groups in **(1)**. Signals corresponding to a five-carbon moiety suggested that the two rings were connected *via* this bridge. The proton NMR, ^{13}C NMR and the 2D NMR of the new compound **(1)** was similar to that of demethylacrovestone **(2)** except for additional signals for the chromene ring and the absence of signals for one isopentenyl group indicating that its structure could be derived by the cyclization of an isopentenyl group in demethylacrovestone. The NMR values for the chromene ring were comparable with those reported for the chromene ring in acronyculatin E **(3)** which has been isolated from the same plant. Cyclization of the isopentenyl group is possible in two different modes giving two possible structures for benzopyran **(1)**. They are 6-acetyl-5,7-dihydroxy-2,2-dimethyl-8-[1-(2-methylpropyl)-1-(3-acetyl-5-(3-methyl-2-butenyl)-2,4,6-tri-hydroxy-benzyl)]benzopyran **(1)** and 8-acetyl-5,7-dihydroxy-2,2-dimethyl-6-[1-(2-methylpropyl)-1-(3-acetyl-5-(3-methyl-2-butenyl)-2,4,6-tri-hydroxy-benzyl)]benzopyran.

Mosquito larvicidal studies confirmed that the benzopyran **(1)** was weakly active (LC_{50} 10.0) against 2nd instar larvae of *Aedes aegypti*.



* vkumar@pdn.ac.lk

Tel: 081-2394436

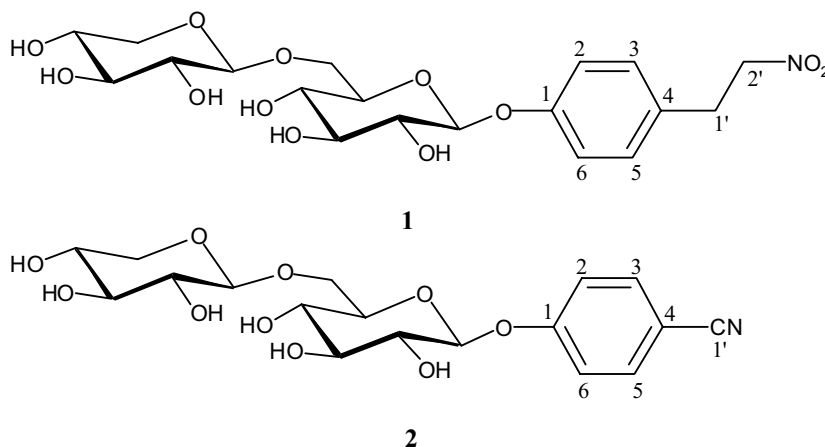
605/E₂

New phenyl glycosides from the fruits of *Diploclisia glaucescens*

U L B Jayasinghe*
Institute of Fundamental Studies, Kandy

Diploclisia glaucescens of the family Menispermaceae is a liana growing in the mid country regions of India and Sri Lanka. Leaves of the plant have been used in the treatment of biliousness and venereal diseases. Several phytoecdysteroids, saponins, triterpenoids and alkaloids have been reported from the seeds, leaves, stem and fruits of the plant. We have recently reported the isolation of a new ecdysteroid 2-deoxy-5b,20-

dihydroxyecdysone, together with 20-hydroxyecdysone, 3-deoxy-1 β ,20-dihydroxyecdysone, 2-deoxy-20-hydroxyecdysone, 24-ethyl-20-hydroxyecdysone and some triterpenoidal and steroidal saponins from the fruits of the plant. This report deals with the isolation of two new phenyl glycosides, 4-(2-nitro ethyl)phenyl- β -D-xylopyranosyl-(1 \rightarrow 6)- β -D-glucopyranoside (1) and 4-cyanophenyl β -D-xylopyranosyl-(1 \rightarrow 6)- β -D-glucopyranoside (2) from the methanol extract of the fruits of *D. glaucescens*. Structures of 1 and 2 were established by detail analysis of ^1H , ^{13}C NMR, H-H COSY, HMQC, HMBC and FABMS.



* lalith@ifs.ac.lk

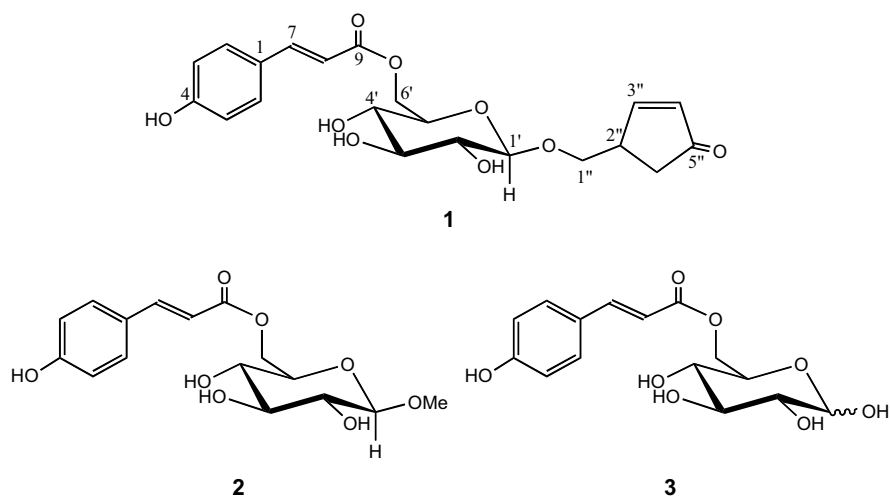
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606/E₂

A new 4-oxo-2-cyclopentenylmethyl glucoside from *Flacourtia indica*

N R Amarasinghe and U L B Jayasinghe*
Institute of Fundamental Studies, Kandy

Flacourtiaceae is a family of 93 genera and over 1000 species. There are two *Flacourtia* species *Flacourtia indica* (Burm. F.) Merr. and *F. inermis* Roxb. in Sri Lanka. *Flacourtia indica* is a moderate size tree growing in Sri Lanka. It is used as an ornamental plant. Its fruit is edible and very popular in Sri Lanka. In a continuation of our studies on edible fruits of Sri Lanka, we chemically investigated the fruit juice of *F. indica*. Flacourtin (3-hydroxy-4-hydroxymethylphenyl-6-*O*-benzoyl- β -D-glucopyranoside) and sitosterol- (6'-*O*-fattyacyl)- β -D-glucopyranosides were reported previously from the bark and leaves, respectively. No phytochemical work has been reported previously from the fruits of this plant. In this paper, we report the isolation and structure elucidation of a new 6-*O*-(*E*)-



coumaroyl glucoside, named flacourside (1), from the fruit juice of the plant together with known methyl 6-O-(E)-p-coumaroylglucopyranoside (2) and 6-O-(E)-p-coumaroylglucopyranose (3).

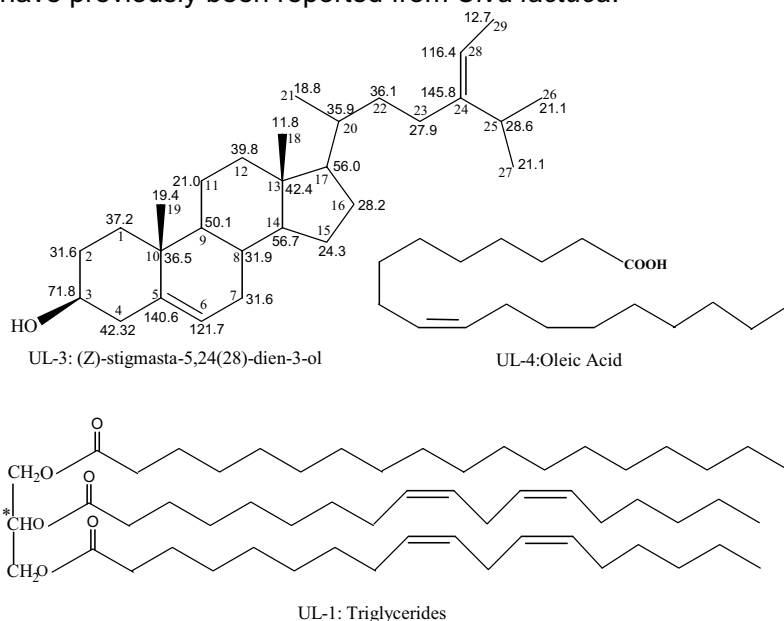
* lalith@ifs.ac.lk
607/E₂

Tel: 081-2232002

Chemistry and biological activity studies of green algae *Ulva lactuca* L.

M H Haroon, S R Premaratne, M T Napagoda and H R W Dharmaratne*
Natural Products Programme, Institute of Fundamental Studies, Kandy

Sri Lankan seaweeds (marine algae) remain largely unexplored. Therefore, the present investigation is initiated with the hope of isolation and identification of biologically active and economically important compounds from Sri Lankan seaweeds. Methanol extract of the common seaweed *Ulva lactuca* was subjected to antibacterial, antifungal, antioxidant, cytotoxicity and seed germination inhibition assays. However, no activity was observed. Column chromatography of the methanol extract of *Ulva lactuca* followed by PTLC gave seven metabolites. ¹³C NMR spectrum of compound UL-3 showed 29 carbon atoms including four olefinic ones. Its ¹H NMR spectrum clearly showed two olefinic proton signals at δ 5.32 and 5.11 as a multiplet and a quartet respectively. The CIMS of UL-3 had M⁺ of m/z 412 with m/z 413 [M + 1]⁺ as the base peak. HMQC and HMBC correlation studies and comparison with literature data suggested UL-3 to be (Z)-stigmasta-5, 24(28)-dien-3-ol. ¹H NMR, ¹³C NMR, HMQC, HMBC data and by comparison with literature, the structures of UL-1 and UL-4 were established as Oleic acid, and a triglyceride with two linoleic acid molecules and one stearic acid molecule (as shown in the figure) respectively. (Z)-Stigmasta-5, 24(28)-dien-3-ol and Oleic acid have previously been reported from *Ulva lactuca*.



* hrwd@ifs.ac.lk

Tel: 081-2232002

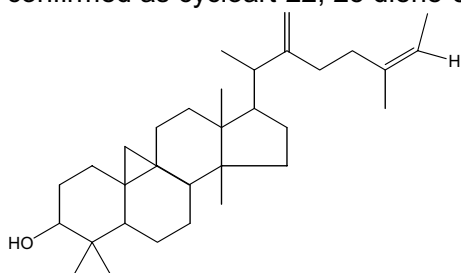
608/E₂

A new cycloartane derivative from *Garcinia mangostana* L.

H R W Dharmaratne*, K G N P Piyasena and S B Tennakoon
Natural Products Programme, Institute of Fundamental Studies, Kandy

Garcinia mangostana L. (Clusiaceae) is a delicious fruit tree found in South East Asia, and medicinal uses such as for the treatment of diarrhea, dysentery, skin infections and as an anti-inflammatory agent are reported. Further, a number of biologically active xanthenes and other natural products have been reported from various parts of *G. mangostana*.

Our chemical investigation on root bark and fruit hull of *G. mangostana* L. yielded β -mangostin, α -mangostin, γ -mangostin, Gartanin, Garcinone E, 3¹-hydroxy-4¹-geranyl-5¹-methoxybiphenyl and an unidentified white crystalline compound with mp. 98 -100°C. In the proton NMR spectrum of this unidentified compound, two ¹H doublets appeared at δ_H 0.35 and 0.57 with coupling constants of 4 Hz clearly indicated the presence of two cyclopropyl protons of a cycloartenol derivative. ¹³C NMR spectral data showed the presence of 32 carbon atoms in the compound. Further spectral analysis indicated the presence of a secondary hydroxyl group and two double bonds. HMQC and HMBC correlation studies clearly indicated the cycloartinol skeleton, positions of the double bonds and the attachment of the hydrocarbon chain. Considering the above information together with literature data comparison, the structure of the unidentified compound was confirmed as cycloart-22, 25 diene-3 β -ol, which is a new cycloartane derivative.



Cycloart-22, 25 diene-3 β -ol

* hrwd@ifs.ac.lk

Tel: 081-2232002

609/E₂

Antinociceptive potential of Sri Lankan BOPF grade black tea (*Camellia sinensis* L.)

produced in different agro-climatic elevations in rats

K R W Abeywickrama^{1*}, A M T Amarakoon² and W D Ratnasooriya³

¹ *Analytical Laboratory, Sri Lanka Tea Board, Colombo 3*

² *Bio-Chemistry Division, Tea Research Institute, Talawakelle*

³ *Department of Zoology, University of Colombo, Colombo 3*

Antinociceptive activity of several herbal drugs is claimed to be due to polyphenols. Tea (*Camellia sinensis* L.) contains high levels of polyphenols. Thus it is possible that tea may also have antinociceptive potential. The aim of this study was to investigate the antinociceptive potential of Sri Lankan black tea of three major agro-climatic elevations: high grown (above 1200 m, mean sea level), mid grown (600 m–1200 m, msl) and low grown (below 600 m, msl) using rats. The content of phyto-chemicals in typical black tea brew (BTB) of three elevations (using BOPF grade) were analyzed using HPLC techniques. Three different concentrations of high grown BOPF grade BTB (containing 60, 120, 480 mg/L tea solids) and vehicle (distilled water) were orally administered (1mL/100g body weight) to healthy adult male Wistar rats (n = 9/group) and antinociceptive potential was evaluated up to five hours at hourly intervals using hot plate and tail flick techniques. In addition antinociceptive potential of mid and low grown BOPF grade black tea was assessed using high dose (480 mg/L, which is equivalent to 12 cups). Results show that, Sri Lankan high grown BOPF grade black tea possesses significant ($P \leq 0.05$) short acting antinociceptive activity when evaluated in the hot plate technique but not in the tail flick technique, indicating a supra spinal antinociceptive activity. The onset of this activity is quick (within two hours) and was dose dependent at 2nd ($r^2=0.91$, $P < 0.05$) and 3rd ($r^2=0.97$, $P < 0.05$) hour post treatment. High dose of mid and low grown BTB of BOPF grade showed comparable antinociceptive activity to that of same dose of high grown BOPF. The BTB of all three agro-climatic elevations did not induce muscle relaxation (as judged by bar holding test) and muscle in-coordination (as evaluated by bridge test) actions, suggesting that the antinociceptive effect observed is genuine. Phyto-chemical analysis of black tea revealed that there is no significant difference ($P > 0.05$) between the total polyphenols in BOPF grade of three agro-climatic elevations (22.6 %, 18.2% and 20.8% for high grown, mid grown and low grown respectively). This may account for similar antinociceptive potential of BOPF grade black tea in three elevations. In conclusion, our results demonstrate that Sri Lankan BOPF grade black tea of all agro-climatic elevations possess centrally acting supra spinally mediated short acting oral antinociceptive activity.

Financial assistance by the Sri Lanka Tea Board is greatly acknowledged.

* lab@pureceylontea.com

Tel : 011-2581576

610/E₂

Chemical composition of coconut haustorium and preparation of dehydrated chips

L L W C Yalagama^{1*}, R A M K Ramanayake² and V Wijerathne²

¹ *Coconut Research Institute, Lunuwila*

² *Faculty of Agriculture, University of Ruhuna, Kamburupitiya*

The coconut haustorium (*Palapi*) is discarded during processing of seasoned coconut. The haustorium (*Palapi*) is palatable at early stages of germination. It is sweet in taste and has about 6 hours of shelf life. A study was carried out to find out the nutritional composition and to deduce the optimum condition to prepare dehydrated chips from coconut haustorium. Germinated coconuts of four germinating stages obtained from Coconut Research Institute were selected for this study. The stages of germination were selected from the size of the shoot. The chemical analysis showed that it contained 88.2 – 91.2 % moisture, 0.83 – 1.24 % ash, 0.71 – 1.70 % protein, 1.35 – 2.91 % fat, 0.53 – 0.82 % crude fibre and 1.35 – 2.91 % sugar. The fat from haustorium showed that it contained 4 – 6 % oleic acid, 47 – 50 % lauric acid and 21 % myristic acid. Fatty acid content did not vary with the stages of germination. Total plate counts were 9×10^3 , 5×10^3 , 4×10^3 , and 2.5×10^3 CFU (Colony Forming Unit) / g at cut opening for 1st germination stage to fourth stage respectively. Plate count increased when it was exposed to ambient conditions. After 6 hours, the plate counts were 1.1×10^5 , 2.1×10^5 , 4.5×10^5 , and 1.2×10^5 CFU/ g for 1st germination stage to fourth stage respectively.

Two preservation methods - direct dehydration and osmotic dehydration were carried out for preservation of haustorium. Six treatments with different sizes of the chips and different ratio of sugar: Haustorium (w/w) were carried out for preservation studies. All the samples were dehydrated at 65 °C for 7 ½ hours. The temperature was increased to 75 °C during last 20 -30 minutes to give crispness to chips.

Kruskal Wallis one-way nonparametric ANOVA test showed that there was a significant difference for organoleptic qualities among chips from different treatments. Osmotic dehydration obtained higher scores on sensory evaluation than the direct dehydration. Out of different treatments for osmotic dehydration 1 x 1 x 4 cm³ size; 1:1 sugar: haustorium ratio obtained highest score for overall acceptability. Initial study showed that the osmotic dehydrated chips could stored at ambient conditions up to 3 months.

* cyalegama@co.in

Tel: 031-2255300

611/E₂

Inhibition of lipid peroxidation in tissue homogenates by selected medicinal oils and their antioxidant activity

Bimali Jayawardena*, Chamara Hiran Jayakody, Kapila N Seneviratne
Department of Chemistry, University of Kelaniya, Kelaniya

This study was aimed at determining the effect of nonsaponifiable fractions of medicinal oils on the inhibition of lipid peroxidation of liver tissue homogenates. Investigations were carried out using oils extracted from the seeds of Domba (*Calophyllum inophyllum*), Mee (*Madhuka neriifolia*), Thala (*Sesamum indicum*) and Aba (*Brassica juncea*). Lipid peroxidation in liver tissue homogenates were analysed by estimating the formations of thiobarbituric acid reactive substances (TBARS).

The inhibition depends on the antioxidant potentials of the four nonsaponifiable fractions of medicinal oils. Antioxidant activity was analysed by several model assay methods, such as linoleic acid method, liposome oxidation method and reducing power method to

elucidate the possible mechanism of antioxidant action. Total phenols content of four different nonsaponifiable fractions of medicinal oils were also investigated.

When comparing the amount of TBARS in the liver tissue homogenates, nonsaponifiable fraction of Thala oil indicated the highest amount of TBARS ($131.48 \pm 3.90 \mu\text{mol/g}$), whereas that of Mee oil showed the lowest amount of TBARS ($105.65 \pm 1.90 \mu\text{mol/g}$) with respect to control experiment. This indicates nonsaponifiable fraction of Mee oil offers the best protection against oxidative damage. The amount of TBARS for Domba and Aba are as follows 117.3 ± 1.0 and $121.4 \pm 2.6 \mu\text{mol/g}$.

Total phenol content of Domba, Mee, Thala and Aba oils are 1224.6 ± 138.1 , 1286.53 ± 109.3 , 286.3 ± 54.1 and $434.25 \pm 99.2 \text{ mg/kg}$ of oil respectively. All the model assay methods indicated good correlation between total phenol content and percent inhibition of oxidation. Based on the model assay, it can be concluded that the nonsaponifiable fractions of the oils offers protection against oxidation due to free radical scavenging and reducing ability.

* bimali@kln.ac.lk

Tel: 011-2914486

612/E₂

Antifeedant acetogenins from *Goniothalamus gardneri* (Annonaceae)

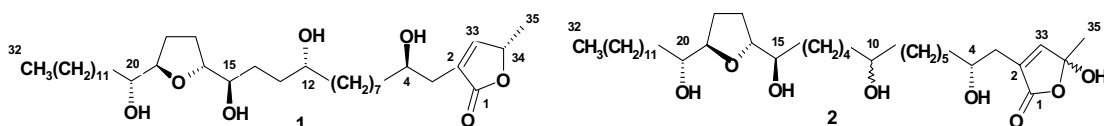
S Puvanendran¹, A Wickramasinghe¹ and V Karunaratne^{1*}

¹ *Department of Chemistry, University of Peradeniya, Peradeniya*

In a continuation of our search for biologically active and/or pharmaceutically important compounds from Sri Lankan endemic plants, the present study was carried out on the flowers of *Goniothalamus gardneri*. *G. gardneri* is an endemic tree of the family Annonaceae growing in the wet part of the country. Several acetogenins, fatty acids, sterols have been reported from the plant. Extracts of the *G. gardneri* showed mosquito larvicidal activity. Acetogenins isolated from the family Annonaceae exhibit a broad range of biological activities such as cytotoxic, antitumor, insecticidal, antiparasitic etc. Diamond back moth, *Plutella xylostella*, is a serious pest of cruciferous crops worldwide, and has developed resistance against almost all kinds of insecticides available in the market. Thus there is a need of find new insecticides with high efficiency and environment friendly. Herein we report on potent antifeedant activities of two acetogenins isolated from the *G. gardneri* against *P. xylostella*.

The methanol extract of the flowers of *G. gardneri*, upon MPLC and Flash chromatography, yielded two acetogenins **1** and **2**. Structures determination of **1** and **2** were done by the comparison of ¹H/¹³C NMR data with reported data and Co-TLC with the authentic samples. In the leaf-dipping method for insecticidal activity, percentage mortality and feeding area were observed and recorded after 24, 48 and 72 h. Cabbage

leaves were used to feed the insects. LC₅₀ values of **1** are 930.60 ppm/ 24h, 356.14 ppm/ 48h and 161.02 ppm/ 72h and **2** are 725.97 ppm/ 48h and 648.13/ 72h. Eventhough the LC₅₀ values of the compounds **1** and **2** were moderate, they acted as good antifeedants, and the feeding area of leaves were very small compared to the control. When the compound **1** used for the treatment, the mean feeding areas were 0.875 mm²/ 24h, 3.125 mm²/ 48h, 5.875 mm²/ 72h and the mean feeding areas when **2** has used were 4.438 mm²/ 24h, 38.438 mm²/ 48h, 55.688 mm²/ 72h. Mean feeding areas in the control were 18.25 mm²/ 24h, 357.00 mm²/ 48h and 782.00 mm²/ 72h (Total feeding area of the leaf disc was 788.00 mm²).



Authors thank the National Science Foundation, Sri Lanka for financial assistance.

* veranjak@pdn.ac.lk

Tel: 081-2389129

613/E₂

A reinvestigation of the profile, content, retinol equivalent and studies of *in-vitro* bioaccessibility of carotenoids of *Carica papaya*

A M B Priyadarshani, E R Jansz* and H Peiris
 Department of Biochemistry, University of Sri Jayewardenepura, Gangodawila, Nugegoda

The yellow-fleshed papaw (*Carica papaya*), is widely recognised as a good source of pro-vitamin A carotenoid. This study was designed to determine the carotenoid profile and the content of yellow-fleshed papaw collected at random from different areas of Kurunegala, which is a major papaw producing District in Sri Lanka. Carotenoids were separated by open column chromatography (OCC). Identification was carried out by UV spectrophotometrically, order of elution in OCC and by the following chemical tests: fuming HCl test on the thin layer chromatography (tlc), test for epoxides with 0.1N HCl and for *cis-trans* configuration by iodine catalysis. The extracts were analysed by high performance liquid chromatography (HPLC). Results showed that the carotenoids present were: phytofluene (ranged from 135 to 241 µg.100g⁻¹ fresh weight (FW)), ζ – carotene (ranged from 29 to 238 µg.100g⁻¹ FW), β-carotene (ranged from 140 to 1030

$\mu\text{g}\cdot 100\text{g}^{-1}$ FW), β -cryptoxanthin (ranged from 230 to 1510 $\mu\text{g}\cdot 100\text{g}^{-1}$ FW), β -cryptoxanthin 5,6-epoxide (ranged from 20 to 190 $\mu\text{g}\cdot 100\text{g}^{-1}$ FW) and an unknown mono epoxy-carotenoid (ranged from 62 to 223 $\mu\text{g}\cdot 100\text{g}^{-1}$ FW). Retinol equivalent (RE) was also varied markedly from 344.8 – 2410 $\cdot 100\text{g}^{-1}$ dry weight. This is 2 to 16 fold, values reported for papaw previously. *In-vitro* bio-accessibility studies showed values $5.2\pm 0.9 \mu\text{g}\cdot \text{g}^{-1}$ FW for β -carotene and $6.9\pm 1.1 \mu\text{g}\cdot \text{g}^{-1}$ FW for β -cryptoxanthin. This is 50.5% and 45.7% the fraction of total available β -carotene and β -cryptoxanthin, respectively.

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* erjansz@sjp.ac.lk

Tel: 011-2803578

614/E₂

Studies on organic non-covalent binders of β -sitosterol

P R Wijemanne¹, P M Jayaweera² and E R Jansz^{1*}

¹ Department of Biochemistry, Faculty of Medical Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda

² Department of Chemistry, Faculty of Applied Sciences, University of Sri Jayewardenepura, Gangodawila, Nugegoda

The β -sitosterol moiety is the common sterol found in a group of compounds known as flabelliferins which are found in palmyrah fruit pulp (PFP), and is known to bind phytofluene and phytoene. It was recently reported that due to impurities isolation from plant sources was problematic. These studies showed that commercial β -sitosterol contained many impurities which can be separated by using a chromatotron, the fluorescent fractions of which were pooled and analysed by RP-HPLC. The fluorescent impurity gave many peaks, none of which coincided with phytofluene and phytoene, showing there were many other binders to β -sitosterol, some of which were probably not fluorescent. Phytofluene isolated from PFP and purified β -sitosterol from Sigma, USA, was mixed and left to stand overnight. The mixture was subjected to thin layer chromatography (TLC). UV light and anisaldehyde were used to detect phytofluene and β -sitosterol respectively. The two compounds co-chromatographed indicating an association. The purified β -sitosterol was used to quench the fluorescence of phytofluene which was detected by a luminescence spectrometer to calculate the association constant. Phytofluene, β -sitosterol and the associated complex were analysed by FT-IR spectroscopy for changes in the spectra. The fluorescence spots and the anisaldehyde spots on the TLC paper overlapped confirming their association, while the quenching studies showed an association constant of $\log K_{\text{ass}}=5.044$ ($R^2=0.9817$), and FT-IR showed minimal distortions between the spectra of complex and the reactants, suggesting a non-covalent binding.

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* erjansz@sjp.ac.lk

Tel: 011-2803578

615/E₂

Determination of essential oil content and the chemical constituents of nutmeg (*Myristica fragrans*, Houtt.) rind oil

I K Indrasena, S P Prematilake*, P D Liyanage, M V Gamlathge
Central Research Station, Department of Export Agriculture, Matale

Nutmeg (*Myristica fragrans*, Houtt.) produces two types of spices, namely nutmeg, and mace. Essential oils are produced commercially from both nutmeg kernel and from mace. The nutmeg rind that represents 70% by weight of the fruit is usually discarded by the farmers.

In this study, essential oil was distilled from fresh nutmeg rind with skin (WS) and without skin (WTS). Percentages of moisture and oil content on dry basis were calculated. The essential oils were analysed to find constituents and their percent concentrations using Shimadzu GC- 9A Gas Chromatograph equipped with FI detector and 10% Carbowax column 20M WAW. Standard samples of major chemical constituents were injected and according to their retention times (Rt) chemical constituents of nutmeg rind oil were identified.

Table: Average moisture % (M), average oil % on dry basis (Oil % DB) and average % concentrations of major constituents according to the treatments (Trt)

Trt	M %	Oil % DB	% concentrations of major constituents					
			β -caryophyllene	Terpene -4-ol	α -terpineol	Safrole	Elimicin	Myristicin
WS	91	1.13	38.00	17.10	0.02	3.80	2.59	2.52
WTS	94	1.18	16.20	7.90	4.45	1.63	13.90	19.25

The average oil content of nutmeg rind was approximately 1.16 %. The aroma of rind oil observed to be similar to nutmeg seed and mace oils. Rind oil showed relatively high concentrations of elimicin and myristicin compared to seed and mace oils. With the outer skin, rind oil content was relatively low.

* premathilakesp@yahoo.com

Tel: 066-2222822

616/E₂

Monitoring air pollution levels in the Horton Plains National Park using passive gas sampling technique

R G U Jayalal¹, O A Ileperuma¹, D S A Wijesundara² and V Karunaratne^{1*}

¹ Department of Chemistry, Faculty of Science, University of Peradeniya, Peradeniya

² National Botanic Gardens, Peradeniya

The technique of passive gas sampling was carried out to monitor air pollution in Horton Plains National Park (HPNP), a cloud forest and the highest plateau in Sri Lanka. This technique was used to analyse sulphurdioxide (SO₂) and nitrogendioxide (NO₂) in the ambient air at five different locations within the park.

