Centre of Excellence for Value Addition

# 5th RESEARCH SYMPOSIUM

## Value Addition for Sustainable Development

Uva Wellassa University


# 5th Research Symposium

## "Value Addition for Sustainable Development"

## PROCEEDINGS

**Uva Wellassa University of Sr Lanka**
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# Content

# Message from the Chancellor

I am delighted to send this message of greeting as the Chancellor to the 5th Research Symposium organized by the Uva Wellassa Univesity of Sri Lanka. I sincerely thank the Vice Chancellor for inviting me to send a message and to participate in this symposium as the Chief Guest. This year the theme of the symposium has been chosen as "Value Addition for Sustainable Development", which is timely and relevant theme of great consequence. The theme is also in line with the vision and mission of Uva Wellassa University. The university organizes this research symposium to disseminate the knowledge gathered through research activities of its students and the staff members to a wider academic community in the country. Organizing such activities uplift the face of the university as well as the Uva region. With the Government of Sri Lanka having a strong commitment to the promotion of research and dissemination of knowledge on important areas of economic and social progress, it is commendable that the Uva Wellassa University, an emerging university, organized a national level symposium on a relevant theme harmonized with the objectives of the Government. This will provide valuable opportunities for researchers to present new research and knowledge on topics of global importance addressed by many disciplines of study available at the university. I would like to personally welcome each of the participants to this important gathering who will share their experiences and research findings for the benefit of the participants.

I would also like to thank each one of the participants for attending our conference and the resource personal for sharing their expertise and experience. I sincerely hope that your deliberations will help us to positively contribute towards sustainable development through value addition. Finally let me to offer my sincere thanks to dedicated symposium organizing team, office staff, sponsors and volunteers for their support and contribution for organizing this event.

May triple gems bless you

**Bengamuwe Sri Dammadinna Nayaka Thero**
**Chancellor**
**Uva Wellassa University**
**Badulla**
**Sri Lanka**

# Message from the Vice Chancellor

Uva Wellassa University of Sri Lanka is standing in front of its next milestone, the 5th Research symposium 2015 with the theme ”Value Addition for Sustainable Development”. It is with great pleasure and keenness I deliver this message as the Vice Chancellor of Uva Wellassa University, the Centre of Excellence for Value Addition. First of all, I would like to extend my appreciation to the many young researches who submitted high-quality papers for this symposium. In addition, I am particularly honored to be joined in this event by very distinguished eminent scholars, chairpersons, panelists, editorial board and the organizing committee.

Uva Wellassa University is the so-called experimentation setup to be a new paradigm in Sri Lankan higher education system. It is a think tank of Sri Lanka. Our university equips its young entrepreneurs with best possible tools to become expert skeptics when they face the society which demands effective action towards national development. Its graduates are the fruits of this concept and successful end-product of the experimentation of Sri Lankan higher education system.

This research symposium provides an appropriate and timely platform to bring together such young and promising researchers to present their work, interact with and learn from each other on innovative theoretical and evidence-based research. Research is formalized curiosity which creates new knowledge. Research is also to see what everybody else has seen, and to think what nobody else has thought. Therefore, for researchers, it is very useful to frequently attend and present their recent research papers at conferences and seminars, and receive feedback and comments.

Further, the government, industry, academia and international organizations have a responsibility to support and nurture our young and early-career researchers. This will lead to realize their full potential. In turn the fruits of this research will lead to the development of the country by adding value to its natural resources.

**Dr. G. Chandrasena**
**Vice Chancellor**
**Uva Wellassa University**
**Badulla**
**Sri Lanka**

# Message from the Chairperson of the 5th Research Symposium

I am indeed privileged to write a massage to the 5th Research Symposium of Uva Wellassa University to be held on 29th and 30th of January 2015 at the university premises under the theme of "value addition for sustainable development". Value addition aimed at sustainable development is an important area of work necessary to conduct in order to overcome the societal challenges faced by the human being today. Realizing this key collective social need, UWU organized its 5th research symposium to showcase the research activities of the final year undergraduates, academic and administrative staff members to a wider academic community with an aim to stimulate, promote and strengthen the research vote at UWU and its academic culture by giving an opportunity to its members to interact and collaborate with leading researchers working outside the university.