The variations of NO₂ and SO₂ levels were analysed from 11th July 2005 to 25th May 2006. NO₂ levels had slight variations and, the highest average value (0.0005 ppm) was observed during April to May, while the lowest values (3.2–4.0 x 10⁻⁵ ppm) were obtained during August to December. Thereafter the values increased till May. This increase may be due to North–East monsoon wind effect and increased number of tourist vehicles during the Sinhala and Tamil new year festival season. SO₂ levels were significantly higher than those of NO₂ levels in the same study period. The highest values for SO₂ (0.01–0.02 ppm) were obtained from September to November while the lowest values (0.001–0.002 ppm) were obtained from July to September and December to January. There was an inverse relationship between rainfall and the concentration of SO₂, since SO₂ is removed from the atmosphere by dissolution in rainwater. A similar correlation was observed with the NO₂ concentration as well.

The Sri Lanka standards for 24 h average of NO₂ and SO₂ in ambient air are 0.05 ppm and 0.03 ppm, respectively. The concentration of each pollutant obtained during the entire period showed, that these standard values were not exceeded in HPNP. Average concentration of NO₂ and SO₂ for a period of 10 months gave very low values, indicating that the ambient air quality in HPNP is very pure and no considerable amount of NO₂ or SO₂ is present. It would be desirable to monitor NO₂ and SO₂ in air for a long period of time to check whether there is any trans boundary pollution in this area due to North-East and South-West monsoons.

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* veranjak@pdn.ac.lk

Tel: 081-2389129

617/E₂

Development of solid phase assays for quantitative, semi-quantitative and qualitative determination of urinary glucose

K M Ferdinando and C Deepal Mathew*

Department of Biochemistry and Molecular Biology, Faculty of Medicine, University of Colombo, Colombo 8

Determination of urinary glucose is important in management of diabetes mellitus and fanconi syndrome. Commercial test strips available for this have used O- toluidine as the colour development reagent. With restrictions on the use of O- toluidine due to its carcinogenic properties, new reagents are being developed for glucoses assays. Use of 4 - methoxy - 1 - naphthol and 5', 5 - dimethyl cyclohexane dione has been demonstrated in our laboratory. In this paper, we describe the use of this assay for quantitative, semi-quantitative and qualitative determination of urinary glucose. The dry reagent element proposed for quantitative and semi-quantitative determination of urinary glucose was prepared by immobilisation of glucose oxidase, peroxidase, 4-methoxy-1-naphthol, 5,5-dimethyl cyclohexanedione in gelatin with phosphate buffer pH 6, followed by uniform

coating using the Meyer rod technique on Whatmann filter paper. The analytical elements undergo a double sequential enzymatic reaction which results in a blue colored oxidised dye conjugate. Dye can be quantified by recording transmittance intensity in solid phase by optical densitometry. The proposed dry reagent strip can be used in quantitative determination of urinary glucose by comparing transmittance intensity developed after 2 minutes from the time of dipping the enzyme coated area in urine at room temperature. No interference was observed with ascorbic acid, ketones, urobilinogen, creatinine, fructose and galactose. Semi-quantitative measurements can also be done with enzyme coated paper strips by comparing the blue colour developed after 1 minute with the rating scale we have developed. Dry reagent element proposed for qualitative determination of urinary glucose was also prepared by immobilisation colour developing reagents on processed coconut kernel. The test detects the presence of glucose with a sensitivity of 99.12 % and a specificity of 100% at a detection limit of 2 mg/dl. Both types of test strips can be stored in closed bottles with a desiccant with or without refrigeration for more than 4 months with no detectable loss of sensitivity.

Tel: 011-2697485

618/E₂

Enhancement of enzyme activity of alpha amylase used in the textile industry

V Lalagini, C Deepal Mathew* and S Jeevathayaparan
Department of Bio Chemistry and Molecular Biology, Faculty of Medicine, University of Colombo 8

Alpha amylase is used in the textile industries for desizing. In Sri Lanka the main foreign exchange source is the textile industries. Enhancement of amylase enzyme activity will reduce the cost of production and improve our competitiveness in the world market. In this study, we have obtained alpha amylase from Multicheme Company which distributes alpha amylase to the textile companies and studied the optimisation of the enzyme activity. Studies on the effect of temperature showed that optimum activity is between 37 °C to 70 °C. The Instruction for enzyme use indicates the use at 50 °C. The decrease in temperature to 40 °C will give the same effect on hydrolysis of starch with a decrease in cost of application. The optimum pH was observed from 5 to 8. At a calcium ion concentration of 0.02mM to 0.04mM the enzyme activity increased to 142% and 180% respectively. At higher concentration, the enzyme activity was inhibited. Studies on chemical modification of the enzyme showed that modification with N – ethylmaleimide increase the enzyme activity to 243%. Modification with pentanedione had no effect on enzyme activity while modification with N – Bromosuccinimide and Carbodiimide inhibited the enzyme activity.

Tel: 011-2697485

619/E₂

Adsorptive transport of chromate by suspended solids in Kelani river

L A Duminda Sanjeewa¹, Janitha A Liyanage^{1*} and Rohan Weerasooriya²

¹ Department of Chemistry, University of Kelaniya, Kelaniya

² Chemical Modeling Project, Institute of Fundamental Studies, Kandy

Intensive industrial development during the past decades along the river banks has led to environmental and health impacts due to discharge of contaminated effluents. The discharge of industrial effluent has led to a substantial increase of metal availability in river, estuarine and marine sediments. Depending on their solubility, these metals may eventually become associated to suspended particulate matter and/or accumulate in the bottom sediments.

This preliminary study was conducted to determine the distribution of chromate in water and suspended solids (SS) and to see the adsorption pattern of chromate at different ionic strengths and pH through the complexation process in the Kelani River SS.

Concentrations of heavy metals in river sediments and water were determined using flame and graphite furnace atomic adsorption spectrometry. It shows that most of the heavy metals are associated with the SS.

The mineralogy of SS was determined by powder X-ray diffraction method. The results showed that the river SS mainly consisted of kaolinite and silica. In addition, some other types of aluminosilicates and titanium containing minerals are present.

The surface charge of the river SS was determined by potentiometric titrations. These acid base titrations make it possible to determine the pH of 'point of zero charge' for river SS and the titrations were carried out on the natural SS and acid treated SS separately. The pH values of 'point of zero charges' are very close to those of kaolinite, which indicates that the SS surface processes, can be modeled mimicking pure-phased kaolinite.

Chromium adsorption on Kelani river SS was examined in batch experiments as a function of pH with background electrolyte concentrations of 0.001 mol dm⁻³, 0.010 mol dm⁻³, 0.100 mol dm⁻³ NaCl by varying the initial Cr(VI) concentration from 0.1 - 50 μmol. Adsorption density decreases with increase of ionic strength and it increases with the initial concentration.

Adsorption edges for Cr(VI) in Kelani River SS were studied in a background solution of 0.010 mol dm⁻³ NaCl. The pH was varied from 2.5 to 11.0 with total Cr(VI) concentration of 100 μmol. The adsorption site density was examined using the fluoride adsorption onto SS in the same ionic strength and pH by varying the initial fluoride concentration from 0.2-10 mmol. The chromium adsorption density of SS increased with the pH and there is a significant variation at high pH. The thermodynamic modeling of the SS Cr(IV) speciation is in progress.

* janitha@kln.ac.lk

620/E₂

Formaldehyde based resins prepared using tannin obtained from bark of *Terminalia arjuna* (Roxb.)

S Arasaretnam^{1*}, L Karunanayaka², P Manoharan¹

¹ Department of Botany, Faculty of Science, Eastern University, Sri Lanka, Chenkalady

² Department of Chemistry, Faculty of Applied Science, University of Sri Jayewardenepura

Terminalia arjuna (Roxb.) is one of the major tannin yielding trees that grow abundant in Eastern province of Sri Lanka. In this study, the use of tannin obtained from *Terminalia arjuna* (Roxb.) for manufacture formaldehyde based resins were investigated. Five protocols were developed to isolate the tannin from the bark of *Terminalia arjuna*. Yields obtained from water, acetone and ethanol extractions were found to be 9.01 %, 4.01 % and 4.34 % w/w, respectively.

The tannin and bark from the *Terminalia arjuna* were liquefied with phenol in the presence of an acid catalyst (H₂SO₄) at different reaction time interval. The rate of liquefaction increased with the amount of sulphuric acid used as a catalyst. After 90 minutes, the amount of tannin residue remaining was 10 % and 5 % for 2.8 % and 5 % addition of sulphuric acid respectively for the tannin liquefaction. The amounts of the residue remaining after reaction with 5 % acid after 30 to 180 min were very similar, ranging from 5.1 % to 6 %. Based on these results, a reaction time of 90 minutes was selected for preparation of the liquefied tannin. After 90 min of bark liquefaction with 7.5 % acid the amount of residue was stabilised near 10 % for whole bark. In this case, the amount of residue remaining after reaction time of 120 and 180 minutes was not significantly different from 90 minutes. At the 2.5 % and 5 % levels of sulfuric acid, an appreciable amount of whole bark residue was found. Thus, the condition selected to liquefy bark for resin preparation was 7.5 % of sulfuric acid and 90 min reaction time.

Chemical structure of phenolated tannin, liquefied bark and prepared resins were identified with Fourier Transform Infra Red (FTIR). Reactions involving in liquefaction of tannin, bark with phenol were confirmed by significant change of absorption in FTIR spectra from that of tannin alone. FTIR spectrum of tannin sample give C-O stretching absorption peak at around 1000-1300 cm⁻¹ significantly but in the case of liquefied tannin resins this peak is not significant. Thus these peaks may be used to confirm the hydrolysis of etherocyclic ring of tannin. FTIR of liquefied tannin sample give significant absorption different from the tannin alone. Tannin molecule exists well shaped and narrow absorption peak in the 1500 – 1700 cm⁻¹ region but in the case of liquefied tannin the peak is broad and split. These signals may then be used as a tool to confirm whether phenol is bonded to the tannin structure.

The existence of strong hydrogen bond interaction between liquefied tannin formaldehyde resins were confirmed by FTIR spectra. The spectra were showed scale expanded infrared spectra in the -OH stretching region ($3000\text{-}3500\text{ cm}^{-1}$) for liquefied tannin formaldehyde resin. The liquefied tannin formaldehyde resin is characterised in the region by a split broad band at around $3000\text{-}3300\text{ cm}^{-1}$. Upon mixing with formaldehyde a second band is observed and could be assigned to hydrogen bonded hydroxyl group. FTIR spectrum of liquefied tannin formaldehyde resin give split strong peak at around $3000\text{-}3550\text{ cm}^{-1}$ but which appears as single strong peak in the liquefied tannin alone. It may indicate the hydroxyl group in the liquefied tannin–formaldehyde resins existing into two different types such as free hydroxyl and bonded hydroxyl group. The spectrum of liquefied tannin resin appears as absence of significance peak at around 1400 cm^{-1} . It is revealed that stretching frequency is changed due to C-H deformation occurring in the phenyl group of tannin molecule. It may give ideas on absorption different to liquefied tannin and liquefied tannin resin. Further studies are very important to confirm this cross linking reaction.

Shear strength of liquefied tannin and bark resins are not of much significant value due to semi liquid nature of prepared resins.

Present Address/es:

¹ Faculty of Science, Eastern University

² Department of Chemistry, Faculty of Applied Science, University of Sri Jayewardenepura

* arasan1976@yahoo.com

Tel: 065-2240755

621/E₂

Distribution of thiram between water and soil

Namal Priyantha*, Ayanthi Navaratne and Chandima B Ekanayake
Department of Chemistry, University of Peradeniya, Peradeniya

Thiram [tetramethylthiuram disulfide] is a fast moving dithiocarbamate fungicide, which has an LD₅₀ value between 620 and 1900 mg/kg in rats. Distribution of thiram between water and soil phases is of great significance in order to predict the levels of thiram in soil exposed to agricultural practices or in soil through which agricultural run-off water passes.

Detection of thiram in CHCl₃ is successfully achieved through absorbance measurements at 280 nm, which result in a linear calibration curve with the following analytical characteristics: A minimum detection limit of 0.170 mg dm^{-3} based on the S/N ratio of 3, a linear dynamic range from 1.00 mg dm^{-3} to 10 mg dm^{-3} , and a sensitivity of $0.0860\text{ mg}^{-1}\text{ dm}^3$. This detection method, extended for the determination of the partition coefficient (K_D) of thiram between CHCl₃ and H₂O phases at ambient temperature, results in an average value of 6.58 ± 1.02 over 30 replicates. Subsequently, the above partition coefficient is used to determine the partition coefficient of thiram between sieved soil (pH = 7.28, diameter < 2.0 mm), used for agricultural practices, and water (K_D'), where by the quantification of thiram in water after adsorption equilibrium with soil is achieved through a solvent extraction step of thiram-contaminated water into CHCl₃.

The K_D' values determined for an initial thiram concentration range of 4.00 mg dm⁻³ to 30.00 mg dm⁻³ show a decreasing trend from 8.70 to 1.71, indicating the strong irreversible adsorption behavior of thiram on soil at low concentrations. However, variation of pH within the usual range of soil causes only a marginal effect on the magnitude of K_D' . Adsorption of thiram on to soil in turn indicates the possibility of bioaccumulation through the food chain, if the agricultural run-off water is contaminated with thiram.

Such studies would easily be extended to determine the amount of thiram adsorbed to soil or present in water when thiram is introduced to soil systems for agricultural practices.

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* namalpriyantha@pdn.ac.lk

Tel: 081-2394445

622/E₂

An electroanalytical sensor for the detection of oxyfluorfen (Goal)

Ayanthi Navaratne* and Sanjeewa B Gamagedara
Department of Chemistry, University of Peradeniya, Peradeniya

Oxyfluorfen [2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene] is a selective pre and post emergence diphenyl-ether herbicide used to control certain annual broadleaf and grassy weeds in vegetables, fruit, cotton, ornamentals and rice. Here we report the use of a non electroactive stearic acid modified glassy carbon electrode as an amperometric sensor for the detection of Oxyfluorfen. Preliminary electrochemical characterisation was carried out by cyclic voltammetry. Analytical characteristics of the sensor were evaluated by steady state amperometry.

Cyclic voltammetric experiments of 1.0×10^{-4} mol dm⁻³ Oxyfluorfen in an ethanol water (4:6) mixed solution of 0.1 mol dm⁻³ NaCl showed two reduction peaks at potentials of -0.39 V and -0.80 V, vs saturated calomel reference electrode. Oxidation peak was obtained at -0.28 V. Scan rate dependence studies of the peak at -0.15 V vs saturated calomel electrode showed that it is a diffusion controlled reaction. The potential of the working electrode was optimised and the optimum operational potential range for the amperometric experiments was found to be between -0.800 V and -0.900 V with respect to the saturated calomel electrode. The amperometric measurements at the above potentials suffered interference from the noise with the sequential addition of Oxyfluorfen at bare glassy carbon electrode. This difficulty can be overcome by modifying the electrode surface with a suitable modifier. In this study, non electro active stearic acid (0.5% w/v) was used as the electrode modifier. When stearic acid was deposited on the electrode surface noise levels of the amperometric results were substantially reduced.

This may be due to prevention of adsorption of the analyte molecules on the electrode surface.

Calibration of the sensor with respect to Oxyfuorfen was done over the concentration range $3.85 \times 10^{-7} \text{ mol dm}^{-3}$ to $3.42 \times 10^{-6} \text{ mol dm}^{-3}$ using steady state amperometry and calibration curves were constructed. Slope of calibration curve was taken as the sensitivity of the sensor. At the potential of -0.800V , the slope is $9.828 \times 10^5 \mu\text{A mol}^{-1} \text{ dm}^3$ while at -0.900 V it is $1.1982 \times 10^6 \mu\text{A mol}^{-1} \text{ dm}^3$. The minimum detection limit of the sensor was estimated to be $2.31 \times 10^{-7} \text{ mol dm}^{-3}$ at signal to noise ratio of 3. The steady state amperometric response time (t_{90}) of the sensor was 6.3 s. The coefficient of variation of the sensor was estimated to be 8.7%. Since the problematic noise levels can be successfully overcome by stearic acid coated glassy carbon electrode, this study demonstrates the potential utility of the sensor as an amperometric detector for Oxyfluorfen.

* ayanthin@pdn.ac.lk

Tel: 081-2394448

623/E₂

Cr(III) adsorption at the feldspar water Interface

Namal Priyantha^{1*}, Rohan Weerasooriya² and Prasad Gunathilaka¹

¹*Department of Chemistry, University of Peradeniya, Peradeniya*

²*Institute of Fundamental Studies, Kandy*

Contamination of the environment by Cr has become a major area of concern due to its high toxicity. Many attempts have been made to deal with this problem with limited success. Feldspar is found to scavenge Cr(III) from aquatic media effectively through interaction between Cr(III) species and $\equiv\text{Al-OH}$ edges of aluminosilicates present in feldspar.

Kinetic experiments show that the percent removal of Cr(III) rapidly increases up to 70 % within the initial stirring time period of 20 min, followed by a slow increase at extended stirring times. The initial increase indicates that, at the beginning of the process, adsorption is the predominant mode of interaction of Cr(III) with the feldspar surface. This conclusion is supported by the observation that settling time does not affect much on the percent removal of Cr(III). Once all the active adsorption sites are occupied, sorption process would take a diffusion-controlled path where Cr(III) species would

diffuse into the available sites in the bulk of the feldspar matrix, which can be predicted from the observation of the slow removal of Cr(III) during extended stirring times.

The predominant adsorption behavior is further supported by the surface charge properties. Surface pH titration experiments of feldspar suspensions having an initial pH value of 8.4, carried out in solutions of different ionic strengths are indicative of the presence of negatively charged feldspar surface. Surface charge density vs pH curves at three different ionic strengths meet at the point of zero charge (ZPC) that lies between pH 9.5 and 10.0 beyond which the feldspar surface possesses a strong potential for adsorption of metal ions. Further investigation of the surface charge density of feldspar suspensions in the presence of Cr(III) points out that the surface charge density has diminished, indicating that the adsorption of Cr(III) on to the surface has balanced the charges of the feldspar surface. Further, experimental results fit with both the Langmuir and Freundlich isotherms which again explain the occurrence of predominant adsorption with an adsorption coefficient of $3.25 \times 10^{-3} \text{ dm}^3 \text{ g}^{-1}$, followed by isomorphic substitution, including ion exchange.

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* namalpriyantha@pdn.ac.lk

Tel: 081-2394445

624/E₂

Electrochemical destruction of textile colorants using Indium Tin Oxide (ITO) coated conducting glass electrode

P T Wansapura and J Bandara*
Institute of Fundamental Studies, Kandy

The degradation of textile colorant, Eosin Y (EY), in aqueous medium of pH 3.0 – 6.0 has been studied by anodic oxidation using indium tin oxide (ITO) coated glass anode. The dye solution with a concentration of 50 μM is totally decolorised in 30 minutes at an electrical charge (Q) of 0.067 C dm^{-3} . The decay kinetics of EY follows a pseudo first-order reaction. The degradation of EY is faster at acidic pH values than at basic pH values. The key advantage of the ITO conducting glass anode is that the deposition of polymeric materials on the anode surface during electro-degradation of pollutant is absent and therefore the electrode fouling is not observed. Hence, the ITO anodes can be employed for an extended period without loss of activity.

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* jayasundera@yahoo.com

Tel: 081-2232002

625/E₂

Use of p- type CuAlO_2 and NiO hole collectors in dye-sensitised solid-state solar cells

J P Yasomanee and J Bandara*
Institute of Fundamental Studies, Kandy

Oxide semiconductors with p-type conductivity were found to be good candidates to be used as hole collectors in dye sensitized solid-state solar cells (DSSC). Delofossite p-type CuAlO_2 semiconductor was synthesized by hydrothermal method and its activity on DSSC as a hole collector was studied. Energy positions of valence band (VB) and conduction band (CB) of CuAlO_2 were found to be suitable for it to be used as hole conductor in DSSC. Efficiency of the solar cells constructed with $\text{TiO}_2/\text{Ru dye}/\text{CuAlO}_2$ was about 0.04%. SEM images show that the particle size of CuAlO_2 prepared by hydrothermal method was larger than that of TiO_2 . Therefore it penetrates weakly into the pores of TiO_2 nanocrystalline matrix resulting weak interaction between dye and hole collector which was found to be one of the reasons for poor solar cell performance of solar cell constructed with CuAlO_2 as hole collector. Bigger particle size and poor p-type conductivity are found to be the major limiting factors of CuAlO_2 as a hole collector. Solar cell performances of electrodes constructed with $\text{TiO}_2/\text{Ru dye}/\text{NiO}$ are also discussed.

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* jayasundera@yahoo.com

Tel: 081-2232002

SECTION F

701/F

Enhancing distance education via online learning: The case of teacher educators

Shironica Karunanayaka*
Department of Secondary & Tertiary Education, Faculty of Education, The Open University of Sri Lanka, Nawala, Nugegoda

Using online methods for learning is becoming an integral component in education worldwide, especially in open and distance learning contexts. These methods provide

flexibility of time, place and pace of learning, while making the students responsible for their own learning. Accordingly, offering distance learning courses using the Web is rapidly becoming an established practice in higher education. This paper describes a case study that explored the experiences of a group of teacher educators who were distance learners, and engaged in online learning through a learning management system (LMS), as a requirement in their professional development programme. The investigation focused on the following research questions: For what purposes had the learners used the learning management system? What were the types of participation by learners? What were the benefits gained by learners through online learning? and, What were the challenges faced by learners in their online learning process?

Learners perceived the online learning environment to be a valuable resource, which enabled them to communicate with academic staff and peers from whom they were physically remote as distance learners. They had used the LMS mainly to receive course information, communicate with the teacher and peers, and submit assignments. Several participation types such as stating viewpoints, supporting or opposing other's views, seeking and providing help, sharing ideas and resources, critical and analytical comments, reflections, and social interactions were observed. Although certain challenges such as limited access to the Internet, coping with the technology, information and interaction overload, time constraints, increased workload and changing from conventional approaches to a more self-regulated approach were faced, a sense of achievement was claimed by the learners, once they became confident in using this facility and gained competence.

Engagement in online learning was a highly challenging and motivating experience for the teacher educators, as it supported them to interact with the subject matter content, with the teacher and with each other, while learning at a distance. The effectiveness of the LMS in enhancing student learning will depend on the quality of the content included, learning resources provided, learning experiences designed, and also whether the students are adequately and constantly facilitated. The role of the instructor, as a facilitator and moderator thus becomes very important, to ensure effective online learning.

* spkar@ou.ac.lk
Ext. 425

Tel: 011-2853777

702/F

The action research environment in Sri Lanka: A meta analysis

G Kodituwakku*, M A A S Dias and N D Dissanayake

Department of Research and Development, National Institute of Education, Maharagama

The paper is on preliminary findings of an ongoing survey on the present Action Research (AR) practice and its historical bases. The objectives were to identify trends in the historical development of AR in Sri Lanka, identify the true nature of its existing situation, identify its strong and weak points, and to make development oriented suggestions. The sample included all the Education Departments of Sri Lankan Universities, National Institute of Education and its Postgraduate Diploma and B Ed regional centers, National Colleges of Education and Teacher Centres. All academic staff members were included in the sample. Through the research, it was expected that a database would be developed to be used for future research activities. Data were collected administering a questionnaire, and interview technique was employed to gather data from the heads of the institutions. Content of a sample of AR reports were also analysed to collect data. Quantitative data were analysed using descriptive statistical methods and qualitative data were coded to identify patterns.

Preliminary findings of the study are: AR tradition in Sri Lanka seems to be an institutionally driven collaborative effort, its initial prompt being given either by the Ministry of Education or National Institute of Education. AR based on the professional concern of teacher educators, school principals, education officers and teachers seems to be very rare. Most of the Action Researches undertaken by trainees in educational institutes of Sri Lanka are of project type. Since most of the advisers are trained under the quantitative research paradigm, there seems to be a tendency to train their students within that framework giving priority to methodology rather than professional role. Collaborative action is not sufficiently manifested in collaborative AR, and AR reports illustrate a low level of reflection by practitioners. It was suggested to develop a forum for professionals to present their AR work. Since the departmental regulations with regard to AR are favourable for AR, there is room for its further development.

* tuwakku@yahoo.com
Ext.241

Tel: 011-2851301

703/F

I am concerned about the wastage of time in my school: An action research

D M N W B Dissanayake *

Department of Teacher Empowerment, National Institute of Education, Maharagama and Ananda Madya Maha Vidyalaya, Puttalam

Time wastage at school level affects the learning of students. It has become a major responsibility of the school management to minimise the educational wastage. Definitions on educational wastage indicate late coming of students and teachers, low achievement of students, non-attendance of school children and absenteeism of teachers as indicators of wastage. Accordingly the major component of wastage is time, which is the focus of the study. The objectives are to find facts on the different aspects of the wastage at a school, to find different strategies to minimise the wastage and as a Principal, to prepare plans and implement them as remedial measures to overcome the problem of time wastage; also to reflect on the results focusing on achievements,

constraints and problems when implementing an intervention programme. An action research approach was used. Classes from grade 1 to 13 in a school in Puttalam Education Zone were the setting. Interviews were conducted using three teachers, who come from very remote areas; two teachers who stay near the school; and two other teachers who are permanent residents of the area. Further, maintaining a reflective diary and analysing the school artifacts were used to collect data. Nearly three weeks were taken to find facts about the prevailing situation and two months were taken for the interventions. A duration of another three weeks was required to analyse the results of interventions.

The quantitative results of interventions revealed satisfactorily minimised time wastage at the school level. The indicators of successfulness were the minimised leave taking of the teachers and students' full engagement of school time. Preparing assignments for the leave days minimised the wastage of student time. Self-evaluation of teachers, by way of reporting their work on their leave days to the Principal, developed the teachers' positive attitude. The attitudinal changes of teachers, developing the researcher's managerial competence as the Principal and school practices of teachers, dispensing with stress of teachers as well as students were the qualitative results of interventions. The final conclusion can be summarised as follows: "Correctly directed management processes and co-operative attempts of teachers are the only way of minimising the time wastage"

Tel: 071-6029753

704/F

An action research to improve English phonic reading skill among a group of grade 7 students

V E Wijesuriya¹ and G Kodituwakku^{2*}

¹*Department of Teacher Empowerment*

²*Department of Research and Development, National Institute of Education,
Maharagama and Gurudeniya Maha Vidyalaya, Gurudeniya*

An action research was carried out in order to improve the English phonic reading skill among a selected group of weaker students of Grade 7 of a Maha Vidyalaya located close to Kandy. It was observed that the above group of 10 students was unable to read English with correct phonetic sounds. There were problems in pronunciation, and identifying some letters. It was found from the initial fact finding that the major reason for their mistakes was lack of loud reading under correct observation. A pre-test was conducted to identify the weaknesses of the students specifically and a questionnaire and an interview were used to reconnaissance, before planning and implementing the interventions. It was expected that as a result of the intervention, the students would be able to avoid the errors they made in reading due to their mother tongue interference and to use accepted Sri Lankan pronunciation. They were also expected to improve their pronunciation of consonant cluster (Combinations) avoiding mother tongue interferences. Moreover, as a result of interventions, they were expected to read any given material apart from their English textbook. During the intervention, Rebus rhymes, children's songs, developed by the researcher and activities taken from accepted workbooks/journals such as nursery rhymes, language games, picture based stories,

reading articles in the children's corner of the Sunday Observer and presentation of news were introduced to overcome the weaknesses. A post-test was carried out to see whether the students had improved their pre-status. Students were given marks using the same banding at both the pre-test and the post-test. Their improvement was measured by comparing marks obtained at the pre-test and the post-test. While the process of research was going on, techniques of observations and diary keeping were used to collect data. All the ten students in the sample were interested in improving their reading ability with correct phonetic sounds and they were of a high standard and eight out of ten showed a progress in their performances due to the intervention programme. The students were willing to continue the programme as they found that it was supporting their progress in achievements. As a result, it is suggested to continue the programme by providing such activities with another set of weaker students in oral reading with correct pronunciation, which leads to intensive reading and extensive reading.

* tuwaku@yahoo.com
Ext.241

Tel: 011-2851301

705/F

Environment related activities (ERA) enriched by student environment

M A A S Dias^{1*} and S Karunaratna²

¹ *Department of Research and Development, National Institute of Education, Maharagama*

² *Post Graduate Institute of Science, University of Peradeniya, Peradeniya*

The present study is one out of 12 case studies aimed at identifying how far the teachers achieve the objectives of Environment Related Activities (ERA) and to assist them to get better outcomes anticipated by the curriculum developers. The study was conducted in a Grade 2 classroom of a Type 2 school. There were 35 students in the class (Male=16; females 17). Except one child, the parents of all others were labourers or casual workers. The teacher was an English trained teacher who was born and bred in an urban environment. The Guided practice was used as the theoretical framework for the study, which consists of three phases: Observation, Conversation, and Co-planning-Co-teaching-Monitoring. Observations, interviews and documentary analysis were the data collection methods. During the 1st phase, a passive participation of students and a teaching style with more teacher domination were observed. The researcher intervened in changing the teacher's usual teaching style by exposing her to different teaching environments while allowing her to reflect on her own teaching. During the 2nd phase, the researcher involved in co-planning and co-teaching and the teacher were given opportunity to participate in workshops to identify the nature of the subject and different teaching-learning methods. The students were given opportunity to participate actively and to express their own ideas. Classroom physical arrangement was changed from lesson to lesson. Field trips and site visits were arranged. Instead of teacher explanations, there were student generated discussions. Students were given opportunity to get into groups and present their ideas in a collective manner.

During the monitoring phase, the teacher had innovated new learning opportunities other than what is mentioned in the teacher guide. The students were involved in different

projects. Teacher had overcome the classroom management problems and had reduced discipline problems. The teacher as well as the students worked with enthusiasm and the teacher was able to exhibit her hidden talents. She took pride for being involved in the project.

The guided practice had positively contributed for the enrichment of learning teaching opportunities of ERA. The study proposes that the teacher trainers should provide teachers more opportunities to reflect on their own teaching in order to develop their teaching capacity.

Acknowledgement: Financial assistance by UNICEF

* sarojinidias@yahoo.com

Tel: 011-2851301 Ext.248

706/F

Baseline survey on schools exposed to the programme of school improvement (PSI): Preliminary findings

M A A S Dias^{1*} and G Kodituwakku²

Department of Research and Development, National Institute of Education, Maharagama

The Programme for School Improvement (PSI), a concept related to decentralisation of decision making authority to the school, has been implemented from January 2006 in selected eight education zones to create awareness. Under PSI, the school principals will be empowered to manage schools in a participatory manner. This research paper is a part of an ongoing research which highlights the current status of school management in the pilot schools and the focus of this paper is mainly on the research procedure and the preliminary findings related to school planning, concentrating on vision, mission, objectives, short-term and long-term planning and school development projects.

The baseline survey will be conducted in three stages. The first stage is an attempt to identify and highlight the prevailing status of school management through a sample of 40 schools selected from the pilot schools. In addition similar number of non-PSI schools will be studied for the purpose of comparison. School profiles of both sets of schools will be prepared, based on the criteria developed on school management practices. In the second stage, in-depth case studies will be conducted in a sub-sample of schools. A survey will be conducted in the third stage, using the same instruments prepared for the initial survey. The information gathered will be compared with the baseline information to identify the impact of the PSI. Interviews were the main technique to collect data. Interview schedules were prepared for teachers, parents, students and community members taken into consideration of school level planning, role of the principal, curricular and co-curricular activities, community members, finance and administration, monitoring and evaluation. An interview schedule for the Zonal Directors was used to obtain their views and opinions about the schools. In addition a separate information sheet was prepared to gather details on the human and physical resources and

examination results of the schools. The study evinces that majority of the principals adopt a participatory approach in the planning process. From the vision and the mission statements and objectives expounded by the principals, it is noticeable that the principals need a practical knowledge in formulating the above. There should be a balanced approach when formulating schools plans. The study indicates that the principals' involvement in educational needs of their teachers is minimal. The main method adopted by the principals for this purpose is sending the teachers for in-service training. Principals need more awareness in identifying staff development needs and should adopt innovative methods in school-based staff development programmes.

Acknowledgement: Financial assistance by UNICEF.

* sarojinidias@yahoo.com
Ext.248

Tel: 011-2851301

707/F

**Tracer study of Science and Technology postgraduates who graduated from
Sri Lankan universities during the period 2000-2002**

P R M P Dilrukshi* and Seetha I Wickremasinghe
*Science and Technology Policy Research Division, National Science Foundation,
Colombo 7*

The study was conducted for the graduates who had graduated from the faculties of Agriculture, Engineering, and Science of the national universities in the period 2000-2002. The surveyed sample consisted of 768 postgraduates. The response rate was 36%. The total sample consisted of 74% M.Sc. graduates, 21% M.Phil. graduates, 3% of Ph.D. graduates and 2% of M.Eng. graduates. The sample consisted of 56% male and 44% female graduates. The age of the graduates achieving post graduate qualifications varied between 24 to 55 years. However, this varied with the type of postgraduate degree. The average age recorded in the survey of getting Ph.D. degree was 35.8 ± 3.03 years while for M.Phil. this was 33 ± 4 years and for M.Sc., 34.6 ± 5.9 years. The results showed that a very few completed their postgraduate degrees in the given minimum time period. Therefore, the average time taken by graduates to complete Ph.D. was 5.4 ± 1.1 years, M.Phil. 4.5 ± 2 years and M.Sc. 2.8 ± 1.3 years and for M.Eng. 2.8 ± 0.9 years. At the time of the survey, 92% of the sample were employed while 4.9% were unemployed, 0.6% self employed and 2.5% involved in further education. Highest employment rate was recorded for the graduates that have Ph.D. (100%) followed by M.Sc. graduates having 94% employment rate and M.Phil. graduates having 88.2% employment rate. The unemployment rate of the graduates with M.Phil. degrees was 5.9% and M.Sc.

degree 5.1%. The proportion of male (62.5%) doing postgraduate degree while employed was higher than that of the female (37.5%).

50% of the graduates were employed in the government sector while 33% in semi-government sector jobs, 9% private sector and 8% in other organisations like NGOs. Most of them were employed in middle management level employment (37.4%) followed by non executive level jobs (26.5%), junior management level employment (21.8%) and senior management level employment (14.3%) The income level and the obstacles they encountered when finding jobs also was investigated.

* dilrukshi@nsf.ac.lk

Tel: 011-2675841

708/F

Employability of Agriculture graduates who graduated from Sri Lankan Universities during the period 1998-2002

P R M P Dilrukshi* and Seetha I Wickremasinghe
Science and Technology Policy Research Division, National Science Foundation, Colombo 7

A study was conducted to analyse the employability status of agriculture graduates who had entered the job market in the period of 1998-2001 from the seven universities in Sri Lanka. The mail survey was carried out in three consecutive studies in years 2001, 2003 and 2004 and the targeted group consisted of 1,515 graduates. The sample consisted of 52% of the target group.

According to the survey, the employment rate of the graduates varied in the three respective years surveyed. In the year 2003, the employment rate has decreased to 47.6% from 75.5% in the year 2001. However, this has increased again to 70% in year 2004. The unemployment rate has increased from 15% in 2001 to 43% in 2002, but this has decreased again to 19% in year 2004.

The employment rate of the graduates showed variation according to the subject areas they specialised. According to the results in the year 2002, the highest employment rate (67%) was recorded for the graduates who followed Agriculture Extension as a special subject, followed by the graduates specialising in the area of Animal Science (58%), Agriculture Engineering (58%), Agriculture Economics (53%), Food Science and Technology (49%), Crop Science (41%) and Agriculture Biology (34%). In year 2004, this pattern shifted a little and the highest employment rate was recorded for the graduates, who specialised in the area of Food Science and Technology (96%), Agriculture Extension (90%), Agriculture Economics (80%), Animal Science (78%), Crop Science (62%), Soil Science (60%) and Agriculture Biology (29%). Both studies showed that the highest demand in labour market was for the graduates who specialised in Agriculture Extension, Food Science and Technology, Agriculture Economics and Animal Science. The lowest demand in the labour market was recorded for the graduates specialised in the area of Agriculture Biology, Soil Science and Crop Science. The study was also extended to investigate the income level of the employed graduates, sector of employment and their job categories.

* dilrukshi@nsf.ac.lk

Tel: 011-2675841

709/F

**Issues of organisational capacity in a devolved system of governance:
The case of general education in Sri Lanka**

Sudatta Ranasinghe*

Faculty of Humanities and Social Sciences, The Open University of Sri Lanka, Nawala, Nugegoda

General education in Sri Lanka has been a devolved subject since the introduction of the Thirteenth Constitutional Amendment in 1987 which led to the establishment of elected Provincial Councils as a means of power sharing. This brought about a significant change in the structure of management of the general education system shifting the responsibility for managing general education from the central ministry and the department of education, which had a fairly coherent regional network, to a Provincial Education Authority (PEA) consisting of four tiers. Currently the government spends about 3 per cent of the GDP on general education provided through a network of over 9000 provincial schools and 328 national schools that deliver primary, junior secondary and senior secondary education to a student population of 3.8 million employing over 185,000 teachers.

Although the subject of general education has been devolved to the provinces, the Ministry of Education has established and nurtured national schools as a distinct category, which has apparently led to a polarization of general education. The responsibility for managing general education is currently shared between the Provincial Councils and the Ministry of Education, which provides policy guidance and a multitude of services that impact on the quality of education as well as the organizational capacity of the provincial education system. It has been observed that the quality as well as performance of general education in terms of student achievement levels has deteriorated since the devolution of power. This also raises doubts about the managerial capacity of the PEAs and the efficiency of the Ministry of Education in playing its role as a facilitator of education development.

A study conducted during the latter part of 2005 covering national and provincial level educational authorities including a sample of national and provincial schools revealed that there were serious capacity gaps in the provinces with regard to human and physical resources as well as the managerial competencies at all four levels of the provincial education system. The linkage between the central ministry and the provincial education authority was found to be top-down and hierarchical. In addition to observed lack of coordination between the centre and the provinces, the present linkage had also led to a dependency relationship, which appears to have had adverse implications for developing institutional capacity of the provincial education system.

In terms of the capacity to deliver quality education, there were marked differences between the national schools and the provincial schools located within the same educational zone. The prevailing management practices and procedures did not allow the weak provincial schools to benefit from the available resources of the national schools located in close proximity. The provincial schools faced serious limitations in regard to both physical and human resources while the PEAs were found to be

vulnerable to political influence on the one hand and poor managerial skills and leadership of the administrators on the other. Thus, there was a felt need for structural as well as policy reforms for improving the performance of the PEAs.

* swran@ou.ac.lk

Tel: 011-2820032

710/F

Some implications of the expansion of the university system in Sri Lanka

Dhanapali Kottahachchi*

No. 4, Wijayamangalarama Road, Kohuwela, Nugegoda

The formal university education commenced in Sri Lanka in 1942 with the establishment of the University of Ceylon. The number of students seeking admission to a university increased and this led to the expansion of the number of universities. The university system expanded to 8 traditional universities and one open university by 1986. A rapid expansion took place since 1995 with the establishment of 6 more traditional universities: three in 1995 (Sabaragamuwa, Rajarata and South Eastern), one in 1999 (Wayamba) and two in 2005 (Uva Wellassa and University of Performing Arts). The latter are referred to as new universities while those established prior to 1995 are old universities.

The objective of the research is to examine the implications of this expansion by analysing the teaching resources. Hence the staff/student ratios were computed and compared with the accepted norms which had been published in the Corporate Plan of the University Grants Commission.

Major findings are:

1. The medical faculties lack qualified teaching staff. The district hospitals too with the exception of Colombo do not have sufficient number of consultants to supplement the academic input. However, two new faculties at Eastern and Rajarata Universities had been created apparently without considering the availability of suitable manpower. Students selected with GCE AL 2005 had already been allocated.
2. An engineering faculty had been established at Ruhuna University when the oldest faculty at Peradeniya university is heavily under staffed having a ratio of 57:1 when the benchmark is 10:1.
3. The Agriculture faculty at Peradeniya University having a staff student ratio 9:1 is a rare exception which conforms with the norm of 10:1.
4. The Law faculty at Colombo is highly understaffed (72:1). Notwithstanding, a new faculty at Jaffna University has commenced to admit students selected with GCE AL 2004.

Most of the existing universities do not have adequate skilled staff and the student staff ratios do not conform to the accepted norms. A few exceptions are the Agriculture faculty at Peradeniya, Science faculty at Sri Jayewardenepura and the Arts faculties at Peradeniya and Kelaniya. The old universities (pre 1995) in comparison to the new ones have more students and staff.

The amalgamation of courses to a few universities should be studied before embarking on new faculties/universities since the output from the Open University and external degree programmes is very small in comparison to their enrolment.

* dhanapali@kottahachchi.net

Tel: 011-2853528 (R)

711/F

**A study of teachers' oral questions in mathematics lessons in primary grades:
A case study of a selected education zone in Sri Lanka**

R M K K Yahampath*

Provincial Department of Education, Western Province, Colombo 7

The main objective of the study was to find out the patterns of teachers' oral questions in mathematics lessons in primary grades within the context of education reforms introduced in 1999. The case study was conducted in one education zone in the Western province. The teachers sample consisted of 24 teachers, selected from 14 schools by using stratified random sampling strategy. The observations of lessons followed by post-observation interviews and a teacher questionnaire were main data collection techniques used for the case study.

The key findings that emerged were that the majority of questions teachers asked required recall of facts. Almost all the oral questions used, except on a few occasions, were closed questions. Questions which challenge pupil's thinking were rarely used. Many teachers were not aware of the different types of questions (such as open-ended questions and explanation demanded questions) and about the questions in different cognitive levels that are available to be used.

The study also reveals that the present teacher guides do not contain enough guidance for using different types of questions. The inclusion of a few examples of different types of questions in the teachers' guide is very essential.

Analysis of the responses given by the teachers shows that most of teachers' questions aim to revise knowledge or to check pupils' understandings. Even though the teachers were aware that questioning is important to diagnose pupils' difficulties and to improve mental skills, such questions were not used in practice.

The study recommends a well planned in-service training for teachers and the development of a module for pre-service teacher training courses focusing on questioning skills.

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* kusumyahampath@yahoo.com

Tel: 011-2693893

712/F

Construction and standardisation of a suitable academic aptitude test for grade nine students

G M T N Perera*

Faculty of Education, University of Colombo, Colombo 3

The research expects to identify the constructs essential to identify the scholastic aptitude of pupils completing their basic education at the end of year nine. Scholastic aptitude is a set of traits used to predict the learning potential. The purpose of measuring the aptitude is to obtain implications about the way in which the student may act successfully in the future. Scholastic aptitude tests are used to investigate the academic potential of pupils during schooling years and also to select students at the university entrance. Only the standardised psychological tests should be used for this purpose. Although several standardised aptitude tests are available in Sri Lanka, no tests have been constructed and standardised to measure the academic potential of pupils at the end of year nine. In the preparation of this test, special consideration was given to abilities used in Sri Lanka and internationally. Five abilities: vocabulary, perception, reasoning, identification of relationships and problem solving were identified and each was resolved in three aspects: verbal, number and spatial. Finally a testing package was designed with five sub-tests consisting of fifteen parts. During the preparation of the test, items were constructed and tested twice. The items were then revised on indicators prescribed by two theories, the classical theory and item response theory. Special attention was paid on the reliability value (KR 20) of the test. The prepared test was standardised using a sample of 100 Sinhala Medium schools in Sri Lanka representing provinces, districts, school types and sex of students. Data collectors were given training in administering tests. As there was an objective to prepare age norms, the sample was selected in two age groups. All the sub tests showed a high reliability value of KR 20. The calculation of the correlation among the sub-parts of the test and the value not exceeding 0.5 is a standing out feature. A difference of values was observed in median, mean and standard deviation between the low age group. Usage of the standardised marks was emphasised in order to reduce the error of the raw score which is currently used in schools. The importance of this test is the ability to calculate either intelligence quotient or aptitude level of pupils using the raw mark obtained for each test. These packages can also be utilised to support the learning process through diagnosing the current status of him or her in relation to the abilities measured. This testing package is of immense use for guidance and counseling needed for the school for reliably predicting the future scholastic potential of a grade nine pupils.

Tel: 011-2851301

Ext.270

713/F

A research study on innovative method of training for teachers to integrate ICT across the curriculum

M N S Edirisinghe*

*Department of Research and Development, National Institute of Education,
Maharagama*

A research study on training of teachers to integrate ICT across the curriculum was conducted to upgrade knowledge and skills of teachers and to facilitate integrating ICT into education. In order to attain the goal, the following sequential methodology was employed: a) Needs assessment with national sample b) Development of teacher trainers manual, teaching and learning materials and software for teaching science, c) Establishment of links and pilot testing of the use of ICT in schools in eight provinces based on the previous activities; d) Training of teachers in computer literacy and in the use of the ICT-based teaching/learning materials in science.

The needs assessment was used to develop a conceptual curriculum frame-work along with a concept map. This facilitated the design of competency based activities that would be adopted at national level. In this context, competency is defined in terms of knowledge, attitudes, skills and practice and the constructivist approach. The 5E model which helps the structuring of lessons based upon constructivist learning theory. It is a model of distinct cognitive stages of learning that include the five activities **engage, explore, explain, extend, and evaluate**. The research team comprised of 16 ICT teachers/teacher trainers from eight provinces, curriculum developers with experience and different capacity, of different ethnic groups and different cultural settings. The training of teachers in computer literacy was conducted through the eight provincial workshops. An opportunity was provided for teachers, during the training period, to prepare and present activity plans integrating ICT to their teaching subjects. The comments of participants consisted of three parts: content, context, and process of the training workshop. The activity plan (lesson plan) was the aspect most participants agreed upon as useful as indicated by the fact that 82.6% of the teachers were of that view. Teachers identified ICT-specific issues as a major difficulty in their attempt to become more effective in the use of ICT with other curriculum subjects. These tasks then result in effective development of both ICT and subject-specific expertise.

Acknowledgement: UNESCO/JIFT funds

* shiyama_j@hotmail.com
Ext.249

Tel: 011-2851301

714/F

Reading development of the grade 1 children: A longitudinal study

D A S D Ratnayake*

*Departemnt of Research and Development, National Institute of Education,
Maharagama*

A longitudinal research was initiated in 2002 to study student participation in primary school education and the way the students develop their competencies. Forty-three classrooms from forty-one schools were the school sample and all the children in Grdae 1 in 2002 were the student sample (1178). Teachers in the selected classrooms collected data and a researcher was appointed to each school for the guidance. Three

sub-instruments were used to measure the reading competence. Fifteen alphabets in the first term, 22 alphabets and thirteen words in the second term, and four sentences including same alphabets and words in the third term in Grade 1 were used to measure the reading competency. The second instrument was used to measure the competencies of the students who obtained the relevant competencies in the first term and the third instrument was used to measure the competencies of the students who obtained the relevant competencies in the second term. At the end of the year, the data were analysed using 13 variables. Achievement of competencies was shown in percentages, which were classified into three main areas as, those who had gained competencies (81-100), those who were approaching the competencies (61-80) and those who had not gained the competencies (0-60). The identified relationships were subjected to chi-square test. Findings are: both Sinhala Medium and Tamil Medium students read the first letters of their own alphabets. A higher percentage of Sinhala and Tamil students read the alphabet / i / secondly. Sinhala Medium students found it difficult to read the alphabet ($|n \wedge|$) (aspirated) and for Tamil Medium students, it was ($|j \wedge|$). Throughout the year, girls led the way in the reading competency. Muslim students studying in Sinhala, showed equal competence levels with the Sinhala students. Sinhala students showed a higher competence level in reading. Although Muslim students showed equal achievement levels in the first and second terms, in the third term, only the Sinhala students were at a higher level. In the first term, a low competence level in reading was shown by Sinhala students and it was Indian Tamil students in the second and third terms. Throughout the year, a higher reading competence could be seen in 1AB schools. A low competence in reading could be seen in Type 2 and 1C schools. With regard to the provinces, North-Western province in the Sinhala Medium and Northern province in the Tamil medium showed a higher competence level. As a whole, the Central province showed a lower competence level in reading.

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Tel: 011-2851301

715/F

Upgrading of mathematical skills needed for the secondary level science education at the Pre- Advanced Level stage

U N B Dissanayake^{1*} and W J Iranganie²

¹ *University of Peradeniya, Peradeniya*

² *Kegalu M.V., Kegalle*

Pupils are selected to the G.C.E. – Advanced Level (A/L) science classes based on the performance at the G.C.E - Ordinary Level examination. Though most of the pupils enter the AL science stream with “A” or “B” grades (Distinction or Credit passes) for mathematics and science at the OL examination, a substantial number of pupils find it extremely difficult to follow Chemistry, Physics and Combined Mathematics subjects at the first year of their AL program due to lack of mathematical skills gained at the pre-A/L stage.

The objective of this research was to identify the weak areas in basic mathematics of pre-AL science pupils and to propose remedial measures that can be adopted at the secondary level education to minimise the shortcomings of the teaching and learning process. The sample selected for this study was 360 pupils from 1-AB schools of Kegalle district with AL science classes. Via pre-tests and pre-test interview schedules, twelve key areas of basic mathematics were identified as essential pre-requisites for AL science subjects. The organised remedial teaching (ORT) programme was experimented for a period of three months via teaching and monitoring the specially prepared lesson units in the twelve key areas to subclasses of the sample which were selected according to the weaknesses in mathematical knowledge and basic mathematical skills.

The results of the post-test show that the sample mean mark has increased from 24% to 59% and also coefficient of variation has increased from 31.96% to 37.46%. Post-test interview schedules have indicated that the ORT program has bridged the gap in basic mathematics of pre-AL science pupils to a certain extent. Paired t-test confirms that improvement due to the ORT program is significant at the confidence level $\alpha = 0.01$. Therefore an ORT programme in mathematics for pre-AL science classes is an absolute necessity to enhance mathematical skills needed for physics, chemistry and combined/higher mathematics at the AL science classes. The adequacy with respect to the time duration of the programme has to be studied separately as a continuation of this research project. Moreover, the OL mathematics curriculum should be revised in the light of ORT programmes so that there will be more coordination between areas of science and mathematics, rather than mathematics being a mere subject for examination purposes. With a good grounding in basic mathematical skills, AL science education can be made more fruitful.

* disa12@yahoo.com
716/F

Tel: 081-2389134

Difficulties encountered by 'Key Stage 3' pupils in solving numerical division problems

U N B Dissanayake^{1*} and A K M Nazeem²

¹ *University of Peradeniya, Peradeniya*

² *K/Azhar Central College, Akurana*

Mathematics knowledge is needed by every individual to live in modern society in a meaningful manner. To have adequate mathematical skills needed for everyday life, it is absolutely necessary to lay a proper foundation at primary level. In Sri Lanka, primary level education system consists of Key Stage 1 (Grades 1&2), Key Stage 2 (Grades 3&4), and Key Stage 3 (Grades 5). The objective of this study was to investigate the difficulties encountered by Key Stage 3 pupils in solving numerical Division Problems with special emphasis on the types of errors that they commit. An attempt was also made to review the sections on Division in the prescribed primary textbooks with an intention to suggest improvements. Thus this research study iwa aimed in the following directions:

- (i) To find the types of Division Problems that Key Stage 3 pupils find most difficult.
- (ii) To find the most prominent error patterns related to Division Problems in the Key Stage3.

- (iii) To find the methods of improving prescribed Primary Mathematics Textbooks to help pupils to overcome the difficulties in solving numerical Division Problems.

The sample consists of 551 students from 6 schools of the Akurana Education Division in the Central Province. Data were collected with the help of primary pupils, primary teachers, and educationists using quantitative and qualitative methods. Three item analyses were carried out using the test information to identify the difficulties and error patterns related to numerical Division Problems at the Key Stage 3.

Analysing the test items, different types of errors and error patterns committed by pupils were identified. In Division Problems, which include zero digits in the dividend or in the answer, facility index of 18 items out of 60 has varied between 11.5 and 24.8. This implies that at least 75% and at most 88% of the students in the sample faced difficulties on those items. A review of the sections on Division in the prescribed textbooks revealed that some of the areas could be improved by including more worked examples and supplementary exercises similar to that of 18 items. Two main types of recommendations can be suggested. One type is focused on special training for primary mathematics teachers and the other one is the use of "Place Value Method" as an alternative method for Division Problems. It is envisaged that these suggestions can be used fruitfully for further research work.

* disa12@yahoo.com

Tel: 081-2389134

717/F

Learning chemistry through social interactions and classroom assessments

S Karunaratne^{1*} and M M Jamila²

¹ Faculty of Science, University of Peradeniya, Peradeniya

² Postgraduate Institute of Science, University of Peradeniya, Peradeniya

This study presents how GCE A/L chemistry students improved their achievement levels through collaboration in their groupwork and assessing themselves and peers. Learning occurs in a social environment. Collaborative learning relies on social interactions of students. The sub unit, dynamic equilibrium, under the unit on "Equilibrium" was selected for the study. After observing how this sub unit was taught in a girls' school in Kandy district, six lessons were planned considering the students' prior knowledge to build up concepts in dynamic equilibrium. A girls' school and a boys' school in Kandy district were selected for the study. Based on prior observations a pre-test was designed and administered in both classrooms before implementing the lesson plans. In the first lesson three worksheet activities were planned to develop students' understanding of equilibrium considering their prior knowledge of equilibrium. The other lessons were planned to develop concepts related to dynamic equilibrium in chemical reactions, characteristics, equilibrium constant, effect and applications of dynamic equilibrium in real world situations. In all the six lessons, students had to work individually as well as in groups. They performed different roles and assessed themselves and peers under the guidance of the teacher. They organised a quiz at the end of the sub unit and made group presentations on applications of dynamic equilibrium in real world situations. Post-test showed their improvement in achievement. Students appreciated their learning habits and collaboration which they wanted to continue in learning other subjects. The whole activity encouraged students' collaboration to reach the objectives of lessons in a friendly environment. Teachers made efforts in constructing a social

environment to enhance learning. Teachers need to be provided with guidance in planning continuous assessments with peer discussions to motivate students to build up science concepts.

* sunrank@yahoo.com

Tel: 081-2394683

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Motivating primary children to learn science

R P K Mahagamage¹ and S Karunaratne^{2*}

¹ *Postgraduate Institute of Science, University of Peradeniya, Peradeniya*

² *Faculty of Science, University of Peradeniya, Peradeniya*

The education reforms introduced in 1997 were considered to focus on the child to improve the status of living by strengthening the skills and behaviours that mould the child to be a useful citizen. Such a child should be up-to-date in knowledge and information with the ability to discover, select, retain, process and apply information. During the childhood, students are very curious about their surrounding. Teacher as the key person in the primary classroom should be responsible for arousing motivation of the child to learn science in the surrounding. The primary stage of education has been divided into three key stages: Key stage 1- Grades 1 and 2, Key stage 11- Grades 3 and 4, Key stage 111 - Grade 5. Key stage II was selected for this study. Environment Related Activities (ERA) is a highly integrated subject of science, social studies, aesthetics, health and nutrition. The aim of this study was to develop science related activities to build up motivation in children at key stage two through the subject ERA.

The study was conducted in three phases. In the first phase, eight classrooms of three schools in the Gampaha district were observed to get an understanding of the practices of teaching science related lessons in ERA. Students' notes and artifacts were collected. All the lessons were tape recorded and detailed field notes were made. It was revealed that most teachers did not possess clear knowledge of science to teach science related lessons and the existing activities were not organised to motivate students to learn science. In the second phase, 25 activities were prepared for five units. Developed activities were tried out in six classrooms in the three schools in the third phase. Detailed fieldnotes were made along with informal interviews with children and teachers. Analysis of data revealed that children not only love to do the activities and ask for more and more activities, but are also able to say what they learned from activities. The involvement in doing activities made children motivated to learn science and to develop science process skills. There were changes in teachers in planning lessons considering children's interest and assessing them in different ways. It is recommended to provide teachers with short-term training to update their knowledge and professional skills as teachers.

* sunrank@yahoo.com

Tel: 081-2394683

719/F

Role play as an active teaching learning approach in science (ATLAS)

T M S S K Yatigammana¹ and S Karunaratne^{2*}

¹ *Postgraduate Institute of Science, University of Peradeniya, Peradeniya*

² *Faculty of Science, University of Peradeniya, Peradeniya*

Teaching techniques used for formal education are mainly teacher centred, where communication is uni-directional and keeps the learners passive in the classroom. In the process of teaching and learning, the teacher should act as a facilitator to engage learners in hands-on activities to develop learners' knowledge, skills and attitudes. A number of different Active Teaching and Learning Approaches in Science (ATLAS) have been developed to motivate learners. Role play was selected for this study to improve active participation of students in reading, writing and listening.

The sub-units, "Effect of digging mines, burning of forest, destroying coral reefs and removing mineral resources on a large scale," of the unit 15 of the GCE Advanced Level chemistry syllabus were selected to study using role play in two grade twelve classes from two mixed semi-urban schools in Kandy district. The class was divided into four where each group was assigned a different topic to be carried out by the Environmental Authority namely, (a) coast conservation, (b) digging mines, (c) petroleum and (d) forests. They were made aware of the five stages of role play namely, preparation, briefing, action, debriefing and follow up. In the preparation stage, the students were informed how to conduct a conference as leaders of the four groups of the Environmental Authority. The group leader assigned different roles to members such as readers, writers and editor. Within the given time, they had to collect information using the available documents. The editor's role was to put all information in a systematic way to present at the conference. After each presentation, groups presented their views and the teacher debriefed the important points of the presentation and asked the groups to write a report as a follow-up work.

It was observed that all students wanted to perform their role best to do the group presentation. They helped each other in sharing ideas. It was found that the role play helped the students to develop their attitudes of team spirit and several skills while improving their knowledge in a friendly, enjoyable learning environment. It was found that this technique fostered group activities and active participation of members of the group while developing their communication skills, critical thinking skills and leadership skills. Introduction of ATLAS based techniques such as role play to the school curriculum will increase the effectiveness of learning by making it more attractive and learner-centered.

* sunrank@yahoo.com

Tel: 081-2394683

720/F

Developing observation skills of children at primary level

P R K A Vitharana¹ and S Karunaratne^{2*}

¹ *Postgraduate Institute of Science, University of Peradeniya, Peradeniya*

² *Faculty of Science, University of Peradeniya, Peradeniya*

The basic skills of science are required for each and every individual to live successfully in the modern complex world. In order to develop these skills, it is essential to provide opportunities at the primary stage of education. The primary cycle of education has been divided into three key stages, namely; key stage one-grade I and II; key stage two-grade III and IV; and key stage three-grade V. The purpose of this study was to provide children at key stage one with enjoyable opportunities to develop observation skills-one

of the important skills that is needed to develop during primary stage of education by planning hands-on science activities through the subject Environment Related Activities (ERA.)

The study was conducted in three phases. In the first phase, thirteen classrooms were observed when teaching ERA lessons at three selected schools at Kegalle district to understand the existing situation in teaching learning process. All the lessons were tape recorded and detailed fieldnotes were prepared. Interviews were conducted with randomly selected teachers to make clarifications of weaknesses observed in classroom observation in developing observation skills of children. A questionnaire was administered to primary teachers to understand the difficulties in planning and presenting activities to develop observation skills. Data obtained from different sources were analysed using triangulation. It was found out that 90% of teachers were incapable of organising their lessons with activities to provide children with enjoyable opportunities to develop observation skills. They were not competent enough to get the active involvement of children. During the second phase of the study, activities were planned for each theme to provide children with various opportunities to develop their senses essential to become keen observers. The planning stage was done with lengthy discussions with teachers in order to get the clear understanding of the activities. These planned lessons were tried out in five classrooms in three selected schools in the third phase of the study. Necessary improvements of the activities were made with the help of feedback obtained from the teachers.

Children were very active in gaining experiences by developing their senses through seeing, touching, tasting, hearing and smelling. They were so curious to observe the outcomes of the activities and to record what they observed. Teachers' responses indicated that children were very interested in learning science through such activities and they were so inquisitive to find out things by themselves. Therefore, it is recommended to organise continuous collaborative work with primary teachers to strengthen the capabilities of planning lessons with activities in order to provide children with early experiences needed for developing observation skills.

Financial assistance given by the National Science Foundation is acknowledged.

* sunrank@yahoo.com

Tel: 081-2394683

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Introducing meaningful activities for primary students

A R G A M Abeykoon Menike¹ and S Karunaratne^{2*}

¹ *Postgraduate Institute of Science*

² *Faculty of Science, University of Peradeniya, Peradeniya*

Acquiring basic knowledge and skills in science is very important to cope up with the present world as it is changing rapidly with new science discoveries. As students in the primary stages of education are very active and curious, they can be easily directed to achieve this objective. In the primary curriculum introduced under the 1997 education reforms, science is integrated with several other subjects under Environment Related Activities (ERA) subject. There are many themes in ERA syllabuses from grades one to

five in which many activities that are related to science can be introduced as collaborative groupwork. However, the analysis of the content in teacher guides for ERA in these classes showed that there were no such inclusions in the teacher guides. If such activities are introduced, it would help the students to acquire science process skills that are very useful to build up the knowledge on science concepts when they are in upper grades. This study was aimed to understand the problems in introducing science related themes in ERA subject from grades one to five. For this purpose, twenty ERA lessons in grade two classes were observed. Ten subject experts and twenty primary teachers were interviewed to understand their views on teaching ERA lessons. Triangulating the collected data it was found out that teachers rarely did activities in the classes and the limited occasions they introduced activities were not focused to develop expected competencies or science process skills in students. Most of the teachers did not have favorable attitudes in introducing science-based activities as they thought that they had to explain the principle behind each activity. When they tried to explain such things, most of the time their explanations were incorrect because they did not possess adequate knowledge. After identifying these problems, an activity booklet was prepared for primary grades. When preparing the activities special attention was given to achieve the expected objectives mentioned in the teacher guides. It was also focused to help the students to develop competencies and acquire science process skills that are suitable for the level of maturity of the students. Some of these activities were tried out in primary workshops and the teachers participated in these activities enthusiastically and were eager to do the activities with the students. As this study was a part of a study which was aimed to develop general chemistry concepts at school level, only the activities related to chemistry were introduced in the activity booklet. It is recommended to prepare activities related to other science subjects so that a basic foundation for learning science can be introduced as an enjoyable experience.

Financial assistance given by the National Science Foundation is acknowledged.

* sunrank@yahoo.com

Tel: 081-2394683

722/F

Science teaching in a ninth grade classroom by two prospective teachers

S Karunaratne*

Faculty of Science, University of Peradeniya, Peradeniya

Science teaching at all levels in the school system needs to be focused on conceptual understanding and scientific inquiry. The aim of this study was to learn how two prospective teachers learn to teach and practise in a science classroom. Two selected prospective teachers followed a course in science teaching where they had to learn different styles of teaching that influence learning. It was a requirement for them to teach in a science classroom to develop skills in teaching. For fifteen weeks, they followed the course and at the same time, they were responsible for teaching science and technology subject for students in the ninth grade in a secondary school. After observing science teaching by the teacher in-charge, for their teaching they developed lesson plans to achieve the objectives given in the teacher guide by introducing hands-on activities using things available from the environment. In their planning they used different techniques that they learned in the course. In all the lessons they did continuous

assessments and provided feedback to students. Classroom observations were made and on collected copies of students' assignments and crafts. As there was a variation in the method of teaching, students loved to be in their classroom to perform different tasks assigned by the two prospective teachers. Students were able to construct meanings for what they did in the classroom. The two teachers shared their experience, both strengths and weaknesses, in the theory course, where they were able to get reflections from peers and the instructor. Teaching and learning in a context where there is ownership for teaching and learning, both teachers and learners are benefited to gain conceptual understanding. It is recommended that in staff development programmes, teachers should be allowed to come up with their own suggestions and to let them try to receive constructive feedback for professional development.

* sunrank@yahoo.com
723/F

Tel: 081-2394683

Information Technology used as a facilitator in the teaching learning process at the classroom level : A preliminary study

K H N Damayanthi*
Teacher Center, Japalawatta, Minuwangoda

Computers were introduced to the Sri Lankan school system in 1983. According to the Central Bank Report 2002, through different schemes, computers were distributed among schools although the percentage of schools that received under any of these schemes does not exceed 10% of the total number of schools. In the school system, a high quality education could be achieved through a live and active classroom. The main interaction between the teacher and the student is through the teaching learning process. Hence, the productivity of the teaching learning process depends on the extent to which the teacher captures the interest and attention of the student during this process. This is a challenge for the teachers.

This study aimed to do a preliminary survey of the Information Technology (IT) used as an educational tool at classroom level.

The main findings of the study were as follows:

A well planned, effective and rapid training should be given to teachers.

Resources and training that are necessary to plan and produce teaching aids should be distributed among computer resource centers and teacher centers.

A well equipped and effective "Teaching Aid Production Unit" should be introduced to the education system.

Considering present status of Sri Lankan education system, a group of 3 experts must participate in the task of designing and practising the computer based teaching: teacher as a subject specialist to the classroom, teacher educator as a planner of the education tool and a person who is competent in computers and Information Technology.

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Present Address: Teacher Center, Katugastota

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A school for mothers: An experiment in Batticaloa

M Selvarajah*

Department of Education & Childcare, Eastern University, Sri Lanka, Chenkalady

A school for mothers was conducted for eight months in the Village Thalankudah in the Batticaloa district from June 2003 to February 2004. The focus was on child development through mothers who have children from age 1-6 years. Mothers were mostly illiterate and were not aware of the importance of early childhood development and pre school education. One of the objectives of the school was to raise the awareness of mothers on child rearing practices and child development activities and to create a home environment for child development.

The total number of mothers in the school was one hundred and ten, and the total number of teachers was eleven. All teachers were trained especially on the objectives. The activities of the school were divided into three categories: Saturday classes, Special projects and Home visits. The curriculum was designed on the advice of persons experienced in the field. Thirty-two themes, which were related to child development were emphasised. On the completion of school activities, an evaluation was made and the results were encouraging. In the following six areas, positive results were observed: child development and child protection; home environment; nutrition and health; home based economic activities; improvement in knowledge, attitudes and skills; and views regarding the education of the children.

In the evaluation, 93% of the mothers said "very good" for the overall benefit they got from mothers' school. Ninety five point six percent of mothers said that they practiced at home what they learnt from school. About the usefulness of the class, 96.7% of them said "satisfactory" and 80% of them said that they were able to establish a healthy relationship with the neighborhood. Ninety nine percent said that they were able to better manage their families. Ninety eight percent said that they had started a savings account in their children's names, and 100% of them said that they gained a good understanding and knowledge of child development and education of the children. On the whole, in all six areas mentioned above, mothers had gained knowledge, attitudes, and skills for better family life, and child development.

* mselva46@hotmail.com

Tel: 065-2240762

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An alternative to the classroom: A new methodology

S Kodagoda*

Society for Promotion of Wisdom, Malabe

UNESCO declared on the eve of the 44th International Conference on Education that the "failure of education" is the cause of resurgence of violence. Similarly, failure of the school has been reported and low achievement is one aspect of this failure.

A new methodology, the Cultural Clinic (CC) and the Wisdom Kit based on the theory of "Education of the Emotions" was developed using a purposive sample of 69 principals and 71 sectional heads in an education division to remedy the errors in the education system. The intervention programmes developed were also pre-tested in three villages.

It was revealed through the present action research that to remove the causes of low achievement of children in the classroom and at examinations, CC developed by the research is very helpful. Role Model Character which developed through the action research was that of the wise person with five attributes: Spirituality (60%), Aesthetic Sense (14%), Versatility (14%), Secular - Vocational Knowledge (6%) and Good Health Habits (6%).

The Wisdom Kit contains the basic materials required for character building, including reading for versatility, developing basic information skills, understanding basic mathematical concepts, competency in English and identifying and promoting latent strengths (nucleus/nuclear element in the character) as early as possible. It is almost an alternative (especially to the primary classroom) which gives clinical attention to each child - as the name indicates - which can never be achieved through "mass education". CC also serves as an aid to the family for character development of children to endow the "cultural heritage" which every child is entitled to.

"Family CC" and the "General CC" are two types of Cultural Clinics according to location. The general CC serves the children and families in the catchment area of a religious institute or community centre. Thus, it can be used very effectively for character development and promoting versatility/erudition in a child of a rich family in the city, or in the poorest of the poor families in a remote village. It can be used very effectively, to build up the lost confidence in street children, refugees, orphans and to rehabilitate young offenders. Further, the new methodology provides a natural honest system of Evaluation. Mentors are the new type of personnel trained to operate the General Cultural Clinic. It promotes qualities in the whole family materialising the concept of Education for All.

* saumyasasiri@yahoo.com

Tel: 011-2790104

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Attitudes of young people towards politics in Sri Lanka

Anton Piyarathne*

Department of Social Studies, Faculty of Humanities and Social Sciences, The Open University of Sri Lanka, Nawala, Nugegoda

Young people are very vital in the political process of any country. In Sri Lanka, colonial intervention introduced a new system of government in place of the local "king" based administration. Political parties, politicians and parliament became powerful under this new political system. Furthermore, the trust of the people in general and young people in particular is very vital for the socio-economic well being of any society. The result of distrust of youth in political processes was demonstrated in two youth insurrections led

by the Janatha Vimukthi Peramuna in 1971 and 1988-1989. In addition to these insurrections, the LTTE in the north showed their dissatisfaction on the existing political structure through a military struggle, which has been in existence for more than twenty years. These movements have sprung from the ineffectiveness of the political process of the country. Recent experience shows that the trust of youth in political activities has been weakening rapidly. This presentation is based on a study conducted by the author to find out the attitudes of the Sri Lankan youth towards politics.

For the purpose of simplicity, the study defined youth as unmarried persons who belong to the age group between 18 years and 32 years. A sample of 692 young persons was selected from 22 divisional secretariat areas using random sampling technique. These young people were interviewed using interviewer-administered questionnaire. In addition, 110 in-depth interviews were also conducted by the author.

The findings of the study show that young people are not satisfied with the political system of the country. Their trust on politics is weakening steadily. Young persons are not satisfied with politicians, political parties and the political process of the country as well. They assume that politicians do not do justice to their positions since they take politics for granted as a "means to earn an income". The positive aspect of the findings is that the young people have some idea about how and what politics should look like. They wanted to have a better political culture in the country. There is a considerable gap in perceptions between the political expectations of the youth and "how politics is really done". As a result, young people do not like to get involved in active politics. This is a very unhappy trend and must be urgently addressed by the politicians, policy planners and civil society since the youth form the future of Sri Lanka.

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* apiya@ou.ac.lk
Ext. 417
727/F

Tel: 011-2853777

Reconstruction of a tsunami damaged village in the south of Sri Lanka

Ramani Kamala Samarasinghe*
481/1, Shanthi Place, Koswatta, Talangama North

The village in this study was selected by chance and can be considered to be typical of similar villages in the south. Sixty families were selected as recipients of resources. The observation of helping the rebuilding process and the interactions between the two field workers (one, a sociologist/counsellor and the other, a teacher) and the recipients, made the author examine the process from sociological and psychological perspectives.

A village is a part of the society in its entirety and it is possible to study the structure of society at the same time as the lives of its individuals. An attempt was made to study a village that had suffered trauma of the tsunami at individual and social levels, and to examine the processes in relation to society as a whole. The main objective of the project was to help rebuild and stabilise the 60 families that were affected by the tsunami. Great care was taken to minimise the effects on the individuals and social structure by this intrusion.

The research methods selected were participant observation, questionnaire and interviews. Notes were made with each visit and a questionnaire and interviews were used to assess the effectiveness of the work done and its underlying effects on the individuals and community.

Financial constrains dictated the progress of project implementation. Since the primary need was the psychological recovery of the villagers, it was found after consultation with them that they required the basic household implements that were washed away to restart the income generating activities. These consisted of large pots and pans for making 'string hoppers', 'kalu-dodol' etc. for the local shops and garden implements to restart small market gardens. These were supplied once they had prepared the gardens for the plants and seeds. The physical activity of preparation and the restarting of various domestic economies had a positive psychological effect as indicated in the responses to the questionnaire. The gardens which the tsunami had devastated began to have a cared for look. It was felt that from this point, they had begun to 'move on' with their lives, and hence it was decided by the team to step back, providing support as and when required, such as a temporary medical clinic, painting and craft classes for children etc.

In conclusion, at a time when many similar villages faced destruction, the attempt made was to help rebuild a self sustaining way of life that has survived and helped them to survive for many centuries with little damage to the environment or to themselves.

* ramani_kamala@sltnet.lk

Tel: 011-2788864 (R)

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Literature evidence of the gem industry in ancient Sri Lanka

P R K Fernando^{1*} and G Adhikari²

¹ *Ceylon Mineral Research Laboratory*

² *Postgraduate Institute of Archaeology, University of Kelaniya, Kelaniya*

Gems are a very important mineral resource in Sri Lanka. According to the chronicles, Sri Lanka's gem industry has a very long history. It is one of the oldest industries of Sri Lanka which continues to make a major contribution to the Sri Lankan economy. In ancient times, Sri Lanka was known as the "Ratnadeepa" (the island of gems). There is much evidence available on the ancient Sri Lankan gem industry and they are found in the chronicles and records of monks, tourists, explorers, historians and others.

The major objective of this research was to find the age of the Sri Lankan gem industry. The methodology consisted of reference to the literature on gem industry, visits to museums and archaeological sites and personal communication with experts. The first record on Sri Lankan gem industry is found in the Mahawansa (Chapter 1:46). According to that in the 5th century BCE, the Buddha (625-545 BCE) arrived in Sri Lanka to settle a battle between two Naga Kings, Chulodara and Mahodara for a gem-studded throne. Also in the 5th century BCE, King Vijaya sent annually a lot of valuable pearls to his wife's father, the Southern Madura king (Mahawansa Chapter 7:73). King Devanampiyatissa who ruled Sri Lanka in 250 BCE sent three types of beautiful gems and eight types of pearls to King Asoka of India as a gift (Mahawansa Chapter 11.22). King Parakramabahu 1 who ruled in 1153-1186 A.D. sent gems and pearls to foreign countries by ships for trade purposes (Mahawansa Chap 69:33). Apart from the Mahawansa, there are many records on Sri Lankan gem industry found in other chronicles too.

According to the information gathered, the gem industry of Sri Lanka has a very long history and it can be assumed that it is more than 2, 500 years old. It is clear that unlike most other industries royal patronage and government involvement were directly focused on the gem industry. Like today even in ancient times gems were a major export product of the country and Sri Lanka was very popular among foreigners for beautiful gems.

* prkf@lycos.com

Tel : 011-2931234 (R)

729/F

How bad is violence? The case of wife abuse in Sri Lanka

Kanchana Sujananie Bulumulle*
The Open University of Sri Lanka, Nawala, Nugegoda

Violence against women is perhaps the most widespread form of violence across all societies and cultures. Research reveals that amongst diverse forms of violence against women within the domestic domain, the most prevalent form of violence is the violence of the husband against the wife. A multiplicity of issues related to the issue has been addressed and one of which is the magnitude of domestic violence. Evidence shows that the gravity of the injuries sustained by the victim in those situations is quite high in Sri Lanka.

The objective of this study was to identify the magnitude of the incidence of wife abuse among the urban community, its physical and social impact on the individual and the family at large. The methodology of data collection was qualitative and the information was collected through in-depth interviews. The sample consisted of 61 victims of wife abuse from two main geographical locations, drawn from privileged and underprivileged socio-economic classes.

The study revealed that the assault began during the very first year of marriage (49.2%) or second year (41%) of marriage. This increased during the first pregnancy and usually intensified with the arrival of the children. Usually victims referred to "physical violence" to be more abusive than emotional violence and hence recognised those incidents of

"assault" as acts of typical violence. However, certain middle class victims clearly identified deprivation of social status, ill-treatment and obstructions to one's professional well being as abuse. The highest proportion of victims 32% stated that violence occurred due to in-law instigations, 23% said it was due to the dowry issue, and 16% extra marital affairs. The patterns of frequency of assaults on wives brought out 33% being assaulted daily, 45% nearly every other day and 14% at least a few times a month. The magnitude of assault showed 49% hit with hands and legs, 21% assaulted with weapons such as knives etc., 10% with clubs, 7% verbal and emotional assaults. It should however be noted that these categories are mutually inclusive rather than exclusive assault types. Most of the victims (28%) reported sustaining bruises, swellings, black marks on the body or dislocation of teeth; 13% percent cuts on throat, neck, hands, and body; 10% had suffered miscarriages; 13% injuries without prominent visibility; 13% with severe head injury and 8% reported severe psychological problems due to abuse.

However, it is hard to explain the high level of assaults in a context of social and economic reasons alone, because the reasons seem to relate also to the values and beliefs, and the socialisation experiences of these victims and perpetrators.

* kbulu@ou.ac.lk
Ext.402

Tel: 011-2853777

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The effect of climatic changes on coconut production and their implications: A case study in a small holding at Madurankuliya, Puttalam district

A Wijedasa Silva*

Department of Management Studies, Faculty of Humanities and Social Sciences, The Open University of Sri Lanka, Nawala, Nugegoda

The objective of this study was to identify direct and indirect effects of climatic changes on coconut production and cultivation. This study was conducted on a 10 acre land situated in *Madurankuliya*. It has about 520 fully-grown palms and about 55 non-bearing young plants. The land is flat with sandy soil and the water table varies from 3 m to over 12 m. The study was conducted for the period 2002-2004 using the data on coconut production obtained from the land owner and daily rainfall figures recorded by the nearest Meteorological Station at Palavi. Only the major climatic factor i.e. rainfall was taken into consideration in order to limit the study and the annual yield was calculated as the total harvest of six picks at two monthly intervals.

The coconut palm produces an inflorescence at the rate of one per month and it has a development cycle lasting one year before the bunch is ready for picking. According to the literature available, the ideal for coconut growing will be a uniform annual rainfall of about 1270 mm and any rainfall below 50 mm per month is considered as a drought month.

The average rainfall received in the *Madurankuliya* area for the period under consideration, from January to March and June to September was 24.0, 35.0, 48.3, 49.2, 4.8, 6.0 and 26.6 mm respectively; accordingly these are drought months. The average

rainfall for the remaining five wet months was 229, 107, 186, 203 and 95 mm. This is a clear indication of uneven distribution of rainfall in the said area.

The output of a coconut land depends on the cumulative effect of rainfall in the previous 12 months of a particular pick. The lowest yield from 2002 to 2004 was 3100, 3300 and 3000 nuts respectively. These figures are related to the December pick of each year. This shows that during drought months, the fall of buttons and immature nuts is relatively heavy. Similarly the highest yield for the years 2002 to 2004 was 4200, 4550 and 4450 nuts respectively. These figures are related to the June pick of each year. Drying up of young plants and loss of fronds in bearing palms are other direct adverse effects on coconut cultivation.

Some of the indirect adverse effects of the dry weather are the fast spread of mita infection, causing a reduction in the size of nuts etc. and damage to the crop caused by wild squirrels.

* wijedasa_silva@yahoo.com
Ext.248

Tel: 011-2851301

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Factor successors for commercialising innovations in Sri Lanka

Pradeesha C Warnasooriya* and R M W Amaradasa
Technology Division, National Science Foundation, Colombo 7

Innovations are regularly generated within organisations and communities, all too often they are not put to use, or commercialised. In literature, obstacles of various types include the institutional framework in which they exist, institutional economics, public choice, the firm, corporate control, finance, social cost, intellectual property rights i.e. relevant legal systems, norms, and markets. In order to narrow down the broad spectrum of prevailing problems in commercialisation of innovations, this analysis was done with the raw data collected in 2005 to study the national innovation system (NIS) of Sri Lanka and findings can be used as a guide line for other innovators to mitigate their problems or even put them to good use.

A random sample of 3 inventors from a sample of 13 inventors, registered with the Inventors' Commission, Sri Lanka who had successfully commercialised their inventions, were interviewed and their case studies were analysed with the broad view of studying the NIS. Main factor successor was identified as government support especially for funding and rewarding their successes. The findings further emphasised that most of the commercialised inventions are not presently in the market due to lack of entrepreneurial skills, lack of knowledge on IP rights, loopholes and insufficient provisions in the legal system and the absence of demand-pull approach. These are found to be critical factors in hindering the commercialisation process especially with regard to its sustainability in the market.

This paper highlights government support, especially for funding, rewarding and celebrating success, demand-pull approach, entrepreneurial skills and acquiring sufficient knowledge on intellectual property rights as factor successors for

commercialising innovations in Sri Lanka with the support of 3 case studies from different innovation sources namely, local universities, R&D institutes and individuals. Based on the empirical evidence, some recommendations are proposed to mitigate the negative consequences of factors hindering commercialisation of technology.

The views expressed herein do not necessarily represent views of the NSF, Sri Lanka or the Ministry of Science & Technology, Sri Lanka.

*pradeesha@nsf.ac.lk

Tel: 011-2676766

732/F

The impact of changing economic policies on construction sector performance

Thanuja Ramachandra* and Nisa Zainudeen
Department of Building Economics, University of Moratuwa, Moratuwa

The performance of each industry in Sri Lanka is closely related to the set of policies laid down by the government to that sector. The period of fifty six years from 1948 to 2004 after Sri Lanka gained Independence was analysed in nine different policy regimes based on the government that was in power. In finding the relationship change in construction value added was used to represent growth rate while policies of each regime were related to the nearest suitable policy archetype it most resembles. The policy archetype was designed based on two dimensions, one was the extent of government involvement in economic activities, and the other dimension was the bias it had on particular sectors of the economy, called "Specificity". The first dimension was divided as interventionist and non-interventionist while the second was divided based on whether the policies were aimed at one single sector, which was called "pure sector policy", or a number of related sectors, termed "cluster policy" or on the economy as a whole called "general policy". Based on the above two dimensions the model containing six different archetypes was used to analyse the change in economic policies.

A major political change witnesses the birth of a new set of policies, often substantially different from earlier ones. These policy regimes had a significant impact on the construction sector performance. It is observed that at one end when policy archetype moves from interventionist to non-interventionist, the construction sector performance changes from very low to very high. According to the second dimension as it moves from General to Cluster type construction, performance decreases. The period of 1965-1970 was characterised as non-interventionist sector type, there was a high rate of growth (17%) due to the implementation of major development projects such as Maskeli Oya hydropower, road development, and public housing schemes, along with increase in loan limits, large scale land acquisition. It can be observed that the periods of 1977-1989 and 1989-1994 characterised as non-interventionist General recorded 5.2 % and 5.3% growth rates respectively while periods of 1994-2001 and 2001-2004 showed a little lower performance of 4.7% and 2.3% respectively as result of archetype changes to Non-interventionist Cluster.

The periods of 1956-1960, 1960-1965 and 1970-1977 characterised as Interventionist Cluster type showed negative growth in construction with no major development projects except few housing schemes, strict controls relating to import of building materials,

property restrictions and rent controls. It can be concluded that government was more involved in economic activities, which neither supported the construction sector nor the overall economy. Less government involvement led to increase in many economic activities thereby achieving high construction growth.

* thanuja03@hotmail.com

Tel: 011-2650738

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Granger causality between construction sector and economic growth in Sri Lanka

Thanuja Ramachandra*

Department of Building Economics, University of Moratuwa, Moratuwa

Many researchers have found that the construction industry has always been closely related to the national economy. This paper investigates statistically the existence of a causal relationship between the construction sector and economic growth in Sri Lanka using data over the period of 1959-2004. In finding the relationship, Construction Capital Formation (CCF) (i.e the share of building and other construction in Gross Domestic Fixed Capital Formation (GDFCF)) was used to represent the construction sector while Gross Domestic Product (GDP) was used for economic growth. The causal relationship between economic growth and construction investment was tested using Granger causality tests. In finding the relationship null hypothesis was tested by running the regressions. In regression analysis the stationarity of the variables were tested using unit root test. Unit root tests prove that the second and third differenced of GDP and CCF is stationary respectively.

The results of regression analysis show that the Granger causality between GDP and CCF is in one direction; construction causes the economy to grow, and not vice versa. This supports the view of Ofori (1990), Chan (2001), and Hillebrandt (1985). They argued that construction flow causes economic output and not vice-versa. However, it contradicts the Tse and Ganesan's (1997) finding that GDP causes the construction flow and not vice versa using Hong Kong data. Although some propose that GDP growth causes the construction flow, we argue that a change in construction will affect the economic growth as it is essential to have a high rate of investment for rapid economic growth. As construction constitutes around 50% of this investment, it is expected that if there is a growth it must be accompanied by a rapid expansion of activity in the construction sector. Ball (1988) suggested that policy makers could use this conclusion in taking decisions, as they often use construction as a regulator of an economy.

It is found that construction investment leads GDP by one year. Chan (2001) found that construction leads the GDP by two years. While, Tse and Ganesan (1997) argued that GDP leads construction flows and not vice versa, at least in the short term. However, this study argues that the one year lead period is reasonable as the physical construction takes nearly one year. Only on completion is its effect realised in the overall economy.

* thanuja03@hotmail.com

Tel: 011-2650738

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**Assessing the impact of mandatory regulation to adopt the
Sri Lankan Standards (SLS) in the fruit processing sector in Sri Lanka**

S Rajapakse and U K Jayasinghe-Mudalige*

*Department of Agribusiness Management, Faculty of Agriculture & Plantation
Management, Wayamba University of Sri Lanka*

This study examines empirically the impact of a number of characteristics of a firm on the decision to adopt the Sri Lankan Standards (SLS) using the small and medium-scale fruit processing sector in the Western Province in Sri Lanka as the case. It is hypothesised that in the presence of a “mandatory” government regulation to adopt the SLS in the firm, the management of which has two options, i.e. it can adopt the standards on all of its major products, or exercise a “product-exit”, or in certain cases a “plant-exit”. This behaviour is influenced by factors such as the type of ownership; the availability or ability to introduce modern processing technologies; enhanced food safety controls in place; whether the firm is involved with international markets; availability of skilled labor, and annual returns of the firm adjusted to the number of employees and major products. The primary data collected through a series of in-depth personal interviews with quality assurance managers/owners of 36 firms during May to July 2005 with a support of a structured interview schedule were analysed using Logit Regression techniques.

The results suggest that factors such as improved technology and availability of skilled labour have the highest impact on firms to adopt the SLS without a product or plant exit. However, the influence of factors such as availability of other food safety controls and exporting to international markets was moderate. The outcome of the analysis demonstrates that policy makers must take into account the business environment of the firm, both implicitly and explicitly, in their attempts to mandate implementation of enhanced food safety controls like the SLS on agri-food processing enterprises. In turn, such firms should be supported with a set of market-friendly policies, including the provision of a grace period to comply, accurate information, training and technical support and low interest credit facilities to comply with mandatory regulations.

* udith@wyb.ac.lk

Tel: 031-2299246

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**Non-plantation agriculture, poverty and prospects for crop diversification:
The socio-economic impact of banana cultivation in Hambantota district**

Upali Vidanapathirana* and Anton Piyarathne

Department of Social Studies, Open University of Sri Lanka, Nawala, Nugegoda

Recent literature on agricultural production in the developing countries highlight a debate that concerns the problems of non-plantation crops vis-à-vis prospects for high valued cash crop cultivation. It is argued that in a market economy, production of paddy is an economic waste and it is the high-valued crops such as horticulture, and cultivation of other cash crops that must be promoted. Farmers in the district of Hambantota in particular have started to move away from the so-called low valued crops towards high

valued crops like 'banana'. The socio-economic implications of this shift are discussed in this paper.

This study focuses on the banana cultivation in the villages of Jayagama and Weheragala where a major shift in terms of choice of crops to be cultivated and an unequal distribution in the farm structures and land ownership has been emerging in the recent years. This paper is based on a set of data collected through a survey of a mixed group of seventy two (72) farmers many of whom have chosen to cultivate paddy and Banana side by side. The data set of the sample survey was supplemented by a series of in-depth discussions.

The study showed that banana cultivation in general is more lucrative as it has the capacity to produce higher economic surpluses and also a flow of income that is regular. To this extent banana cultivation should naturally be preferred to those other alternative cropping mixes such as paddy, maize, millet etc., as these crops do not ensure a regular flow of income. Yet, this study found that successful banana cultivation requires a set of pre-conditions such as a stronger asset base, which includes, irrigated land holdings, draught power, finances, etc. Therefore only those 'well-to-do' farmers are able to reap these benefits. It is revealed that the process of this transformation has contributed to an intense form of differentiation pertaining to asset and income distribution. In fact in most of the villages covered by this study, a few rich farmers who operate large holdings have successfully carried out banana cultivation. Farmers cultivating small tracts of banana plots (say an Alli), have not been able to make any headway. One of the ultimate outcomes of this process is the creation of a landless class of small holders who have leased out their plots to the rich cultivators to become labourers on their own land.

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* uvida@ou.ac.lk
Ext. 436

Tel: 011-2853777

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Peasant farming in semi arid areas: Vulnerability and coping strategies

Upali Vidanapathirana* and Anton Piyarathne
Department of Social Studies, Open University of Sri Lanka, Nawala, Nugegoda

Farming is the most important form of livelihood for the peasantry in the semi-arid areas in the district of Hambantota. It is associated with a high element of risk which stems from covariant and idiosyncratic shocks. The former refers to shocks arising from sources such as droughts while the later refers to shocks arising from sickness or crop damage caused by wild animals. Incidentally, these semi-arid areas are characterised by the persistence of chronic poverty. According to records maintained by the Samurdhi office of the district, more than 60 percent of the households received poverty assistance.

The purpose of this study was to ascertain how those predominantly peasant households respond to different forms of shocks that undermine their prospects for

economic mobility. The paper aims at identifying the major forms of shocks, the degree of vulnerability of the peasants to these shocks and the different forms of coping strategies adopted by the peasantry. This study was conducted in the Suriyawewa Divisional Secretariat area for which a sample of 155 households was surveyed using a combination of techniques including a questionnaire survey, and focus group discussions.

The impact of shocks and vulnerability as identified in this paper is twofold. First, it undermines the production potentials of the peasantry. Periodic droughts for instance make even the Maha crop difficult when rainfall fails to provide adequate water. Even when the rainfall is adequate, crop damage caused by animals including wild elephants and stray cattle, or pest attacks brought the production levels much below their potential. Moreover, price fluctuations of output during the harvesting period aggravate the situation as crops like paddy, gingerly (Tala), cowpea and finger millet etc., recording a sharp fall in their market prices. The response of the peasantry to these shocks takes the form of cutting down food and health expenses etc., which cause malnourishment, sickness and unattended morbidity conditions. They eventually lead to a severe form of poverty trap among those who are adversely affected by these changes.

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* uvida@ou.ac.lk
Ext. 436

Tel: 011-2853777

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Assessment of farmer share of export agriculture crops

A P P Disna*
Department of Export Agriculture, Peradeniya

Export Agriculture Crops (EAC) sector in Sri Lanka has become an attractive foreign exchange avenue in recent past with about 31,000mt. of exports and Rs.10,000 million of earnings in 2005. The group was ranked as the 4th main export avenue in the agriculture sector next to major plantation crops. EACs have historically established long market channels with several village level collectors, retail and whole sale buyers and spice auctions or exporters at the last end. However backward linkages of upper segments of the market channel (eg. whole sale buyers, exporters) with producer level are very poor hence farmers always complain that they do not get a fair share and the middlemen get the benefit of their hard work. The objective of the study was to assess the producer share of the above crops from the local auction and international prices during 1998-2005. The analysis showed that the farmers were getting a considerably higher share from the auction prices and the monthly averages for the period were cocoa 74%, coffee 87%, pepper 89%, clove 90%, nutmeg 94% and cardamom 87%.

Producer share from the international price not only indicate the Exporter's margin but also shows the recognition of Sri Lankan products at the world market. The average producer shares from the world prices showed wider fluctuations with cocoa 60%, coffee 63%, pepper 80%, clove 132%, nutmeg 34% and cardamom 101%. Nutmeg and cardamom farmers had received higher prices than the world price while coffee and cocoa growers had received fairly lower prices. Lower producer shares for coffee and cocoa may be due to the lack of established world market and poor quality of Sri Lankan products in the highly quality conscious huge international market. Sri Lankan producers pay no concern over quality due to non-commercialised farming and trading system for those products. Pepper producers were getting fair share mainly due to the transparent trade relations, established market links and recognition of the quality of Sri Lankan pepper. Results indicate that the producer price of clove was always higher than the International price of Madagascar clove. High demand from India for the clove, which is vital for their value addition industry, may be the main reason. Nevertheless, Sri Lankan producer share for nutmeg for the period was much below and only around 34% of the price of Indonesian nutmeg. Restricted imports by major buyers such as Europe and USA due to well reported higher aflatoxin levels in Sri Lankan nutmeg may be the major reason. International prices doubled during 2000-05 due to scarcity of nutmeg but Sri Lankan producers had not benefited from that. Cardamom farmers had received fair share but quantity of exports averaged less than 10mt. and stagnating throughout the period. Producer shares for many EAC, both at the local and international markets are attractive but products such as nutmeg are in a highly unfavorable position at the world market mainly due to poor quality.

Tel: 081-2388651

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Fertilizer use behavior among cinnamon farmers

A P P Disna* and J K Lindara
Department of Export Agriculture, Peradeniya

Cinnamon is important to Sri Lanka in the international spice trade as the country supplies over 80% of true cinnamon requirement of the world market. The export volume and earnings from cinnamon in 2005 exceeded 12,000mt. and Rs. 5000million respectively and cinnamon is grown in about 30,000 ha in Sri Lanka mainly in Southern, Sabaragamuwa and Western provinces. Over 1,00,000 families in these areas involve in the cinnamon industry mainly in farming, processing and trading and earn substantial part of their family income. Fertilizer application and weeding are regular practices in most of the cinnamon cultivations. Although clear technical recommendations have been given on the type, quantity and the method of application of fertilizer it has been reported

that these recommendations are not fully adopted by many cinnamon farmers. The objective of this study was to find out the fertilizer use behavior among cinnamon farmers in Sri Lanka. Primary data, gathered from two surveys in cinnamon growing districts, were used for the study. Results revealed that 79% of cinnamon farmers use inorganic fertilizer comparative to other spices such as pepper (29%) and cardamom (28%). Average fertilizer use for cinnamon in the study area was found as 1031 kg/ha while the fertilizer recommendation is 900kg/ha. The highest rate of fertilizer application of 1159kg/ha was reported in Galle district followed by Matara, Kalutara and Colombo with 1092kg/ha, 1032kg/ha and 832kg/ha respectively. Although it was recommended to apply fertilizer twice per year 82% farmers had applied fertilizer only once a year with the maha rains. The recommended fertilizer technology for cinnamon is to make mixtures using bulk fertilizer at the rate of 23: 07:15: 02 of N:P:K:Mg with urea as the N base. The survey in Galle district revealed that only 8% follow the above recommended technology while others use packed fertilizer available in the shops under different trade names. The Baur mixture was the most popular (41%) followed by Lak pohora (11%), Agstar (7%), CIC (7%), Maclean and Laksaru respectively. It was revealed that all mixtures, except CIC mixture, had the recommended nutrient composition. About 4% of farmers had used "cinnamon fertilizer" available at shops without knowing any other details. About 42% farmers, who apply packed fertilizer, used ammonia based mixtures while 16% farmers who used urea also applied ammonia mixtures once in two to three years. Farmers who preferred ammonia fertilizer believe that increased plant growth due to urea application make the bark rough which cause difficulty in peeling if peeling is practiced once a year. They also viewed that urea is better if harvesting is done twice per year but only 7% of them had practised double harvesting. Majority of cinnamon farmers use inorganic fertilizer but the quantity, type and method of application are different from the technical recommendation.

Tel: 081-2388651

739/F

Life cycle environmental impacts of up-country potato farming systems in Sri Lanka

P R Weerakkody^{1*} and P Gunawardane²

¹ *Hector Kobbekaduwa Agrarian Research and Training Institute, Colombo 7*

² *University of Sri Jayewardenepura, Nugegoda, Sri Lanka*

Potato cultivation is an integral part of the upcountry vegetable farming system due to its high income generating potential. However, it is characterised by several negative environmental impacts. The goal of this paper is to assess relative impacts of cultivating potatoes in two landscapes in the upcountry, uplands and lowlands, during two cultivation seasons, namely Maha and Yala respectively based on Life Cycle Assessment (LCA) tools.

The study was based on the data collected at field level and secondary sources of information. In a first step, all emissions and the consumption of resources connected to the different processes were listed in a Life Cycle Inventory (LCI) and related to a common unit, which is 1 cwt (50kg) of potatoes. Next, a Life Cycle Impact Assessment (LCIA) was done, in which the inventory data were aggregated into indicators for environmental effects, which included climate change, eutrophication, human toxicity, terrestrial eco-toxicity and atmospheric acidification.

It appears that the LCA tool is appropriate in determining the environmental hotspots between such comparable production systems. It also depicts the sources and relative significance of environmental impacts of intensive crop production systems and on the basis of which farmers could make alternative and appropriate agronomic decisions. The comparison of two production scenarios shows that environmental impacts are highly dependent on varied cultural practices adopted in the two landscapes. These variations are attributed to socioeconomic reasons such as financial and human resource availability at the time of planting and accessibility to two land use systems. The study also suggests how these impacts could be minimised through proper cultural practices. It is also demonstrated that the pollution sources of highest concern could be identified and the alternative environmental management practices could be promoted at farm level. Overall, the results suggest that if cash values are assigned to these environmental impacts through appropriate instruments, the LCA methodology could play an important role in internalising environmental externalities.

* hartiarm@slt.net.lk

Tel: 011-2698539

740/F

A comparison of the trade of heavy berry and light berry produce of black pepper in Matale district

M A P K Seneviratne*

In-Service Training Center, Department of Export Agriculture, Elwala, Ukuwela

Pepper light berry trade has increased significantly over the last five years. Light berry produce is used for oil and oleoresin extraction. The objective of the study was to identify pepper light berry trade in Matale district and compare with that of heavy berry trade in the same district.

Matale is the second largest pepper producing district and an area where pepper light berry harvesting takes place to a great extent. Therefore, Matale district was selected as the study area. Key- informant interview was the method employed in data collection. Main spice dealers in Matale town, spice dealers in small towns (Rattota, Ukuwela and Pallepola), village level spice collectors and the people who harvest the pepper crop on lease were interviewed. The number of individuals in each category was 05, 10, 10 and 10 respectively. Thirty black pepper producers (15 regular light berry harvesters and 15 regular heavy berry harvesters) were also interviewed across the district to identify trade channels of the two types of black pepper products. Heavy berry products can be sold both in raw and dried forms. Regular spice dealers and collectors were involved in the heavy berry trade. Heavy berry prices were fairly stable and ranged from Rs. 120 to 130/kg during the study period between 2001 and 2002. Price of heavy berry was determined according to demand and supply.

Light berry harvesting was taking place from three-month maturity onwards. The high demand period for light berry lasted between May and June where the pepper crop in Matale attained the desirable state of maturity for oil and oleoresin extraction: between, 4.5 - 5.5 months after initiation of flowers. The price of products is unusually high (approximately 50 rupees/kg higher than the heavy berries on dry basis) during this one

month period and seems to be determined by the exporters to coincide with the maximum amount of extracts in the produce. In addition to the full-time spice dealers, a number of buyers were involved in the light berry trade including non-spice traders like hardware and jewelry merchants, mobile traders from Kandy district and individuals who buy the crop from borrowed money from large scale spice dealers. Unemployed youth and government officers such as teachers, grama niladaris, samurdhi animators have also acted as part-time buyers. People from Kandy district were involved in the drying process of raw products of light berries.

* mapks@sltnet.lk

Tel: 066-2243450

741/F

Practices of grading and marketing of clove (*Eugenia caryophyllus*) in Ukuwela Divisional Secretariat Division in Matale district

K M M W D K K Narampanawe^{1*} and M A P K Seneviratne²

¹ *Sewalanka Foundation, 432A, Colombo Road, Boralesgamuwa*

² *In-Service Training Centre, Department of Export Agriculture, Elwala, Ukuwela*

The aim of the study was to identify the grading and marketing methods (form of selling, time of marketing, sales avenues) of cloves at domestic levels, reasons for non-grading and problems related to these practices. Among the clove growing areas in Sri Lanka, Matale has the third largest land extent (1132ha). The selected area for the study was Ukuwela Divisional Secretariat Division (DSD) in Matale District covering 355 hectares of clove. Ukuwela DSD has three Agrarian Service Centre (ASC) areas Tenna, Elkaduwa and Ukuwela, which have respectively 40%, 30% and 30% of extent under clove. For the study 24, 18, 18 clove growers were selected randomly from Tenna, Elkaduwa and Ukuwela respectively proportionate to the land extent. Altogether 60 clove growers were interviewed. Field survey was conducted during the months of May, June and July 2004.

The stalks, immature cloves, clove flowers in bloom, fermented cloves and damaged buds need to be separated from quality products. Half of the respondents graded their cloves. The rest (46%) did not grade their products. Reasons for not grading were narrow price gap between the graded and non graded products (48%), disinterest (40%), and lack of knowledge on correct method of grading (4%). There were instances where separation of stalks was practiced in unhygienic places. Half of the respondents sold clove produce in dry form. Nearly 11% sold in fresh form while 40% of the respondents sold in both dry and fresh forms. Forty six percent of respondents sold their cloves at the prevailing market price whereas 11% sold as soon as harvested. Majority of the respondents (72%) sold their produce to Matale spice collecting centres expecting higher prices.

Grading of clove is an insignificant practice among clove growers in this area due to low price gap. Hygienic handling, adequate drying and use of proper storage have to be promoted to increase microbial qualities. One solution for these weaknesses is to introduce processing centres where good practices can be performed to yield a quality product.

Tel: 011-2545362

742/F

Potential knowledge transfer through tea leaf supervisors

U G H P Dharmadasa¹, M K S L D Amarathunga² and M Wijeratne^{1*}

¹ *Department of Agricultural Economics, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya*

² *Advisory and Extension Services Division, Tea Research Institute (Low Country Station), Ratnapura*

Tea provides 82.35% proportion of the foreign exchange earnings coming from plantation crops in Sri Lanka. Tea cultivation is carried out by two categories of producers; large estates and smallholders. Even though the smallholding sector is increasing in terms of area of cultivation and contribution to total tea production, their adoption rate for innovations developed by Tea Research Institute (TRI) is found to be low. However, with the assistance of leaf supervisors, there is a potential to disseminate technologies to the smallholdings. Therefore, objectives of this study are to assess the efficiency of knowledge transfer through tea leaf supervisors, to identify and estimate drawbacks, and propose appropriate solutions to improve the efficiency of this communication channel. Most of the information in the study is based on field investigation carried out with 30 leaf supervisors and 100 smallholders selected from the Ratnapura district.

The findings of this study indicate that there is a wide knowledge gap between leaf supervisors and smallholders, and knowledge of leaf supervisors is higher than that of smallholders. Lack of knowledge was one of the major constraints in adopting innovations in the smallholding sector. In this respect, leaf supervisors with sound educational background and experience about tea cultivation have a greater role to play. They should be trained at TRI before sending for leaf collection, especially to deal with smallholders as communicators for tea technology transfer. It is necessary to establish a strong link to feedback TRI for necessary improvement. Productivity of smallholdings as well as quality of end product of tea factories could be upgraded by implementing the above technique.

Tel: 041-2292200

743/F

Valuation of recreational benefits of village tank systems

E B I Dayananda^{1*} and U A D P Gunawardene²

¹ *Department of Agricultural Economics, Faculty of Agriculture, University of Ruhuna, Kamburupitiya*

² *Department of Forestry and Environmental Sciences, Faculty of Applied Sciences, University of Sri Jayawardanapura, Gangodawila, Nugegoda*

Village tank systems are ecosystems that provide a number of goods and services that have an economic value to the local people living adjacent to the tanks and also to communities outside the tank ecosystem area. Quantifying those economic values of village tank systems will be helpful to set priorities and to allocate spending on conservation initiatives. This paper reveals the findings of an economic valuation, which was undertaken in 10 village tanks in Hambantota district of Sri Lanka during the *maha* season of 2005. The total sample size was 175 villagers who live adjacent to the tanks. Contingent valuation method was used to measure the annual net recreational benefits received by villagers who use these tanks. Open-ended willingness to pay (WTP) format was employed to estimate the recreational value. Results of Independent sample t test indicates that there is no significant difference between two strata; tanks in isolation and tanks in cascades, with regard to mean willingness to pay value (t value 0.352, significant p value 0.506). The mean willingness to pay for the preservation of village tanks was estimated at Rs. 1020 per household per year. The recreational benefits of the village tanks of Hambantota district were estimated to have an annual value of Rs. 8,374,200. Results of regression analysis revealed that the respondent's income, age and education level had a positive relationship with WTP. Distance showed a negative relationship. The standardised coefficient of income (0.370) indicated that income has more influence on WTP than age (0.104) or years of schooling (0.088) or distance (0.212). The adjusted R square value was 0.308. As the F value (20.539) is significant (0.000) at 5% level, it can be concluded that the regression equation predicts the dependent variable at greater than chance level. The study concludes that the villagers are willing and economically able to support the conservation of tanks for recreational benefits they offer. Furthermore, if income status improves in the area, people will contribute more towards conservation of the tanks.

* buwani@agecon.ruh.ac.lk
Ext.358

Tel: 041-2292200

744/F

**Valuation of social capital in irrigated agricultural systems:
A case study of village tanks in Southern Sri Lanka**

E B I Dayananda^{1*} and U A D P Gunawardene²

¹ *Department of Agricultural Economics, Faculty of Agriculture, University of Ruhuna, Kamburupitiya*

² *Department of Forestry and Environmental Sciences, Faculty of Applied Sciences, University of Sri Jayawardanapura, Gangodawila, Nugegoda*

Under the supervision of Agrarian Services Department, farmer organisations have been given legal authority to undertake the management of village tank systems. Considering farmer organisations as social capital, this study tries to investigate its impact on irrigated agriculture in Hambantotata district of Sri Lanka. One functional tank and one abandoned tank of Tiisamaharama D.S. division were selected for this study during the *maha* season of 2005. Seventy farmers who lived adjacent to both tanks were interviewed using a pre-tested questionnaire.

Considering social capital as a function of level of trust towards the leadership and participation in collective action, an index was developed to measure the level of social capital in each tank community. To develop the Social Capital Index (SCI), percentage acceptance of the leadership by farmers (percentage of farmers who agree with the leader in agricultural decisions) was added to the participation percentage (percentage of farmers who participated in the collective activities organised by the farmer organisation). Functional tank, which is managed by an active farmer organisation received high social capital index (1.7). The abandoned tank having an inactive farmer organisation, received lower social capital index (0.3). When the average agricultural incomes of the two tanks were compared, the farmers of functional tank having high social capital, receives Rs. 3616 per acre per month and it is 6.7 times higher than that of the abandoned tank. The average agricultural income of the abandoned tank was Rs. 535.71 per acre per month. As the other conditions of the two tanks were quite similar to each other the difference in average agricultural income could be attributed to the difference in social capital in the two communities. Therefore, the study concludes that, social capital is of vital importance for the enhancement of irrigated agriculture.

* buwani@agecon.ruh.ac.lk
Ext.358

Tel: 041-2292200

745/F

Farmer perceptions of farmer institutions: A case study

R K C Sandamali¹, A P R Jayasinghe² and M Wijeratne^{1*}

¹ *Department of Agricultural Economics, Faculty of Agriculture, University of Ruhuna, Kamburupitiya*

² *Irrigation Management Division, Department of Irrigation, Bauddhaloka Mawatha, Colombo 7*

The non plantation sector in Sri Lanka, is suffering from low productivity, low investments, and also a high dependent population. Many efforts have been taken to improve the living standard of this sector through agricultural productivity enhancement. Farmer Organisations (FO) were institutionalised to fortify the process of development. However, in the national context, this policy has not rendered benefit to the efforts and investment made. Hence, this study attempts to reveal farmer perceptions of the activities of FOs.

Walawe left bank in Ridiyagama irrigation scheme was selected as the study location. Simple random sampling technique was used to select 75 farmers: 35 farmers from FOs, 24 from farmer companies, and 16 from agricultural productivity societies. Data were collected using a pre- tested questionnaire during September to October; 2005. The study revealed that the farmers are satisfied with the contribution of FOs for water sharing activities such as the amount of water received, fairness of distribution, and timeliness. However, the canal maintenance is at an unsatisfied level. The contribution for input supply, credit facilities, quality seed production, and awareness programmes were impressive. Farmers were unsatisfied on activities such as maintenance contracts

and farm mechanisation handled by FOs. Contribution for the agri-business and product marketing activities and the paddy purchasing programme were not adequate. The study reveals that the FOs in Ridiyagama area perform at a moderate satisfactory level but there is a potential for further improvement.

* mahindaw@agecon.ruh.ac.lk

Tel: 041-2292200

746/F

**Application of Participatory Rural Appraisal (PRA) techniques:
A case study in Weliganga Wasama**

M Wijeratne*, D Koralagama and N De Silva
Department of Agricultural Economics, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

Farming communities have much wisdom regarding production of food from land, but their level of living and productivity could be improved by learning more of what is known outside their community. To bring this to reality Participatory Rural Appraisal (PRA) was introduced to improve the decision making process at community level. Weliganga Wasama in Kothmale was selected to execute PRA activities in collaboration with Hadabima Authority. In fact, the villagers in this locality have encountered adverse impact from the resettlement scheme of Kotmale electricity project.

The activities were conducted during April, 2006. First, pair-wise ranking was carried out to identify the problems in the area. Two matrix rankings were used to select the most appropriate crop and soil conservation method for the area, respectively. About 10 to 15 members participated in each and an extension officer facilitated the activity.

Results showed that the prime problem for the area is poor accessibility to water. Lack of planting materials and animal threats were ranked as second and third, respectively.

First matrix ranking showed that the most suitable crop for the area was tea. Pepper and clove were next best. According to the second matrix ranking the most applicable methods for soil conservation were live fences and stone ridges.

Hence, PRA tools practised in Weliganga Wasama helped to identify the important problem which should be immediately addressed. Also it provided an idea about the crops which are suitable for the area and also the most applicable soil conservation methods.

* mahindaw@agecon.ruh.ac.lk

Tel: 041-2292200

747/F

**Productive application of forward sales contract system for rice marketing:
A case study in Rajanganaya area**

P G N M Peramuna^{1*}, A P R Jayasinghe² and M Wijeratne

¹ Department of Agricultural Economics, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

² Irrigation Management Division of Ministry of Agriculture, Irrigation and Mahaveli Development, Baudhaloka Mawatha, Colombo 7

Drastic price fluctuations occur in the rice market between the harvesting season and the off-season. This creates a serious problem of marketing farmers' paddy production at a stable and reasonable price. As a measure to solve this problem, Central Bank of Sri Lanka introduced a Forward Sales Contract system in 1999, named "Govi Sahanaya". A Forward Sales Contract is an agreement made between a buyer and a farmer to sell agricultural commodities on a certain future date at a predetermined price. In addition to the farmer and the buyer, a facilitator (usually a bank) also participates with this system. This study has two objectives as, assessing the farmer response to FSC system and to propose practical approaches to improve the FSC system. Rajanganaya Irrigation Project was selected for this farmer survey because higher numbers of farmers who have an experience with the FSC system were concentrated in that area. Primary data were collected from pre-tested questionnaires through personal interviews during March 2006. Data were tabulated using MS. Excel package and analysed using descriptive statistical tools such as charts and percentages.

FSC system has become the second highest farmer preference, out of three main opportunities of rice marketing (Guaranteed Price Scheme, private dealers, FSC system). Most of the farmers (80%) have a positive attitude towards the FSC system. There was an increasing trend of farmer number, engaging in FSC system from 2004/05 Maha to 2005 Yala season. Farmers prefer this system due to good quality seed paddy, straight fertilizer and support services rendered by the Seylan Bank in addition to the availability of reasonable price for the farmer production. The most critical reason for not consenting with this system is weaknesses of Seylan Bank's facilitating activities. The major problems in implementing this system are violating the contract by the buyers by 33% as well as the farmers by 45%. But still 70% of farmers are willing to engage in this system again. With regard to the Bank's procedure, farmers expect the Bank to make the procedure easier and grant the credit in correct time, while for the improvement of the FSC system, 83% of farmers expect to have a government involvement to some extent. Farmers expect to improve awareness and build confidence on FSC system by having freedom to engage individually. There is a higher trend in preference to have awareness programmes through monthly meetings of Death Donation Society in the area.

* niwyadi_peramuna@yahoo.com

Tel: 011-2297306 (R)

748/F

Sausage marketing in Sri Lanka: The household perception

M A P D P Wickramaratne* and M De Zoysa

Department of Agricultural Economics, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

Sausage is one of the oldest forms of processed meat. Processed meat industry, like any other has to keep pace with consumer demand. The aim of marketing is to meet and satisfy target consumer needs and wants. Household buying behaviour is the decision process, which leads to the household buying and using products. Hence it is very

important to study how households behave in the market to enable the supplier to develop and maintain an effective marketing management system for sausages, which precisely match the utility of consumers in the target market. The objectives of the study were: to examine knowledge, attitudes, and behaviour of households and to identify the factors affecting their purchase of sausages. The study was conducted in Colombo, Gampaha, Chilaw, Rathnapura, Kurunagela, Kandy, Anuradhapura, Kalutara, and Galle through a field survey. Three hundred selected housewives of sausage consuming households were interviewed using a pre-tested structured questionnaire.

According to the consumption status of sausages many of the households (43%) are rare users. Consumption status (user, lag user, rare user) of sausages is significantly related to the income level of the household ($\chi^2 = 17.76$, P value = 0.0068), presence of different age group of children in the family ($\chi^2 = 15.40$, P value = 0.0174) and employment category of the housewives ($\chi^2 = 26.15$, P value = 0.0002). But consumption status was not related with the religious background of the household ($\chi^2 = 5.45$, P value = 0.0657). Housewives have a good perception of sausages as a type of processed meat considering preference of children, attractiveness and effectiveness of the promotional programme, convenience, hygienic condition of the product, availability of different packet sizes, and availability in the market. However, they are not aware of the nutritive value of the product and impact on the health condition of the family. Housewives have knowledge of the quality certificates of the product but they are lacking knowledge on the nutritive value of the product and price difference among brands. Although the buying decisions are mostly (64%) made by the husbands in the families, 73% of the households consider their children when buying sausages. Majority (60%) of households bought 250 g size packet of sausages for their normal consumption. Selecting a particular brand depends on brand loyalty and the image that brand has. Moreover, quality, taste, and availability in the market also influence their selection. Price also influences the purchasing decision. However, personal, psychological, social and cultural factors have only little impact on the purchasing decision of the households.

* aruni_dpw@yahoo.com

Tel: 041-2292200

POSTERS

SECTION B

201/B

A comparative study of the growth of field established *in vitro* plants with conventionally propagated plants of *Munronia pinnata* (wall) Theob. (Binkohomba, family Meleaceae)

K G P H Chandrasena* and W T P S K Senerath

Department of Botany, University of Sri Jayewardenepura, Gangodawila, Nugegoda

In vitro grown plants of *Munronia pinnata* were successfully established in the greenhouse and after one year, they were introduced to the field (10,000 Lux - 12,000 Lux light intensity, 6.8 soil p^H and watering was carried out to maintain average wet condition) with conventionally propagated plants in order to determine their survival and growth in the natural habitats. It is important to determine whether tissue cultured plant are true-to-type when they are produced in commercial scale. Morphological parameters such as plant height, number of leaves, number of branches, flowering habit and seed germination ability were measured and physiological parameters such as photosynthetic rate and stomatal resistance were also measured over a period of one year in tissue cultured plants and conventionally propagated plants (50 plants from each type) and data were compared. Completely randomised block design was applied for experiments and statistically analysed using MINITAB.

All the tissue cultured plants transferred to the field survived with no visual deformation. Height increment and leaf number increment was significantly increased in both types of plants over the tested period. When compared to the initial measurements; height increment of tissue cultured plants and conventionally propagated plants after one year were 5.55±1.2 cm and 6.28±0.97 cm respectively, where the values were non-significant. For increment in leaf number it was 9.1±0.4 and 9.3±0.84 respectively in tissue cultured plants and conventionally propagated plants where the values were non-significant. Branching was only observed in tissue-cultured plants with the increment of 2.5±0.45. Flowering habit was similar in both plant types and no differences were observed in percentage seed germination.

Photosynthetic rates were increased in both plant types during the observation period and there was no significant difference between tissue cultured plants and conventionally propagated plants. Stomatal resistance was low in tissue cultures plants at the initial stage but significantly improved when establishing in the field. There was no marked difference in stomatal resistance between two plant types after one year in the field. No chemical fertilizer or pesticide was applied during the experimental period and only a solution of tobacco leaves (12 cm long, 10 petioles) soaked in 1 L of water was applied to all plants to control insect attacks.

* phemalal@yahoo.com

Tel: 071-7977082

The effect of number of leaves and length of the cutting on rooting of Masbedda (*Gymnema sylvestre*) cuttings

K K I U Arunakumara^{1*}, U Wickramasinghe¹, B C Walpola² and S Subasinghe¹

¹Department of Crop Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

²Department of Soil Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

Gymnema sylvestre is grown over many parts of India and some parts of Sri Lanka too. The species has a reputation in traditional medicine as a remedy to control diabetes. Though, it has a ready demand in the market, systematic cultivation is yet to be practiced and thus the natural habitats have been over exploited. The present study focused on vegetative propagation of *Gymnema sylvestre* by means of cuttings.

The healthy, disease-free, semi hard wood cuttings were incorporated for the experiment. Two parallel experiments were conducted in order to study the effect of number of leaves remains (experiment 1, with four treatments) and length of the cutting (experiment 2, with three treatments) on rooting. The Randomize Completely Block Design (RCBD) was used with four replicates. Rooting was assessed 75 days after planting. The percentage survival was significantly ($p \leq 0.05$) high (91%) in cuttings with two leaves, followed by single leaf cuttings (78%), whereas the lowest survival (19%) recorded from the cuttings with four leaves. However, no significant ($p \leq 0.05$) differences in the number of roots per cutting and the length of roots were recorded among the cuttings with two, three and four leaves. Though results demonstrated that the importance of leaf area on rooting, retention of too many leaves on cuttings might cause increased water loss, which can eventually lead to death of the cutting. Results of the experiment 2 revealed that the percentage survival and number of roots per cutting were significantly ($p \leq 0.05$) lower in single nodal cuttings than that of any other cuttings. *Gymnema sylvestre* can be propagated by means of cuttings. Double nodal semi hard wood cuttings demonstrated better results, furthermore, rooting performance of cuttings with two leaves was impressed.

* kkiuaruna@yahoo.com

Tel: 041-2292200

203/B

Production of disease free foliage plants for export

M H A D Subhashini^{*} and U R Weerasinghe

National Plant Quarantine Service, Canada Friendship Road, Katunayake

The National plant Quarantine Service took initiative to guide plant nursery men on how to identify properly plant diseases and also on proper disease eradication methods. Samples collected were examined in the laboratory to ascertain bacterial and fungal diseases. Important bacterial diseases observed were bacterial leaf spot and tip burn caused by *Xanthomonas campestris* pv, *dieffenbachiae* in *Philodendron* spp, *Dieffenbachia* spp.; *Anthurium* spp.; bacterial leaf spot caused by *Pseudomonas cichorii* in Pothos, some *Philodendron* spp.(*Epipremnam aureum*) , *Aglaonema* spp (*Chinese Evergreen*), & *Monstera* spp.(Split- leaf *Philodendron*), bacterial leaf blight by

Xanthomonas spp. in *Syngonium* spp. *Aglaonema* spp., bacterial leaf spot caused by *Xanthomonas* spp. in *Dracaena sanderiana* and *Philodendron* spp; bacterial blight caused by *Erwinia chrysanthemi* in *Aglaonema* spp. *Dieffenbachia* spp; *Philodendron* spp and *Syngonium* spp.; bacterial soft rot caused by *Erwinia chrysanthemi* and *Erwinia carotovora* pv *carotovora* in *Aglaonema* spp. and *Dracaena sanderiana* and bacterial leaf spot and stem canker caused by *Xanthomonas campestris* pv *hederae* in English Ivy, *Hedera helix*. Among the fungal problems identified were anthracnose leaf spot caused by *Colletotrichum* spp. in *Livistonia chinensis*, *Dracaena sanderiana*, *Aglaonema*, *Miscanthus*, *Codiaeum variegatum* and *Polyscias*; wilt, leaf spot and leaf rot by *Fusarium* spp. in *Dracaena godseffiana*, *Dracaena sanderiana*, *Dracaena marginata*, *Polyscias*, *Gardinia jasminosa* and *Miscanthus*; leaf spot caused by *Alternaria* spp. in *Dracaena glauca*, *Schefflera*, *Polyscias*, *Livistonia chinensis* and *Calathea*; stem rot and root rot by *Sclerotium* spp. In *Schefflera*, *Codiaeum variegatum*, *Cosandra* and *Chlorophytum*; leaf spot caused by *Pestalotia* spp. in *Cordyline* and *Dracaena marginata*; dieback, Canker and Blight caused by *Phoma* spp. in *Dracaena sanderiana*, *Gardinia jasminosa* and *Cordyline*

Leaf and stem rot caused by *Aspergillus* spp in *Dracaena purple compacta*. Stem rot, collar rot, leaf blight caused by *Rhizoctonia* spp *Chlorophytum*, *Philodendron*, *Scindapsus aures*, *Dracaena godseffiana*, *Codiaeum variegatum* and *Ixora*; stem rot and root rot caused by *Phytophthora* spp. in *Dracaena marginata*; wilt and root rot caused by *Pythium* spp in *Scindapsus aureus*.

Several serious quarantine pests have been detected in exported foliage consignments during inspection by several recipient countries. Therefore, it is important to educate exporters to produce disease-free, good quality produce at nursery level for the international export market and also to improve conditions in their nurseries.

* npqs@sltnet.lk

Tel: 011-2252028

204/B

The influence of Nitrogen and Potassium fertilizers on peel colour development and stem-end rot disease development of ripe Karuthacolomban mango

P M S Jayathilaka*

Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya, Peradeniya

Mango is grown in almost all districts in Sri Lanka, although the dry zone has more suitable environmental conditions for commercial production. Karuthacolomban is one of the mango cultivars indigenous to Sri Lanka and is popular due to its exquisite taste and aroma. Lack of attractive color and high susceptibility to the stem end rot disease are the major post harvest problems in Karuthacolomban mango for both local and export markets.

Trees have been planted, according to the statistical design of Randomized Complete Block Design (RCBD) with 10 blocks. As a pre-harvest technique, recommended dose of Nitrogen (N), Phosphorous (P) and Potassium (K), double dose of Nitrogen with recommended levels of P and K (excess N) and double dose of K with recommended

levels of N and P (excess K) were applied to these mango (*Mangifera indica*) trees at two consecutive bearing stages, to find out the effect of nutrients on above problems. The recommended level of NPK was applied as Urea 235g/plant, Triple super phosphate 120g/plant and Murate of Potash 945g/plant, respectively.

Mango fruits were harvested from treated plants to find out the effect of Nitrogen and Potassium on post harvest diseases and peel color development in Karuthacolomban mango. Stalks of every fruit were removed without touching the latex on the skin. Then fruits were cleaned and allowed 1-2 hours to dry in air under the sample preparation. Fruits were harvested at fully mature stage and allowed for natural ripening and induced ripening using ethrel at different temperatures in experiment 1. The fruits of prepared sample were inoculated with *Lasiodiplodia theobromae* for stem-end rot disease development. Then fruits were stored 3-4 hours under room temperature at 25 ± 2 °C and ripening treatments were followed in experiment 2. Peel colour development and stem-end rot disease intensity were recorded when fruit was at table ripe stage. Analysis was done by using statistical package Minitab/ Freidman test.

Excess K treatment was found to be the most effective fertilizer level for developing peel color and it took more time, hence post harvest life was longer. Excess N fertilizer application did not improve yellow color of the peel. None of the fertilizer levels showed a significant difference on stem-end rot disease development under the conditions of these experiments.

* jayatilake@email.com

Tel: 077-3695723

205/B

***In- vitro* propagation of sugarcane (*Sacchurum officinarum* L.)**

P S Warakagoda*, S Subasinghe and D L C Kumari
Department of crop Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

Experiments were carried out to find out the suitable surface sterilisation procedure using different concentrations (15%, 20% and 25%) of Clorox (5.25% Sodium hypochlorite) with different time durations (10, 15 and 20 minutes) to obtain higher survival percentage of *in- vitro* cultured sugarcane auxiliary buds. Murashige and Skoog (MS, 1962) medium was used as establishment medium and after establishment cultures were transferred to proliferation media. Different combinations of IBA (0.3, 0.4, 0.5 and 0.6 mg/l) with 1 mg/l BAP in MS media were tested as shoot proliferation media. MS medium with and without charcoal along with different combinations of IBA (0.5, 1.0, 1.5 and 2 mg/l) and 0.2 mg/l BAP were tested as rooting media. Time taken for rooting and length of the roots was recorded in weekly intervals.

Results revealed that 25% Clorox for 20 minutes exposure time was the best sterilisation procedure to obtain highest survival percentage of sugarcane auxiliary buds. 0.4 mg/l IBA and 1 mg/l BAP gave the highest proliferation rate (1: 10). Long hairy type roots were observed in media containing activated charcoal. The time taken for root induction was 2 weeks in MS medium with 1 mg/l IBA, 2 mg/l BAP and activated charcoal.

* priyanwada_sajee@yahoo.com

Tel: 041-2292200

206/B

**Characterisation of phytoplasma that cause phyllody in
Sesamum indicum L. (Sesame) by PCR-RFLP**

H A C K Ariyaratne^{1*}, E Jayamanna² and E H Karunanayake¹

¹ IBMBB, Cummarathunga Munidasa Mawatha, Colombo 3

² Coconut Research Institute, Lunuwilla

Sesame is cultivated in all agro-economic zones of Sri Lanka, particularly in the intermediate and dry zone. Sesame phyllody (SP) caused by phloem-limiting phytoplasma, is a common occurrence in all agro-economic zones where sesame is cultivated. Infected plants produce large number of leaves of reduced size; and short internodes resulting rosette-like branches. Flower buds produce vegetative parts and no flowering or fruiting occur in infected plants causing substantial loss of harvest. This paper communicates results of a preliminary investigation made towards characterisation of the causative phytoplasma strains of sesame phyllody (PS) by PCR-RFLP technique.

Plant samples, leaves and young twigs, were collected from farmer fields at Ampara. Total DNA was extracted following CTAB protocol. DNA quantity and Quality was estimated by 0.8% agarose gel electrophoresis and by the Genequant (Pharmacia Biotech). DNA obtained from phyllody sesame (PS); asymptomatic sesame (Non-PS) (negative control), and Japanese Hydrangea phyllody (JHP) (positive control) was subjected to PCR using the universal phytoplasma primer pair Pc399/P1694 (Skzeczowski,2001). PCR products were purified by ethanol precipitation and subsequently digested with a series of restriction enzymes in order to determine the restriction enzyme digestion profiles for the particular phytoplasma strain.

CTAB protocol yielded sufficient amount of high quality DNA; PS (200 ng μ l⁻¹, DNA / protein=1.76). Non-PS(200 ng μ l⁻¹, DNA / protein =1.84), and JHP (200 ng μ l⁻¹, DNA / protein =1.87). The primer pair P399 and Pc1694, amplified target DNA from all SP symptomatic samples as well as DNA from JHP. The PCR product appeared as a unique band around 1.2 kb on 1% agarose gel. However, the primer pair did not amplify DNA from asymptomatic sesame samples.

The restriction enzyme digestion profiles, of the PCR products show that both enzymes results the same profile for JHP while contrasting profiles for SP. Further, the enzymes EcoR I, and AluI distinguish SP uniquely; from JHP.

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* ckariyaratna@yahoo.com

Tel: 051-2222601

207/B

An investigation of induction of flowering in vanilla (*Vanilla fragrans*) using foliar fertilizer

Y M H B Yapabandara*, A M C I M Attanayake and H M R Hennayake
Research Station, Department of Export Agriculture, Matale

Vanilla is a tropical climbing orchid which belongs to the family Orchidaceae. *Vanilla fragrans* is by far the most economically important species as a source of natural vanillin. The major problem in vanilla cultivation in Sri Lanka is low yield due to unavailability of sufficient number of flowers for pollination even after adopting recommended cultural practices. Therefore, this study was undertaken to investigate the feasibility of enhancement of flowering and yield in vanilla by application of foliar fertilizers.

The experiment was conducted in Rambukkana using 6-8 year-old well-grown vanilla plantation established under coconut plantation. Well grown six vines with five loops were taken for a plot. These vines were looped on trellis and they were allowed to droop after 5-6 feet. Shade was reduced to receive 70-80% sunlight and vines were pruned by removing 4-5 nodes in January. Flowers were pollinated in April – May. Two different foliar fertilizers i.e., (a) NPK 20:20:20 (b) Foliar fertilizer NPK 13:27:27 were applied in 10 day intervals from January 2003 to end of 2005. Control vines were sprayed with water without fertilizer. All treatments were replicated 4 times and experimental design used was RCBD. Data were collected on number of flower clusters and number of pods developed. Pod length and pod weight were taken and recorded at the harvesting stage. Data on length and weight were analysed using ANOVA and LSD was used to compare the treatment differences. Data on counts (number of clusters and pods) were analysed using non-parametric method (Kruskal Wallis test).

Flowers initiated in March and pollinated in the same day of opening. Significant difference was found only in number of pods per plot in 2005. The number of pods was significantly higher in vines sprayed with fertilizer 13:27:27 (166.3 pods per plot). High phosphorous and potassium were known to be inducing flowering in plants. However similar trend was not observed in the data in 2005 due to interruption of the dry period in January-February. As a result, more vegetative buds were produced instead of flower buds in vanilla. Very poor vanilla production was reported in other areas in the country during the year 2005.

* sadrmt@slt.net.lk

Tel: 066-2222822

208/B

Correlation between Net Assimilation Rate (NAR) and crop yield of selected *Piper nigrum* .L (Black Pepper) selections/ varieties

H M P A Subasinghe*
Central Research Station, Department of Export Agriculture, Matale

Black Pepper (*Piper nigrum* .L) is a spice and root climber, mainly cultivating in wet and intermediate zones of Sri Lanka. Farmers cultivate local pepper types and an Indian introduction called Panniyur-1, but not the recommended local selections. The Dept of

Export Agriculture is about to release several high yielding black pepper selections in the very near future. Even though, the department has gone through different germplasm evaluation programmes at field level, such programmes at nursery level are minimum.

Therefore, this study was carried out to study the correlation between NAR and crop yields of selected black pepper selections/varieties and also to compare the growth parameters at the nursery level. Five different black pepper selections of Panniyur-1, GK-49, MB-12, MW-21 and MW-18 were selected for the study. Rooted stem cuttings were collected using bamboo rapid multiplication method and raised them in humid chambers to get plants by vegetative propagation.

NAR and crop yield of black pepper highly correlated with a R Square value of 0.5947. The results of this study suggest that the NAR can be used for germplasm evaluation of black pepper at nursery level. Panniyur-1 showed highest performances when compared with local pepper selections and GK-49 and MB-12 are better among the black pepper local selections

* suba630718@yahoo.com

Tel: 066-4460850

209/B

The effect of broiler litter combined potting media on growth and yield performances of spinach (*Basella alba* L.)

P E Kaliyadasa¹ and N S B M Atapattu^{2*}

¹ Department of Crop Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

² Department of Animal Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

An experiment was conducted to study the effect of three potting media and mixing of above media with broiler litter in three different ratios on the growth and yield performances of spinach (*Basella alba* L.). Three media (coir dust, sawdust, sand) were mixed with broiler litter in three different ratios (1:1,1:1.5,1:2). Broiler litter was heaped and covered with a polythene sheet for two weeks before used for the experiment. Each treatment combination had four replicates. Polythene bags (25×38cm) were filled with respective mixture of potting medium. One germinated seedling was planted in the bag.

The number of leaves per plant was taken in weekly interval. At the end of the seventh week, the total leaf area and fresh weight were measured. After first harvest, the plants

showed typical nitrogen deficiency symptoms of yellowing in ratoon crop. Data was analysed using Factorial Completely Randomized Design with SAS computer package.

The highest no of leaves per plant was observed in treatment of litter: sand in 1:1.5 whereas litter: coir dust in 1:1.5 gave the lowest. Results also revealed that, treatment of litter: sawdust in 1:1.5 recorded the highest fresh weight (241.2 g) and total leaf area (2689.2 cm²). Therefore it can be concluded that litter: sawdust in 1:1.5 mixture could be used as a potting medium for spinach but it supported only one successful harvest.

* mahindaatapattu1@yahoo.com

Tel : 041-2292200

210/B

A study on allelopathic effect of *Lantana camara* L. (Gandapana) on seed germination and cotyledon expansion of *Ludwigia decurrens* Walt. and *Ludwigia hyssopifolia* (G. Don) Exell (Wel Karabu)

T M S S De Silva* and S M W Ranwala

Department of Plant Science, Faculty of Science, University of Colombo, Colombo 3

Gandapana (*Lantana camara* L.) is an invasive shrub belonging to Family Verbenaceae. However, it is used as mulch in paddy fields. Allelopathic effect of *L. camara* on agricultural crops have been reported but its effects on weeds have been poorly investigated. The objective of the present study is to determine the effect of allelochemicals in a crude extract of *L. camara* on germination and cotyledon expansion of *L. decurrens* and *L. hyssopifolia* seeds.

Composite samples of mature leaves of *L. camara* were used to prepare an aqueous extract of 1:5 (w/v) by soaking ground leaves in distilled water for 7 days at 10 °C. A portion of this solution was diluted using distilled water and a 1:10 v/v extract was obtained. Half of each extract was boiled. All solutions were stored at 10 °C. Distilled water was used as the control. Mature seeds were obtained from *L. decurrens* and *L. hyssopifolia*, separately. The experiment was arranged in a completely randomized design with 20 replicates. Ten seeds of each weed species were placed separately on filter papers in separate petri plates which were moistened daily with *L. camara* extracts (boiled and unboiled) of different strengths given above. Germination was recorded and expansion of cotyledons of the seedlings was also observed for both species. Results were analysed separately for germination and cotyledon expansion of each species using a one way Analysis of Variance (ANOVA).

L. hyssopifolia was more sensitive to allelopathic effects of *L. camara* than *L. decurrens* since both the germination and cotyledon expansion of *L. hyssopifolia* were affected by the allelochemicals of *L. camara*. Among the high and low concentrations of *L. camara* extracts, the higher concentration of 1:5 w/v (boiled extract to a greater extent) was significantly found to be inhibitory for cotyledon expansion in both species affecting the seedling establishment of *L. decurrens* and *L. hyssopifolia* species

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* colombolady@yahoo.co.uk
(R)

Tel: 011-2715072

211/B

Differentiation of isolates of *Colletotrichum gloeosporioides* using RAPD

K L Wasantha Kumara*

Department of Agricultural Biology, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

Randomly amplified polymorphic DNA (RAPD) method was used to differentiate isolates of *Colletotrichum gloeosporioides* isolated from papaya grown in different parts of Southern India. DNA samples were initially amplified by twenty different random OPA primers, of which, 2 of them (OPA 3 and OPA 14) found informative and were used in amplifying individual DNA samples from eight isolates. Experiment was repeated to confirm the reproducibility of the amplified products obtained. OPA 3 and OPA 14 gave polymorphic PCR products from all isolates of *C. gloeosporioides*. There was a common band for all isolates when amplified with OPA 3 (1200 bp) and OPA 14 (965 bp). It is often assumed that DNA fragments of the same molecular size amplified in RAPD assays represent homologous sequences. Therefore, isolates with monomorphic banding pattern can be considered having similar genetic composition and may be specific to *Colletotrichum gloeosporioides* in this study. However, there was a greater variation observed among isolates according to band patterns, despite those two common bands. With OPA 3 primer, IIHR-1, AP-FP and CB isolates produced same band pattern while band patterns of AP-FB, NM-P and IIHR-0 isolates were similar. Both, HD-3 and NM-F isolates produced different types of band pattern. The RAPD fragments amplified with primer OPA 14 showed similar band pattern with CB and IIHR-0 isolates. There was a similarity observed among isolates of HD, IIHR-1 and NM-P. Isolates AP-FP, AP-FB and NM-F all differed in their band pattern among themselves and with others. According to the experiment, RAPD technique can be useful in differentiating isolates of *C. gloeosporioides* causing anthracnose disease of papaya.

* wasantha@agbio.ruh.ac.lk

Tel: 041-2292200

212/B

Screening of field crop varieties for the infection of *Cuscuta chinensis* Lam

K K S D Pradeepika*, M Rambukkana and D P P Jayakody
National Plant Quarantine Service, Katunayake

Thirty three varieties of nineteen field crops were screened for the infection of *Cuscuta chinensis* Lam. under net house conditions. Seeds were planted in clay pots filled with garden soil arranged randomly and replicated twice. Red onion (*Allium cepa*) var.

Vedalan and maize (*Zea mays*) var. Badra were used as the susceptible check and resistant check, respectively. *Daucus carota* (Carrot), *Brassica oleracea* (Cabbage), *Spinacia oleracea* (Spinach), *Cucumis sativus* (Cucumber), *Momordica charantia* (Bitter gourd: var.MC 43), *Trichosanthes cucumerina* (Snake gourd: var.MI Short), *Glycine max* (Soybean: var.Pb 1 and PM 13), *Vigna radiata* (Green gram: var.MI 5, Ari and MI 6), *Capsicum annum* (Green chilli: var. MI 1,MI 2, MI Hot, KA 2 and Arunalu), *Lycopersicon esculentum* (Tomato: var.Donna 091) and *Solanum melongena* (Brinjal: var. SM 164) were identified as susceptible crop varieties for the infection of *Cuscuta chinensis* . *Raphanus sativus* (Raddish: var. Big ball and Beeralu), *Arachis hypogoea* (Groundnut: var. Walava and Indi), *Abelmoschus esculentus* (Okra: var. Haritha and Sudu bandakka) were found to be resistant for the infection. However, the parasite grew and flowered on *Vigna unguiculata* (Cowpea: var. Dawala, Wijaya, MI 35 and Waruni) and *Vigna unguiculata*, sub sp. *Sesquipedalis* (Vegetable cowpea: var. Polon mae and AC 000555) showing different response for the infection. In this case, vine and haustoria died after few days indicating that they are tolerant for the infection. Thus, these resistant crop varieties for the infection of *Cuscuta chinensis* Lam. could be included in a crop rotation programme to manage this parasitic plant.

Tel: 011-2252028

213/B

Identification of causal organism of nutmeg leaf fall disease

M G Nirmala* and R S Kularathna
Research Station, Department of Export Agriculture, Matale

Nutmeg leaf fall disease is considered a serious disease and causes a considerable damage to the cultivation. Small brown color spots appear on the young leaves first. Then brown color spots spread from margins and the affected leaves fall from trees leaving the bear twigs on the tree, resulting low yield. After that small branches die and this condition spread top to bottom of the tree. Then large branches die and ultimately, after about five years whole tree will die. The experiment was carried out in the Central research station of the Department of Export Agriculture, Matale. To identify the causal organism of Nutmeg leaf fall disease, Humid chamber and culturing methods were used to isolate the causal organism. Two different media (i.e. Potato Dextrose Agar and nutrient Agar) were used for the culturing method. According to the results most frequently isolated fungus was *Colletotrichum* sp. Pathogenicity of *Colletotrichum* fungus was proved by the Koch's rules.

* ganganirmala@yahoo.com

Tel: 066-4460850

214/B

The influence of the herbicide propanil on soil microbial biomass carbon as affected by the rate of application

B C Walpola^{1*}, S D Wanniarachchi¹ and J A Liyanage²

¹*Department of Soil Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya*

²*Department of Chemistry, Faculty of Science, University of Kelaniya, Kelaniya*

The present paper focused on soil microbial biomass carbon as affected by the rate of application of propanil, a widely used herbicide. The experiment comprised three propanil treatments (i.e. 0.0224, 0.224, and 2.24 µg/g soil) with a control (without propanil). A Completely Randomized Design (CRD) was used with four replicates. Determination of soil microbial biomass carbon was carried out at 1, 3, 5, 7, 14, 21 and 35 days after herbicide application. Data were statistically analysed using SAS package.

Results showed that soil microbial biomass carbon decreased during the first 5 days of incubation with higher reductions at higher application rates of propanil. The highest reduction (76 %) of the soil microbial biomass carbon was observed at the application rate of 2.24 µg/g soil. Whereas the reductions were only 46 % and 9.7 % for the application rates of 0.224 µg/g soil and 0.0224 µg/g soil, respectively. After the initial reductions, it kept increasing the soil microbial biomass carbon continuously, suggesting that microorganisms may adapt to the applied herbicide quickly. Results could be concluded that as soil microfauna has affected only in first few days, careful application of propanil would not be harmful in the long term.

* buddhiwalpola@yahoo.com

Tel: 041-2292200

215/B

The effect of Kalanduru (*Kyllinga mallanosperma*) on the performance of milking buffalo cows

Sujatha Premaratne^{1*}, G G C Premalal² and M S S C H Thundeniya¹

¹*Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya*

²*Pasture and Fodder Division, Veterinary Research Institute, Gannoruwa*

Main objective of the present study was to find out the effect of feeding of Kaladuru on performance of milking buffalo cows. Nine lactating buffalo cows were selected and divided into three groups according to the body weight (394 ± 64kg). Animals within a block were allocated to three treatments namely; Kalanduru, Hybrid Napier grass variety CO-3 (*Pennisetum purpureum* x *Pennisetum americanum*) and whole vegetation cover (grass + legume + sedges + other shrubs). All animals were stall-fed *Adlibitum*. Each animal was fed with 3 kg of rice (*Oryza sativa*) bran and 50 g of mineral mixture along with the grass. Feed offered and refusals were measured every day for each animal for a period of 20 days. Live weight and milk production of animals were measured during the experimental period. Data were statistically analysed and means were separated using LSD.

Dry matter and ash content of Kaladuru (20.7% of DM and 12.7% Ash) was higher compared to CO-3 (17.4% DM and 12.1% Ash) or whole vegetation (18.5% DM and

14.8% Ash), but the crude protein content of Kalanduru (13%) was lower than that of whole vegetation (13.6%). No significant differences were observed between treatments for forage dry matter intake as well as for total dry matter intake. However, intake of whole vegetation (70 g/kg^{.75}/d) was somewhat higher compared to Kalanduru (65 g/kg^{.75}/d) or CO-3 (65 g/kg^{.75}/d). Dry matter intake of Kalanduru was similar to that of CO-3 indicating that Kalanduru can be used as palatable forage to feed cows. Feeding of CO-3 increased (P<0.05) the milk production (3750ml/d) of cows compared to other two feeds and, the lowest milk yield was recorded with Kalanduru (2500ml/d) (3000ml/d for whole vegetation). According to the results, Kalanduru is a palatable forage, which can be used for feeding of milking buffalo cows in southern part of Sri Lanka under waterlogged condition.

* suep@pdn.ac.lk

Tel: 081-2387179

216/B

The effect of three different organic wastes on the performance of Napier-Clone 13 (*Pennisetum purpureum*)

D Senaratna*, V L R Gamage and Thakshala Seresinhe
Department of Animal Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

The effect of poultry litter (PL), goat manure (GM) and spent tea leaves (STL) on bio-mass production and quality of *P.perpureum*-Clone 13 were investigated in a simulated field experiment (annual rain fall ± 2352 mm with fairly constant temperature of 28°C). Galvanised containers (0.28m²) filled with normal soil (150 kg) were amended either with PL, GM or STL at a rate of 50 kg N ha⁻¹. The amounts added/container were 34, 104 and 79 g for PL, GM and STL respectively. Two stem cuttings of Clone 13 were planted in each container two weeks after the soil amendment. Containers were placed in outdoor garden arranged in a randomized block design (3 x3) and shaded with a green net to simulate near-the-canopy environment (35% reduction of normal light -665 x10² Lux). Approximately four months after planting, an initial harvest was done at 10 cm height above ground level. Subsequent 3 harvests were done at 4 week intervals. Same quantity of PL, GM and STL was applied after each harvest.

Plants treated either with PL or STL out yielded (P<0.05) the plants treated with GM in respect of fresh and dry matter at each harvest. The mean cumulative dry matter yields were 138, 134 and 53 g plant⁻¹, respectively for plants treated with PL, STL and GM. In contrast, plants treated with GM had highest crude protein (CP) content in herbage (8.98%) followed by plants treated with STL (8.65%) and PL (8.13%) confirming that there was a dilution effect of nitrogen (N) due to increase in bio-mass yield. The mean cumulative CP yield was highest in plants treated with STL (12 g plant⁻¹) followed by plants treated with PL (11.24 g plant⁻¹). Plants grown in GM had lowest (P<0.05) cumulative CP yield of 5 g plant⁻¹. Although not significant, soil ash contents were rather high for all treatments while soil with STL had slightly higher N content than other two treatments. This may have affected positively on the growth of grass.

The results suggest that, the performance of clone 13 near the canopies could be easily boosted by adding poultry litter or spent tea leaves in order to enhance the use of

organic waste to protect the environment. However, the effect of goat manure on the performance of Clone 13 should be further investigated.

* dsenaratna@yahoo.com
Ext. 250

Tel: 041-2292200

217/B

Socio-economic aspects of dairy and goat farming in Rambukkana and Aranayake

Sujatha Premaratne*
Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya

A field survey was carried out to assess the socio economic aspects of dairy cattle and goat farming in Aranayake and Rambukkana Veterinary Service (VS) ranges. Forty farmers including 20 dairy and 20 goat farmers were selected and interviewed using a detailed questionnaire on family characteristics, socio economic status, livestock and crop production, labor distribution, monthly budget and income composition.

Majority of farm families in both VS ranges were Buddhist while only 40% of goat farmers in Aranayake VS range were Muslim. Almost all farmers were males except 10% dairy farmers were female in Aranayake VS range. Education level of all farmers in all VS ranges were less than the secondary education. According to data, 10% of dairy farmers in Rambukkana worked on fulltime basis however, none of the goat farmers in this area were fulltime. In contrast 30% of dairy farmers and 20 % of goat farmers in Aranayake range were fulltime farmers. Both dairy and goat Farmers in Rambukkana VS range were having more total land area compared with the farmers in Aranayake VS range. Almost all dairy animals in both ranges were crossbred animals of Friesian, Jersey and AMZ while majority of goats were crossbred animals of Sanan and Jamnapari. Most of the farmers in Rambukkana VS range offered concentrates and minerals to increase the milk yield whereas usage of concentrates among Aranayake dairy farmers was about 10 - 20 %. Income contribution from dairy sector in both Rambukkana and Aranayake VS ranges was less than that of goats in the same VS ranges. Income contribution to net annual income of households from dairy farming in Rambukkana VS range was higher (27.61%) as compared to Aranayake VS range (20.65%). Goat farmers in Rambukkana VS range were having more income (34.4%) from goat compared with that of goat farmers in Aranayake VS range (20.65%). According to the survey, it was found that average income % generated from goat farming was higher than that of dairy farmers in both Rambukkana and Aranayake VS ranges and, the values ranged from 20 to 30% out of the total income.

* suep@pdn.ac.lk

Tel: 081-2387179

218/B

Tikiya (*Eleocharis dulcis*) in water logged saline lands as a ruminant feed

G G C Premalal¹, Sujatha Premaratne^{2*} and H M S S C H Thundeniya²

¹ Pasture and Fodder Division, Veterinary Research Institute, Gannoruwa

² Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya

Tikiya is a non-conventional forage plant, which grows, in waterlogged saline lands in Sri Lanka. The main objective of the present study was to find out the effect of feeding of Tikiya on feed intake and milk production of buffaloes. Nine lactating buffalo cows were selected and divided into 3 blocks based on the body weight (409 ± 52 kg). Animals were fed with Tikiya or CO-3 (Hybrid of Pennisetum purpureum x Pennisetum americanum) or whole vegetation cover (grass+ Legume+ Sedges + other shrubs) with 3 kg of rice (*Oryza sativa*) bran and 50 g of mineral mixture per day. Stall feeding (*Adlibitum*) was practised. Feeding trial was conducted for 15 days. Feed intake and milk production of animals were measured daily. Data were statistically analysed and means were separated using LSD.

Dry matter content of Tikiya (27%) was much higher ($P < 0.05$) compared to CO-3 (17.4%) and whole vegetation (18.5%) however, crude protein content of Tikiya (9%) was much lower ($P < 0.05$) compared to CO-3 (12%) or whole vegetation (13.6%). Furthermore dry matter intake of Tikiya ($75 \text{ g/kg}^{0.75}/\text{d}$) was much higher ($P < 0.05$) compared to CO-3 ($65 \text{ g/kg}^{0.75}/\text{d}$) or whole vegetation ($65 \text{ g/kg}^{0.75}/\text{d}$). Milk production of buffalo cows consuming CO-3 (3750 ml/d) was higher compared to Tikiya (3050 ml/d) or whole vegetation (3000 ml/d) even though they were not significantly different from each other. This higher production in cows fed with CO-3 may be related with higher quality of that feed compared to other two diets. Therefore, Tikiya can be considered as palatable forage, which can be fed to buffaloes without affecting their milk production.

* suep@pdn.ac.lk

Tel: 081-2387179

219/B

Analytical observations on hygienic milk production in buffalo farms of Nilwala basin

S P P N Gayani, W W D A Gunawardena* and N M N K Narayana

Department of Animal Science, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

The objective of this study was to ascertain the conditions and management practices related to clean milk production and the variation of raw milk quality under the prevailing conditions of the buffalo farms of Nilwala basin. Thirty randomly selected farmers from four selected divisional secretariats were included in the survey (Forty-three milk samples from randomly selected individual animals and 30 bulk milk samples were analyzed). Survey data were collected using a pre-tested questionnaire. The study was focused on prevailing management practices including housing, surrounding of the milking place, and type of utensils used in milk collection etc. Raw milk samples were analyzed using standard procedures for Standard Plate Count (SPC) and Coliform Count (CC) to determine microbial aspects and to check the physico-chemical properties (pH and acidity). Keeping quality was also tested using Methylene Blue Dye Reduction

Test (MBDRT) for all the milk samples. Effect of mentioned management practices on the quality of milk were analyzed by using one-way ANOVA and t-test from JMP IN version 3.26 of SAS system.

Standard Plate Count (SPC) of milk produced by cows reared by the farmers who have completed only primary education showed a higher value (2.7×10^6 cfu ml⁻¹) compared to the farmers with higher education (1.3×10^6 cfu ml⁻¹). The SPC was higher (2.36×10^6 cfu ml⁻¹) when plastic utensils were used as compared with aluminum containers (2×10^6 cfu ml⁻¹). Samples drawn from unclean animals showed a higher SPC (2.95×10^6 cfu ml⁻¹) than from clean animals (1.3×10^6 cfu ml⁻¹). The SPC of the individual samples varied from 1.09×10^6 cfu ml⁻¹ to 3.33×10^6 cfu ml⁻¹. In bulk samples it was from 2.92×10^6 cfu ml⁻¹ to 5.38×10^6 cfu ml⁻¹. The Coli form Count (CC) of individual milk samples varied from 2.8×10^4 cfu ml⁻¹ to 4.9×10^4 cfu ml⁻¹. In bulk milk, CC varied from 3×10^4 cfu ml⁻¹ to 5.1×10^4 cfu ml⁻¹. The range of tritratable acidity of milk varied from 0.16 % to 0.35 % and from 0.19 % and 0.39 % in individual animals and in bulk milk samples, respectively. The pH values of individual and bulk samples varied from 6.46 to 6.68 and 6.45 to 6.64 respectively. From bulk milk samples, 46.6 % reduced its color within 2 hrs and none of the individual samples reduced its color within 2 hrs in MBDRT so keeping quality of bulk and individual milk samples can be graded as fair and good respectively. CC of the individual and bulk samples are higher than the standard values.

Tel: 041-2292200

220/B

Performance of rabbits as affected by type and form of grass

Sujatha Premaratne^{1*}, G G C Premalal² and H M S S C H Thundeniya¹

¹Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya

² Pasture and Fodder Division, Veterinary Research Institute, Gannoruwa

Rabbit meat is high in protein and low in fat and rabbit can be successfully raised on diets that are low in grain and high in roughage. Therefore, the main objective of this experiment was to investigate the effect of type and form of grass on the performance of growing (7 wks \pm 6 d) rabbits. Twenty rabbits were selected (600 g \pm 250g) and housed in individual wire net cages. It was a Randomised Complete Block Design (RCBD) with four treatments and five replicates. Diets consisted of fresh grass or hay. Grass species used were CO-3 (*Pennisetum perpurium* x *Pennisetum americanum*) or signal grass (*Brachiaria brizantha*) as fresh or in the form of hay (2 grasses x 2 forms = 4 treatments). In addition to forage or hay, each rabbit was fed with 50 g of broiler finisher. The trial was consisted of an adaptation period of one week, followed by three days preliminary period and 28 days collection period. Initial body weight of each rabbit was recorded at the beginning and once per week, there after. Feed offered, refusals and faeces output were recorded daily and sub samples were taken for dry matter determination and for chemical analysis. Dry matter intake, weight gain, dry matter digestibility and feed conversion ratio was calculated using the above data. Data was statistically analysed using the SAS computer package. Means were separated using LSD test.

No significant differences were observed between four treatments for any of the parameters studied. However, intake of fresh grass (68 and 69 g/head/day for CO-3 and Brachiaria respectively) was always higher compared to any type of hay (64 and 66 g/head/day for CO-3 and Brachiaria respectively). Weight gain of rabbits and dry matter digestibility were much higher with fresh grass (weight gain of 132 and 140 g/week and, digestibility of 70 and 73% for CO-3 and Brachiaria respectively) compared to hay (weight gain of 123 and 116 g/week and, digestibility of 73 and 69% for CO-3 and Brachiaria respectively) diets. Total cost of production per kg of live weight was low with Brachiaria fresh grass (130 Rs/kg) compared to other treatments (136, 191 and 190 for CO-3 fresh, CO-3 hay and Brachiaria hay respectively).

* suep@pdn.ac.lk

Tel: 081-2387179

221/B

The importance of dairy industry for economic growth and associated socio economic aspects

D N A Gunasekara^{1*}, K Perera² and M Wijerathna¹

¹ Faculty of Agriculture, University of Ruhuna, Kamburupitiy

² Faculty of Agriculture, University of Peradeniya, Peradeniya

This study was conducted to investigate the status of the milk marketing network, its impact on socio economic condition of the dairy farmers and identifying the exiting constraints for dairying in the *Kandy* district. A total of 90 farmers representing different channels (A; n=49; B₁, n=20; B₂, n=10, C, n=6, and D, n=5) were selected for the study. Data were collected through a field survey of farmers, from different channels in the milk marketing network and data were analysed using simple descriptive statistics.

There are well established formal and informal milk marketing channels in *Kandy* district. The majority (94.4%) of the farmers used formal channel, which is dominated by either semi government organisation (A) which had FMSs, commercial private organisations (B₁, B₂), and independent private collectors (C), who collect milk and sell it to consumers. Very few (5.6%) farmers used informal marketing channel (D). Enterprise A collects 54.81% of total milk collection of the district while B₁ collects 21.6%. When purchasing milk, both A and B₁ consider the fat percentage and solid non fat (SNF) content. The majority of the farmers used Jersey cattle (60%) and Friesian cattle (56.7%) for dairy purpose. All farmers artificially inseminated the cows. The majority (61%) used cut and carry system of feeding and concentrate feeding. Mean herd size was 3.95±2.94 with 1.83±1.22 milking cows. Mean milk yield was 11.28±7 L/herd/day. 54% of farmers used fresh milk produced for house hold consumption. Feed supply became scarce during the dry season (March, April). Dung was used as manure by 25.6% of farmers, while 35.58% of farmers sold manure at Rs. 30/= /bag. Family labour (mean no. 1.5±0.48 / family) was used for dairy activities by all farms. Approximately 28% farmers were members of FMS (farmer management societies), while 39% supplied to two major collectors B₁ and B₂. Farmers complained about feed scarcity during dry season (51%), inadequate lands for grazing (71%), Inadequate supporting services, Problems regarding with AI (42%), Inaccurate milk testing and low milk yield Income from dairying and price fetched by milk were not different among farmers supplying to formal channels whereas these sell through informal channel D received highest price

(Rs.33/= /L). Those selling through channel C, private collectors received lowest price (Rs.19/=/L). Profits of dairying were positively related to the number of total animals ($r = 0.514$; $p < 0.05$), and number of milking animals ($r = 0.6861$; $p < 0.05$) in the herd. Approximate monthly variable cost/ animal was about Rs. 901, of which the feed cost was about Rs. 1305/=, and medical cost was Rs. 146/=. Mean monthly profit was estimated to be about Rs. 952.7 / milking animal (including costs for labor and forages). The cost of risk was not included in these estimates. The total fixed cost per animal was about Rs. 71000/=, and at least 9.5 years are needed to recover this cost by using one animal. Therefore, in *Kandy* district the potential of new comers to take up dairy industry without subsidies is low, despite the presence of a well distributed marketing network.

* dnagunasekara79@yahoo.com

Tel: 011-2901443 (R)

222/B

Computer software for evaluation of farm animals – Swine Breeder

V L R Gamage¹, Asoka Gunawardane^{1*}, Nimal Hettiarachchi² and Gamini Senanayake³

¹ *Department of Animal Science, Faculty of Agriculture, University of Ruhun, Kamburupitiya*

² *University of Ruhuna, Matara*

³ *Department of Biology, Faculty of Agriculture, University of Ruhun, Kamburupitiya*

Livestock industry plays a significant role in the Agricultural sector in Sri Lanka. A major constraint to the livestock production is lack of proper evaluation systems to ascertain the suitability of the breeding and management practices. This attributed to lack of proper record keeping system. The new information technology can be efficiently used to improve the farm evaluation systems provided suitable software for the local situation is developed.

This project was aimed at designing and construction of computer software package with the main objectives being the development of an information system to supply the management practices of swine and simulation of the breeding practices. The data were collected from Welisara and Horakele farms of the National Livestock Development Board (NLDB).

Data was analysed and a statistical model was developed in half sibs under R-square = 87.4% accuracy. That model gives average body weight gain in F1 generation. Accuracy of the model can be increased using the pedigree details of the animal further. The software was developed with the use of Microsoft Access as a relational database, Structured Query Language Statements and the Visual Basic Programming Language.

The developed system contains emanation features such as menu bars, shortcut keys, tool bars and tool tips for data inserting, editing, finding and deleting. Preventing the data duplication, help function is also available. Furthermore the software provides multiple user interfaces. Several types of records such as animal welfare, feeding, matting, farrowing, litter, location changing and management practices can be handled by this software. Automatically find the scheduled task such as rooting practices, weight measuring, ear notching, castration, tooth clipping and so on.

The present software can be used to identify the problem breeders from other healthy animals. The developed statistical model incorporated into this package helps the farmer to choose the elite Sow and given the pedigree information about the selected Sow/s. Pedigree of the simulated heard and animal location changing with the activity.

The developed system has been evaluated by using data received from NLDB for checking the validity and the accuracy of the statistical model. The package further can be developed as web base information system.

Tel: 041-2292200

223/B

Water intake of broiler chicken as affected by dietary microbial phytase

N S B M Atapattu^{*} and V L G Gamage

*Department of Animal Science, Faculty of Agriculture, University of Ruhuna,
Kamburupitiya*

Water can reasonably be regarded as an essential nutrient for poultry though the precise requirements have not been set. Apart from environmental factors, several dietary factors such as the level of dietary protein, minerals, crude fibre, physical form and the pH influence the water intake. In order to increase the availability of dietary minerals, particularly of phosphorus, and amino acids, many commercial poultry diets are now supplemented with microbial phytase. The objective of the present study was to determine the effects of dietary microbial phytase on water consumption of broiler chicken. A 2*3 completely randomised design experiment was conducted. 21-days old broiler chicks (n=120) were allocated into six deep litter pens so that between cage weight variation is minimum. Birds in three pens were fed with control diet (without phytase) while the birds in other three pens were fed with a diet containing 1000 units of phytase (Natuphos)/kg diet. Diets were formulated to meet the NRC (1994) standards. Each pen had a feeder and a drinker. Feeding and watering was done twice a day. Feed and water were provided ad lib. Birds were weighed on day 34 and found no significant weight difference between treatments. Daily feed and water intakes were measured for five days from day 35-39. In general the growth performances were inferior. This may mainly be due to high dietary rice bran (RB) level (40%) used. Phytase supplementation did not change the weight on day 40 and the feed intake during day 35 and 39. Intake of water/day/bird was not significantly different between the treatments but was numerically higher in phytase given birds. Water:feed ratio was higher (p=0.08).for the birds given phytase supplemented diets compared to control. The water:feed ratio of the control diet fed birds was within the normal water:feed ratio. Contrary, the water:feed ratio of birds given phytase supplemented diets was higher than the normal values reported for broilers in literature. Interestingly, the intake of water per unit of live weight was also higher significantly (p<0.01) when diet was supplemented with microbial phytase. The reason as to why and how dietary phytase increased the water intake per unit body weight and water:feed ratio are not clear, but may be related to the increased phytate hydrolysis due to phytase.

^{*} mahindaatapattu1@yahoo.com

Tel: 041-2292200

224/B

The effects of dietary rice bran level on the quality and quantity of broiler litter

N S B M Atapattu*, C J Gajaweera, G A Chandana and S S Paththinige
*Department of Animal Science, Faculty of Agriculture, University of Ruhuna,
Kamburupitiya*

A completely randomised design experiment was conducted to determine as to how the quality and quantity of broiler litter are affected by different diets. Day old broiler chicks (n=300) were randomly allocated in to 12 pens. Birds were raised on paddy husk based litter from day 1 to 42 and fed one of the following diets: 1) starter and finisher diet with 25% rice bran (RB), 2). starter and finisher diet with 35% RB, 3). starter and finisher diet with 45% RB and 4).a commercial diets (starter and finisher). Starter diets were given from day 1-21 and the finisher diets thereafter. Three litter samples were taken from each pen at weekly intervals. Litter moisture %, ash %, N %, and bulk density were measured weekly and the total litter production was measured on day 42. Litter N % was not significantly affected by the dietary types but varied from 1.6 – 2.5 %. Birds fed commercial diets produced litters with lowest N percentage possibly, due to higher protein digestibility. The litter moisture and ash contents were also not affected by dietary treatments. Over the six week period, both litter moisture and ash content increased in all groups. The litter bulk density was also increased over the time. On day 42, the bulk density of the litter of the birds fed commercial diets was significantly lower than those on other treatments. Lower dry matter content in faeces arising from better digestibility of the commercial diet may be the reason for lower bulk density. The litter production (on fresh weight) per unit of live weight ranged from 0.89-1.1 kg. Litter production both on dry and fresh weight basis, per unit of live weight was significantly higher in birds fed 25% RB based diets. It is concluded that every Kg of broiler live weight production gives rise to one kg of paddy husk based litter and on farm-mixed mash form broiler diet results in higher litter N levels than commercial diets.

* mahindaatapattu1@yahoo.com

Tel: 041-2292200

225/B

Development of a rice cake with Kurakkan flour as a value added rice based product

V Wijerathne*, A A M Subodinee and E H Dammalage
*Department of Food Science & Technology, Faculty of Agriculture, University of Ruhuna,
Kamburupitiya*

The demand for the development of rice-based products has increased tremendously over the recent parts. At present, to increase the consumption of rice flour instead of wheat flour, priority has been given to develop value added rice based products in bakery industry.

In this study, it was attempted to produce rice based kurakkan cake by increasing the amount of kurakkan flour instead of rice flour and to examine the sensory properties of the prepared cakes.

Three cake mixtures were prepared by substituting rice flour with 5%, 10% & 15% kurakkan flour. As in normal cake preparation, cream margarine (250g) with sugar (200g) until soft. Then eggs (4) were added one at a time to the mixture and continued beating. Three rice flour samples sifted 7 times and substituted with kurakkan flour (5%, 10% & 15%) to reach a final weight of 250g. Flour mixtures were then sifted once again with baking powder (5g), added in to the egg mixtures. Finally a few drops of vanilla and mixed thoroughly. Prepared cake mixtures were baked in a moderate oven at 190°C for 40 minutes. Sensory evaluation was conducted for prepared cakes by a panel of 11 members using five-point hedonic scale.

The sensory data were obtained and analysed using Kruskal-Wallis rank sum test. Data illustrate that there were no significant differences among the three samples (5%, 10% & 15%) with respect to taste, odor and overall acceptability. When considering the colour and texture, sample which contained 5% kurakkan flour was preferred than the other two samples by most of the panelists.

Development of rice cake by adding kurakkan flour up to 15% was in an acceptable level. It indicates, that further improvements could be done to the rice based kurakkan cake in near future.

Tel: 041-2292200

226/B

Performance of salad cucumber (*Cucumis sativus*) in a newly formulated hydroponics nutrient solution in two different growing media under protected house conditions

W G S P Kumari¹, K D N Weerasinghe¹, Janitha A Liyanage^{2*} and Indumini S Kariyawasam¹

¹ Department of Agric. Engineering, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

² Department of Chemistry, University of Kelaniya, Kelaniya

Hydroponics is the growing of higher plants with their roots in a dilute nutrient solution. The major advantage of hydroponics is it permits control supply of all mineral elements. The basic principle behind the process is that of growing plants with their roots in contact with a solution containing all the essential plant nutrients in amount needed for optimum plant growth.

This study was conducted under protected house conditions at the Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, during July-December 2005 to assess the performance of salad cucumber (*Cucumis sativus*; Var. Cansas) in a newly formulated hydroponics nutrient solution compared to commercially available Albert's solution in two different growing media (coir dust and sand).

During the experimental period, environmental data (air temperature, light intensity, relative humidity) inside the protected house, growth parameters of plants and data relevant to the consumption of nutrient solutions were recorded. Temperatures inside the protected house during the research period ranged between 27-35 °C. Light intensity varied between 8,800-64,800 lux and relative humidity remained between 58%-87%.

Fresh yields of 4611.25, 3977.50, 3400.00 and 3065.00 g/ plant obtained with Coir dust medium/Albert's solution, Coir dust medium/New solution, Sand medium/Albert's solution and Sand medium/New solution respectively. The nutrient solutions show no significant difference between each other in respect to total yield. Growing media show a significant difference while coir dust medium has a higher yield compared to sand medium. The yield of cucumber is reduced by 24.73 % when it is grown in sand medium compared to coir dust medium.

The sugar content, dry matter, vitamin C, moisture and calcium content of the fruits had no significant difference in two solutions and were in accordance with the values reported for cucumber. However, in the case of growing media, coir dust medium does not differ significantly from sand medium in respect to all nutritional parameters except dry matter and moisture content of the fruit.

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* janitha@kln.ac.lk

Tel: 011-2914486

227/B

Development and characterisation of Hydroponics medium for salad cucumber

Janitha A Liyanage^{1*}, Dilru R Ratnaweera¹ and K D N Weerasinghe²

¹ Department of Chemistry, University of Kelaniya, Kelaniya

² Department of Agriculture Engineering, Faculty of Agriculture, University of Ruhuna, Kamburupitiya

Growing of plants with their roots in solutions of a mixture of mineral salts instead of in soil, hydroponics, has led to a vastly increased understanding of plant nutrition. The future of hydroponics will greatly depend on the development of systems of production and nutrient formulations that are competitive in cost. A nutritionally balanced, cost-effective formulation having all necessary ingredients would have the capability of increasing yields under suitable production systems. In Sri Lanka, it is a national requirement to formulate and test hydroponics nutrient mixtures, since the commonly available formulations in the market are expensive, have precipitation problems with pH variations during the crop cycle, not crop-specific and also the formulation is not revealed. Among the number of crops, which are grown under hydroponics, the rapid growth and high productivity make cucumbers an excellent choice for a hydroponics garden.

A hydroponics mixture, which contains the nutrients requirement for salad cucumber was developed using low cost, available chemicals and the formulation was characterised using computer aided chemical speciation programs. The new medium was developed

to supply required chemical species in correct concentrations for salad cucumber in the medium at the pH range 5 – 6. Modeling was done to find out the optimum amounts of compounds that can be added to the solutions to avoid precipitation due pH change during the crop cycle. A chelating agent was to be added to the solution to resemble the bulky groups like humic acids in soil to provide a controlled supply of nutrients to the plant.

It was resulted that the best chelating agent that can be added to the hydroponics solution is EDTA. Within the optimum pH range for salad cucumber all the metals are in the solution as either in free form or complexed with EDTA and they are readily available for the plant. All the nutrients are in completely soluble form in the entire pH range that is needed for the plant and the results obtained from the field trials using this nutrient mixture shows that this formulation can be used as a low cost hydroponics mixture for salad cucumber.

Financial assistance from CARP is acknowledged.

* janitha@kln.ac.lk

Tel: 011-2914486

228/B

Comparative assessment of soil moisture depletion pattern of forest species *Alstonia macrophyla* compared to bare soil

K D N Weerasinghe and K P C K Kumara*
Faculty of Agriculture, University of Ruhuna, Kamburupitiya

The present research was carried out in a long term experimental plot established in the Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, in May 2001. Soil moisture extraction by *Alstonia* plantlets compared to bare soil and the root development pattern of *Alstonia* were studied during May-October 2001. Dielectric capacitance method using Diviner 2000 was used to assess the moisture depletion pattern of the soils.

The soil in the experimental site was clay; bulk density of the soil varied from 1.36 to 1.53 g/ cm³ with maximum values at 40-60 cm depth. The silt content of the soil had a considerable increment (from average of about 15% to 30%) beyond 70 cm depth. A distinct hard laterite layer was observed at 50 - 60 cm depth.

Results revealed that Dielectric capacitance method using Diviner 2000 as a reliable and easy method to assess in situ soil moisture monitoring in field experimental plots.

Throughout the period of research, soil moisture levels in the *Alstonia* plots were comparatively low. During this period 9.55mm of additional moisture was extracted by *Alstonia* plantlets from 60 cm depth profile compare to bare soil. The highest moisture extraction was observed at the depth of 10 – 20 cm and 20- 30 cm depth. Furthermore, high moisture recharge was observed in *Alstonia* plots after the rains. *Alstonia* root system may have promoted the moisture penetration to the soil profile after the rain.

Observation made at the vertical and lateral distribution of roots after 6 months of establishment indicated that the depth and lateral distribution of the root zone of *Alstonia* as 57 cm and 46 cm respectively. It was also noted that more than 85% of roots are

concentrated in the top 30 cm depth level and maximum root density lies at 20-30 cm depth layer.

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* cinrs@sltnet.lk

Tel: 041-5673931

229/B

Extraction of pectin from nutmeg (*Myristica fragrans* Houtt.) rind and determination of pectin content with the maturity of the fruit

M V Gamlathge, S P Premathilake*, P D liyanage and I K Indrasena
Research Station, Department of Export Agriculture, Matale

Nutmeg tree (*Myristica fragrans* Houtt.) is unique among the spice plants as it produces two separate and distinct products namely, the seed or kernel and mace. But this edible part represents only 30% and the rest 70% of fruit is represented by the pericarp or rind, which is discarded during processing of nutmeg.

Pectin is a natural substance which is present in a great many vegetable foodstuffs, e.g. fruits and vegetables. It is a component of a great variety of products in the food industry, where it is used in the production of jams, confectionery articles, baked and diary products etc.

Nutmeg fruits were selected and plucked in terms of monthly maturity level commencing from one month up to six months. 100 g of rind were taken with three replicates from each maturity and pectin was extracted by boiling in water for 30 min. The extract was filtered through a muslin cloth followed by filtration through Whatman no. 4 filter paper. The pectin was then precipitated as a gel from the resultant extract by adding 95% ethyl alcohol in 1:2 proportion. The pectin gel is then filtered and weighed after drying in an oven at 45 °C. The average value of pectin percentage was determined with the maturity status of nutmeg fruit.

Table 1: Percentage Pectin content with the maturity status of nutmeg fruit

Maturity status	1 month	2 months	3 months	4 months	5 months	6 months
% pectin content	0.17	0.23	0.23	0.33	0.39	0.43

The results indicate that 1 month old fruit contain very low amount of pectin and with the increment of maturity level pectin content is also increased. 6 months old fruit contains considerable amount of pectin. Therefore, the nutmeg rind thrown away can be used as a valuable raw material in production of pectin.

* sadrmt@sltnet.lk

Tel: 066-2222822

230/B

Changes in fat and fatty acid content of soybean (*Glycine max*) seeds during germination

S Vasantharuba*

Department of Agric Chemistry, Faculty of Agriculture, University of Jaffna, Jaffna

Soybean (*Glycine max*) has been considered an important world crop because it contains about 20 % fat with a high proportion of essential fatty acids such as linoleic and linolenic acids. Several studies have demonstrated that dietary essential fatty acids have many health benefits. The main objective of this experiment is to examine the changes in essential fatty acids (linoleic and linolenic acid) contents with increasing duration of germination time. Changes in fat % and other fatty acid contents with time were also observed. Fat and major fatty acids (like palmitic, stearic, oleic, linoleic and linolenic acid) contents of the germinated soybean seed samples and ungerminated sample of variety Pb-1 were determined along with germination period. (24, 48 and 72 hours) Fat and fatty acid were extracted by Soxhlet method and fatty acids were estimated by Gas Chromatographic (GC) method.

Fat content of variety Pb-1 seeds progressively and significantly decreased with increasing duration of germination time (24, 48 and 72 hours) when compared to ungerminated seeds. The percentage loss of fat in seeds after 72 hours of germination is 8%. Soybean seeds germinated for 48 hours had the highest amount of palmitic acid (14.3%) compared to others. Stearic acid content increased in seeds germinated for 24 hours (4.3%) when compared to control and then declined. When compared to ungerminated seeds (27.2%) oleic acid content, declined during germination. The essential fatty acid content of the germinated soybean seeds increased with germination time and the highest linoleic (53.6%) and linolenic acid (9.3%) content were observed after 72 hours of germination. The percentage increase of linoleic and linolenic acid contents in seeds after 72 hours of germination when compared to control is 6 and 40 % respectively.

SECTION D

231/D

Testing the antibacterial activity of *Curcuma longa*

N Ravimannan^{1*} and N Lohini²

¹ *Department of Botany, University of Jaffna, Thirunelvely, Jaffna*

² *Department of Botany, The Open University of Sri Lanka, Nawala, Nugegoda*

The use of plant parts for different health purposes is common in the world. Growth of microorganisms may be inhibited by the antimicrobial activity of plant extracts. Herbal medicine has been traditionally used by many communities as a source of maintaining good health as well as treatment for various illnesses.

Various sesquiterpenes and curcuminoids have been isolated from the rhizome of *Curcuma longa*. These contribute to a wide array of biological activities including antibacterial activity.

For the experimental studies on antibacterial activity, common food borne pathogenic bacteria namely Gram-positive (*Staphylococcus aureus*, *Bacillus*) and Gram-negative (*E.coli*, *Klebsiella* sp, *Proteus* sp) were used. Various extracts such as fresh rhizome extract, steam distilled extract (fraction I), chloroform extract (fraction II), methanol extract (fraction III) and water extract (fraction IV) were tested for antibacterial activity by well method. The concentration of each fraction used was 2mg/ml. The antibiotics gentamycin and ampicillin were used as positive controls and the activity was calculated for each fraction.

Experimental design was a Completely Randomised Design (CRD) and data were analysed by Least Significant Difference (LSD) at P=0.05 level. There is significant difference (P<0.05) in the antibacterial effects of fresh rhizome extract and the fractions. The fresh rhizome extract and fraction III inhibited all the tested bacteria. The fraction I did not have any inhibitory activity against the selected bacteria. The fraction II showed inhibitory activity in the range of 31-45% against *Staphylococcus aureus*, *Klebsiella* and *Proteus*. Of all, the fraction III showed highest inhibitory activity (78%) on *Staphylococcus aureus*. Further studies on the suitable concentrations of the extracts would help upgrade the manufacturing process to develop quality and to maintain standards in the preparation of natural drugs from *Curcuma longa* for food-borne diseases.

* botany@jfn.ac.lk

Tel: 021-2229645

232/D

The effect of ethrel and some other chemicals on vase life of flowers

M G P Mahagamasekera^{1&2*} and N A A D K Hirantha¹

¹ Department of Botany, University of Sri Jayewardenepura, Gangodawila, Nugegoda

Thirty five flowers belonging to different families collected from the Rattanapitiya area were used to study the effect of ethrel (an ethylene releasing agent) on their vase life. This was done by dipping stem ends bearing flowers in 480 mg/ L ethrel solution continuously or for 30 min and then transferring to distilled water. When ethrel hastened the symptoms of senescence, the effect was compared with the controls (distilled water) and expressed as a percentage reduction of vase life or a percentage stimulation of abscission. The percentages were then grouped in to 5 classes as follows: class 0: no response (not sensitive); class 1: up to 33% effect (low sensitivity); class 2: 33%-66% effect (intermediate sensitivity); class 3: 66%-99% effect (high sensitivity); class 4: immediate dramatic response (very high sensitivity). Of the 35 species (spp.) tested, there were 13, 3, 10, 5 and 0 number of flowers falling in to classes 0,1,2,3 and 4 respectively. All these flowers showed wilting or abscission as the initial symptom of senescence.

Of the 35 spp., 20 were treated with 15.8 g/ L Potassium permanganate (KMnO₄) either continuously or for 30 min and then transferred to distilled water. This treatment had extended the vase lives of *Mussaenda frondosa* (Ethrel sensitivity class 0) and *Hibiscus rosa-sinensis* (Ethrel sensitivity class 1) by 20% and 5% respectively. KMnO₄ treatment reduced the vase life of 11 spp while it had no effect on flowers of 5 spp.

Flowers of some selected spp. were treated with 100 or 300 mg/ L sucrose, glucose and fructose solutions continuously or for 30 min and transferred to distilled water. All sugar treatments reduced the vase life of *Thunbergia grandiflora* while fructose treatments reduced the vase life of *Osbekia octandra*. The sugar treatments used in this study did not alter the vase life of other tested spp.

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Present Address:

² Department of Plant and Microbial Sciences, University of Canterbury, Christchurch, New Zealand

* mgm46@sjp.ac.lk

233/D

Preliminary investigations on the seasonal dynamics of algicidal bacteria and protozoa on regulation of *Microcystis aeruginosa*

M M Pathmalal* and M U S N Premetilake

Department of Zoology, University of Sri Jayewardenepura, Gangodawila, Nugegoda

Seasonal variations of algicidal bacteria and protozoa on regulation of *Microcystis aeruginosa* in Beira Lake was studied, from July 2005 to February 2006. During August to mid-October, the cell density of *M. aeruginosa* reached to the maximum (3.0×10^6 cells ml⁻¹) recording low density of algicidal bacteria ($2.1-1.28 \times 10^2$ PFU ml⁻¹) and protozoa (30 PFU ml⁻¹). Thereafter, algicidal protozoa were tended to increase towards late October, reaching the maximum of 60 PFU ml⁻¹ while decreasing the cell density of *M. aeruginosa* and algicidal bacteria. In contrast algicidal protozoa density was decreased to 20 PFU ml⁻¹ during January when the cell density of algicidal bacteria was increased up to 2.3×10^2 PFU ml⁻¹ following the decrease of *M. aeruginosa* cell density to the lowest (1.3×10^5 cells ml⁻¹). The results show that the reduction of protozoan predatory pressure on algicidal bacteria enhance the bacteria infectivity on *M. aeruginosa* which temporary regulate the abundance of *M. aeruginosa* density. In the laboratory experiments, it was observed that the significant decline of cell density *M. aeruginosa* (PCC 7820) when the culture of isolated algicidal agents was inoculated. Based on morphological and chemical characters, three algicidal bacteria strains and one algicidal protozoa species were isolated from clear plaques on *M. aeruginosa* algal lawn and the agents were tentatively identified as *Pseudomonas sp.* and *Amoeba radiosa* respectively. The algicidal mechanism of isolated bacteria showed that infection on *M. aeruginosa* was by direct contact and not by extracellular inhibitors.

Thus, the results obtained from field and the laboratory studies signify that the *M. aeruginosa* population is alternatively regulated by algicidal bacteria and protozoa and these agents play an important role in regulating *M. aeruginosa* in the freshwater environments.

* path@sjp.ac.lk

Tel: 011-2804515

234/D

**The study of duration of effectiveness of neem seed oil against
Callosobruchus chinensis (Coleoptera:Bruchidae) on green gram seeds**

Nithiyagowry Ratnasabapathy*
Department of Zoology, University of Jaffna, Jaffna

Green gram is a protein rich source on which the major pest *Callosobruchus chinensis* cause severe damage. Neem seed oil at 2-5 ml/kg was found to be a good protectant of green gram seeds against *C. chinensis*.

To determine the duration of effectiveness of neem seed oil on green gram seeds against *C. chinensis* on the basis of oviposition and adult emergence, infestation free green gram seeds mixed with neem seed oil (5 ml/kg) and stored for different periods before mated adults were introduced. One batch of untreated seeds was served as control. The results were analysed by using ANOVA, T-test, and Duncan's Multiple Range Test (DMRT).

It was found that significantly lesser ($P < 0.05$) mean number of eggs were laid on green gram seeds treated with neem oil three months before storage than on untreated seeds, whereas after six months of treatment there was no significant difference ($P > 0.05$) in number of eggs laid on treated seeds and untreated seeds and also between seeds those treated three months and six months before storage. From DMRT analysis treated seeds stored for three months and six months shows equal effect on number of eggs laid and greater number of eggs laid than on one months stored seeds.

Although there was no significant differences in number of eggs laid on seeds treated with neem oil before six months of storage, significantly lesser number of adults were emerged ($P < 0.001$) compared with the untreated seeds and 50 % ,77 % of the adult emergence was observed in those treated with three months and six months before storage respectively, therefore 5 ml neem seed oil / kg of green gram seeds gave good protection for up to three months against *C. chinensis* by reducing oviposition and emergence of adults.

* rngowry@yahoo.com

Tel: 021-2225925

235/D

Social grooming in chimpanzees (*Pan troglodytes*)

W S P Y N Kanthilatha^{1*} and M M Pathmalal²

^{1*}*Department of Sociology & Anthropology, University of Sri Jayewardenepura, Gangodawila, Nugegoda*

²*Department of Zoology, University of Sri Jayewardenepura, Gangodawila, Nugegoda*

One of the most frequent natural social activities is grooming. Almost all primates groom one another. Grooming occurs in other species but social grooming is a unique primate activity and plays an important role in the life of most primates.

The present study was carried out at the National Zoological Gardens, Dehiwala and the sample consisted of troop of seven chimpanzees (3 males and 4 females) living in captive conditions. Data were collected using focal animal sampling method. In accordance with social bonding, females, as the long-term residents of this matrifocal group, groomed each other and juveniles more often than males groomed one another or juveniles. On the other hand, males groomed females (mean duration 5.20min) more often and for longer durations than females groomed males (mean duration 4.85min) and, whereas both males and females groomed juveniles (mean duration 1.29min, 5.86min) more often than juveniles groomed them (mean duration 1.31min, 4.30min), juveniles groomed their elders for longer durations. Although both sexes groomed subordinate females more than vice versa, males groomed dominant males more than females groomed subordinate males more than they receive grooming from them. Grooming was concluded to function to establish and maintain affiliative social bonds rather than as a specific mechanism to obtain matings or any other specific reciprocation in terms of services or favors.

* nelum@sjp.ac.lk

Tel: 011-2802207

SECTION E₁

236/E₁

Matlab for analysis of time series with multiple seasonality

T M J A Cooray

Department of Mathematics, University of Moratuwa, Moratuwa

In this paper, a new approach is proposed for forecasting a time series with multiple seasonal patterns. A state space model is developed for the series using the single source of error approach which enables us to develop explicit models for both additive and multiplicative seasonality. Parameter estimates may be obtained based on the Kalman filter by using a powerful software call MATLAB. The proposed model is used to examine hourly and daily patterns in hourly data for both utility loads and traffic flows. Our formulation provides a model for several existing seasonal methods and also provides new options, which result in superior forecasting performance over a range of prediction horizons. The approach is likely to be useful in a wide range of applications involving both high and low frequency data, and it handles missing values in a straightforward manner

* cooray@math.mrt.ac.lk

Tel: 011-2651123

SECTION E₂

237/E₂

Spatial variations of selected heavy metals in water and sediment in Negombo lagoon, Sri Lanka

P Indrajith¹ and K A S Pathiratne^{*}

Department of Chemistry, University of Kelaniya, Kelaniya

With rapid industrialisation and urbanisation, Negombo lagoon is being polluted with hazardous materials including toxic metals especially due to various effluents from multiple sources. The present study was carried out to assess the total levels of eleven metals (Pb, Cu, Hg, Cd, Cr, Mn, Zn, Ni, Sn, Mo, and V) in water and sediment of Negombo lagoon. Water and sediment were sampled from twelve sampling locations representing north (N), east (E), west (W) and south (S) sides of the lagoon in 2003. The levels of Hg in water and sediments were analysed by cold vapour atomic absorption spectrometry whereas the other metals were analysed by flame and/or graphite furnace atomic absorption spectrometry. Out of the eleven metals investigated, the concentration ranges (in $\mu\text{g L}^{-1}$) of the detected seven dissolved metals in water were: Zn (40.3-180.4), Ni (1.1-7.4), Pb (1.0-5.7), Cu (0.6-2.5), Cr (0.9-1.2), Cd (0.6-2.1), Mn (0.6-0.9). No significant spatial differences were however found in four sides of the lagoon with respect to Zn and Cr in water. The levels of the other detected five metals in water of the lagoon followed the decreasing order: Pb, N > E > S \approx W; Cu, N > E > W > S; Cd, N \approx E \approx W > S, Ni, N > E \approx W > S; and Mn, N \approx E \approx W > S. The sediment associated metals in the lagoon (in $\mu\text{g g}^{-1}$ dry weight) showed irregular distribution of metal contamination reflecting many individual metal inputs: Mn (121.9-792.6), Zn (119.5-207.4), Cr (19.2-73.5), Ni (9.2-34.7), Cu (5.3-24.2), Pb (4.8-20.0), Sn (0.6-3.9), Hg (0.3-2.2), Cd (0.03-0.22), and V (0.97-9.46). Sediment bound metals in the four sides of the lagoon followed the decreasing order: Pb and Mn, N < E \approx W \approx S; Cd, E \approx W \approx S < N; Zn, N \approx S < E \approx W; V, N \approx E \approx < W. No significant spatial difference was found with respect to the sediment bound Cu, Hg, Ni, Sn and Mo. The present study revealed that except for Zn, the levels of other metals in Negombo lagoon water have not exceeded the maximum tolerance limits of dissolved metals laid down by the international regulatory authorities for aquatic life in estuarine water. However, sediment bound Cr, Cu, Hg, Zn, and Mn at several locations have exceeded the guide levels specified by the international regulatory authorities for sediment dwelling organisms.

¹*Present address: SGS Lanka laboratory Services, 141/7, Vauxhall street, Colombo 2*

^{*} kaspathi@kln.ac.lk

Tel: 011-2914486

238/E₂

Vitamin "C" content of underutilised fruits in Sri Lanka

V Thisajeni and D N Liyanage^{*}

Department of Food Science & Technology, Faculty of Livestock, Fisheries & Nutrition,
The Wayamba University of Sri Lanka, Makandura, Gonawilla

L- Ascorbic acid which is known as Vitamin C, is an important naturally occurring substance to health and its antioxidant property helps to reduce several physiological disorders in body. Active forms of vitamin C are L-ascorbic acid and dehydro-L-ascorbic acid. L-Ascorbic acid readily oxidised to form dehydro-L-ascorbic acid and it further oxidised to form diketo-L-gulonic. This study was conducted to find out the vitamin C content of six underutilised fruits and to find out the rich source of vitamin C among analysed fruits. Fruit extract was prepared from edible portions of flesh and titrated against standardised 2, 6-Dichloroindophenol dye. It was found that, the vitamin C content of the fruits ranged from 4 mg/100 g in Galsiyambala to 253 mg/100 g Veralu in fresh basis. Vitamin C contents of the tested fruits were as follows:

Fruits	Mean Vitamin C content (mg/ 100 g \pm SD of flesh)	Given Median (mg/ 100 g of flesh)
Bilin (<i>Spondios dulicis</i>)	5.64 \pm 0.8	4.84 - 6.44
Veralu (<i>Elaceocarpus serratus</i>)	252.82 \pm 17.6	235.22 - 270.42
Ambarella (<i>Spondios dulicis</i>)	92.69 \pm 6.8	85.89 - 99.49
Guava (<i>Psidium guava</i>)	231.64 \pm 8.2	223.44 - 239.84
Galsiyambala (<i>Adenanthera agalaosperma</i>)	4.12 \pm 0.5	3.62 - 4.62
Star fruit (<i>Averrhoa carambola</i>)	12.98 \pm 2.9	10.08 - 15.88

n=10

* dnliyanage@wyb.ac.lk

Tel: 031-2299870

239/E₂

Preliminary studies on the development of an economical extraction procedure for Bromelain from pineapple waste

S Jeevathayaparan and S R Sirimanne*

Department of Biochemistry and Molecular Biology, Faculty of Medicine, University of Colombo, Colombo 8

Bromelain is a general name for a family of sulfhydryl proteolytic enzymes obtained from *Ananas comosus*, the pineapple plant. Bromelain was first introduced as a therapeutic compound in 1957 and its therapeutic applications include inhibition of platelet aggregation, fibrinolytic activity, anti-inflammatory action, anti-tumor action, modulation of cytokines and immunity, skin debridement properties, enhanced absorption of other drugs, mucolytic properties, digestive assistance, enhanced wound healing and cardiovascular and circulatory improvement. Bromelain preparations are available as over-the counter pharmacological preparations all over the world. Bromelain is well absorbed orally and available evidence indicates that its therapeutic effects are

enhanced with higher doses. In Sri Lanka, pineapple is a popular fruit that is grown in almost all backyards. Pineapple shops and juice producing factories discard about 30% of the pineapple fruit as the skin and unedible part. Bromelain exists in all parts of the pineapple plant. In this study we have explored whether bromelain is extractable from discarded pineapple parts following an economical procedure. Of the tissues tested the skin that is removed during the preparation of the fruit for human consumption has the highest bromelain content. In addition, we tried to evaluate ammonium sulfate precipitation and acetone precipitation as partial purification methods which utilise fairly inexpensive, partially recyclable materials. Of these two methods used, acetone precipitate of the extract from fruit homogenate was found to give the highest yields. Fast-protein liquid chromatography indicates that the component of the purified sample with proteolytic activity is about 80%.

* sarath.sirimanne@gmail.com

Tel: 011-2697485

240/E₂

Preliminary studies on minor cereals grown in Sri Lanka

K M S Jayawardena, D Rajapaksa*, R C Pitipanaarachchi and Y W C P Kumara
Industrial Technology Institute, Bauddaloka Mawatha, Colombo 07

Proximate analysis of popular varieties of minor cereals grown in Sri Lanka ie Kurakkan (*Eleusine coracana*), Meneri (*Panicum missiaceum*), Sorghum (*Sorghum vulgare*) and Thanahal (*Setaria italica*) were carried out. These varieties of cereals i.e. Kurakkan (Ravi and Rawana), Meneri (AC 254), Sorghum (ICSV 94002) and Thanahal (935) were obtained from the Field Crop Research Development Institute at Mahailupallama.

Moisture content of the cereals ranged from 7.1-11.5% and carbohydrate content ranged from 71.0 – 80.5%. Low content of fat (1.5 – 1.9%) was found in kurakkan and meneri while relatively a higher fat content (2.8 - 4.6%) was seen for sorghum and thanahal. Crude protein content of these varieties was between 6.9-12.6% and crude fiber content were between 0.5-3.6 %. Energy values were in the range of 426 - 454 kcal/100 g. Both varieties of kurakkan showed very high levels of calcium 203.0 mg/100 g and 203.5 mg/100 g. Phosphorous content varied between 100-300 mg/100 g. Percentage iron contents in the minor cereals are 2.9 - 5.6 mg/100 g.

The following food products were developed using the above minor cereals; A malted drink using kurakkan, sugar, milk powder and green gram, instant porridge with meneri and thanahal using green gram, rice, spices and salt and a breakfast cereal using sorghum, green gram, sugar, milk and dehydrated fruits. Their sensory attributes were evaluated using a nine point hedonic scale. The mouth feel of Kurakkan malted drink was judged to be coarse and there is a tendency for separation of two phases. Porridges made out Meneri and Thanahal were judged to be satisfactory. The breakfast cereal made out of Sorghum was also acceptable.

* damitha@iti.lk

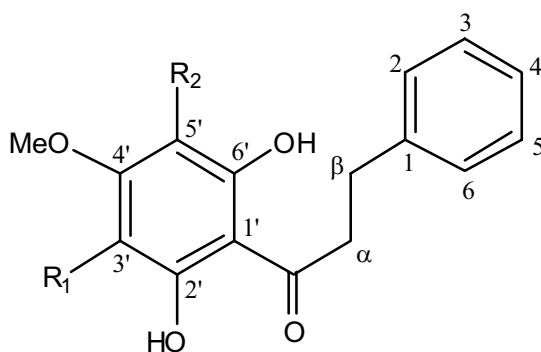
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241/E₂

Antioxidant dihydrochalcones from the leaves of *Syzygium jambos*

R M S Ratnayake, M M W S Medawala and U L B Jayasinghe*
Institute of Fundamental Studies, Kandy

In a continuation of our studies towards the search for biologically active compounds from Sri Lankan plants, the present study is carried out on the leaves of *Syzygium jambos* (L.) Alston of the family Myrtaceae. *Syzygium jambos* is a tree of moderate size, cultivated in the home gardens of Sri Lanka for its delicious fruit as well as an ornamental plant. Chromatographic separation of the dichloromethane extract of the leaves of *S. jambos* furnished three rare dihydrochalcones, phloretin 4'-O-methyl ether (2',6'-dihydroxy-4'-methoxydihydrochalcone (1), myrigalone G (2',6'-dihydroxy-4'-methoxy-3'-methyl dihydro chalcone) (2) and myrigalone B (2',6'-dihydroxy-4'-methoxy-3',5'-dimethyldihydro chalcone (3) with antioxidant properties towards the DPPH radical by spectrophotometric method.



1: R₁, R₂=H

2: R₁=Me, R₂=H

3: R₁, R₂=Me

* lalith@ifs.ac.lk

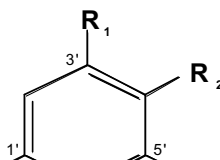
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242/E₂

Flavonol glycosides from *Elaeocarpus serratus* and *Filicium decipiens*

B G S Arundathie, G K Rupasinghe, M H A N Jayathilake and U L B Jayasinghe*
Institute of Fundamental Studies, Kandy

In a continuation of our studies towards the high polar secondary metabolites of Sri Lankan plants, present investigation is carried out on the leaves of *Elaeocarpus serratus* of the family Elaeocarpaceae and the fruits of *Filicium decipiens* of the family Sapindaceae. Both are moderate size trees growing in Sri Lanka. Chromatographic separation of the *n*-butanol fraction of the methanol extract of the leaves of *Elaeocarpus serratus* yielded rare flavonol glycosides myricitrin (1), mearnsetin 3-*O*- β -D-glucopyranoside (2), mearnsitrin (3), tamarixetin 3-*O*- α -L-rhamnopyranoside (4) and the *n*-butanol fraction of the methanol extract of fruits of *Filicium decipiens* yielded three



flavonol glycosides, kaempferol 3-O-rutinoside (**5**), kaempferol 3-O-robinobioside (**6**) and trifolin (**7**). Structures of **1** - **2** were established by detail analysis of ^1H , ^{13}C NMR, H-H COSY, HMQC, HMBC, FABMS and comparison of reported data.

1	R ₁ = OH	R ₂ = OH	R ₃ = OH	R ₄ = -rha
2	R ₁ = OH	R ₂ = OMe	R ₃ = OH	R ₄ = -glu
3	R ₁ = OH	R ₂ = OMe	R ₃ = OH	R ₄ = -rha
4	R ₁ = OH	R ₂ = OMe	R ₃ = H	R ₄ = -rha
5	R ₁ = H	R ₂ = OH	R ₃ = H	R ₄ = -glu ⁶ -rha
6	R ₁ = H	R ₂ = OH	R ₃ = H	R ₄ = -gal ⁶ -rha
7	R ₁ = H	R ₂ = OH	R ₃ = H	R ₄ = -gal

glc- = *b*-D-glucopyranosyl
gal- = *b*-D-galactopyranosyl
rha- = *a*-L-rhamnopyranosyl

* lalith@ifs.ac.lk

Tel: 081-2232002

243/E₂

Screening of vegetable greens for antioxidant activity: A comparative study on three cooking methods

B M G K Balasuriya and H R W Dharmaratne*
Natural Products Programme, Institute of Fundamental Studies, Kandy

Food provides not only energy and essential nutrients needed for life, but also other bioactive compounds for health promotion and disease prevention. Epidemiologic studies have consistently shown that diet plays a crucial role in the prevention of chronic diseases. Consumption of fruits and vegetables, as well as grains has been strongly associated with reduced risk of cardiovascular disease, cancer, diabetes, Alzheimer disease, cataracts and age-related functional decline. In this context, antioxidants play a major role. Common antioxidants found in food are vitamin A, vitamin C, vitamin E and beta-carotene, and believed to be the most beneficial.

In our present investigation, qualitative and quantitative analysis of the antioxidant activity of popular vegetable greens consumed in Sri Lanka were tested and evaluated according to three common cooking methods, using DPPH (2,2-diphenyl-1-picrylhydrazil) radical scavenging assay. Qualitative assay demonstrated the presence of

antioxidants in all the tested vegetable greens. Quantitatively highest amount of antioxidants were found in *Sesbania grandiflora* - Kathuru murunga (EC₅₀ 219.94ppm) and *Brassica sativa* - Kola gowa (EC₅₀ 249.45ppm), while the positive control Ascorbic acid had an EC₅₀ value of 82.295ppm. Further, our results revealed that microwave cooking considerably reduces the antioxidant activity of vegetable greens while traditional cooking tends to reduce the antioxidant activity to a certain extent, when compared with the uncooked greens. Therefore, the best way to preserve the maximum antioxidant activity of vegetable greens is to consume them in raw state (e.g. as salads). Figure shows an example of the results of a popular vegetable green *Ipomoea aquatica*.

* hrwd@ifs.ac.lk
244/E₂

Tel: 081-2232002

Carotenoids from two different varieties of emberella (*Spondias ceytherea* and *Spondias dulcis*)

K S S P Fernando^{1,2}, U G Chandrika^{1*} and K K D S Ranaweera²

¹ Department of Biochemistry, University of Sri Jayewardenepura, Gangodawila, Nugegoda

² Department of Food Science and Technology, University of Sri Jayewardenepura, Gangodawila, Nugegoda

In Sri Lanka, among embarella varieties, the two most popular varieties are the local tall variety (*Spondias dulcis*) and a dwarf variety (*Spondias ceytherea*). Embarella fruits are usually consumed raw as fruits or cooked as vegetable curries. The carotenoid composition of these fruits has not been studied. Hence, a study was carried out to analyse carotenoid composition of these two varieties of emberella as a part of a main project on preparing a database on the carotenoid composition of commonly consumed Sri Lankan fruits and vegetables.

Isolation of carotenoids was carried out according to the Rodriguez-Amaya (1999), which involved extraction of carotenoid, partitioning to petroleum ether, separation of carotenoids by open column chromatography (OCC), identification of carotenoids using ultra violet visible absorption spectra (λ_{max} and spectral fine structure), order of elution of OCC and chemical tests. Quantification of carotenoids carried out using three samples in three replicates. Embarella collected from the home gardens in the Colombo district was used in this experiment. Carotenoid composition of two varieties of emberella are shown in the Table 1

Table 1: Carotenoid composition of two varieties of emberella

Carotenoids	<i>Spondias ceytherea</i> (µg/ g)	<i>Spondias dulcis</i> (µg/ g)
β-Carotene	0.7 ± 0.2	2.1 ± 0.2
Lutein	0.9 ± 0.7	ND

(N=3)

ND: Not detectable

Average moisture content of *Spondias dulcis* is 91.4% and *Spondias ceytherea* is 80.5%.

There are only two types of carotenoids found in *Spondias ceytherea*, β-carotene, a provitamin A and Lutein, which has anti-carcinogenic effects. *Spondias dulcis* was found to contain only β-carotene. Therefore it can be considered as an important source of β-carotene.

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* chandri@sjp.ac.lk

Tel: 011-2803578