Over the past four (04) research symposia, research activities at the university have considerably grown up from its nursling status. Today we are holding our 5th research symposium, where in addition to final year undergraduate's research presentations, a substantial number of speeches are given by members of the academia. We highly appreciate members of the academic community who contributed to this event by sending their novel research findings to our symposium. Having contributions from academia encourages our journey to develop a robust research culture at UWU. We look forward to improve and keep sustained this in future. In this symposium, we have organized number of parallel technical sessions covering all our eleven (11) degree programs and a poster session. More than 200 presenters are expected to present their research findings in these sessions which we truly believe will be exploited by the participants to create a platform to exchange and discuss valuable scientific ideas to be developed later into more meaningful interactions.

I wish to express our deep gratitude to Chancellor Most Venerable Bengamuwe Sri Dammadinna Nayaka Thero for his generous endowment to make this event success. I also wish to extend my sincere gratefulness to the Manager, Bank of Ceylon, Badulla for being the main sponsor of our event. My thanks are also due to Hemsons (Pvt) Ltd, Analytical Instruments, Organic Trading, Techno Instruments, Rajarata Tiles and People's Bank, Badulla for sponsoring and extending their generous support to make this event a success. I also take this opportunity to thank you the symposium organizing committee, specially the secretary, faculty coordinators and activity coordinators who worked hard with great enthusiasm and dedication amidst so many obstacles to organize this event successfully. Last but not least, I extend my thankfulness to Vice Chancellor, Registrar and all academic and administrative staff members of UWU and members of the review panel for their continued support to make this event success.

I wish the 5th research symposium of UWU to be a great success.

**Dr. A. R. Kumarasinghe**
**Chairperson of the 5th Research Symposium**
**Uva Wellassa University**
**Badulla**
**Sri Lanka**

# Keynote Speech

## The economic potential of nanotechnology

Nanotechnology can be defined as research and development at the atomic or molecular scale involving the manipulation of manufacturing structures less than 100 nm; it is also an enabling technology bringing into collaboration, ideas in chemistry, physics and biology mixed and blended with engineering and medicine. Scientists and engineers have shown a great interest in nanotechnologies because at sizes below 100 nm, the fundamental chemical or electrical properties of materials can change. For example, silver metal used in jewelry is typically inert, however, at the nanoscale, it becomes chemically more active possessing antibacterial properties. Such useful changes in property have become the catalyst for predictions of a range of fundamental new advances in chemistry and physics over the next 10 – 50 years, mostly in the domains of new materials, the environment, in medicine and information technology.

Fundamental building blocks of nanotechnology are nanomaterials, which have novel optical, electric or magnetic properties. They are semiconductors, metals, metal oxides, carbon materials and organics. The emerging commercial growth areas in nanotechnology are nanomaterials and nanomaterials processing, nanobiotechnology, software, nanophotonics, nanoelectronics and nanoinstrumentation. Nanomaterials and nanomaterials processing companies develop the materials and methods to manipulate and manufacture products based on nano materials.

Globally, nanotechnology is projected to have applications in many sectors. It has been incorporated into tyres, toothpaste, sun cream, tennis rackets, shirts, trousers, CD payers etc. It makes day today consumer goods such as smaller, lighter, faster and cheaper.

Currently, nanocomposites which are used in packaging, food, drinks, electronics and pharmaceuticals have about a 5 billion (USD)global market; nanofibers used in electronics, aerospace, energy and medical areas is about 1 billion (USD); carbon nanotubes used in electronics, energy and medicine is around 1.3 billion (USD); quantum dots which have applications in solar cells, biological labelling has a

global market of 1 billion (USD); nanocoatings used in thin films, engineered surfaces applied across electronics and chemical engineering applications is about 10 billion (USD); and nanoparticles such as metal oxides – silica, alumina, titania, iron oxide etc. is about 12 billion (USD). Like any technology, nanotechnology's advances will depend on available venture capital funding. Risk debates related to possible dangers of nanoparticles which emerged around 2000, still remain in the public domain. Life cycle analysis of nanomaterials is essential as research is progressing.

**Prof. Veranja Karunaratne**
**Associate Director/Research & Strategic Relations**
**Sri Lanka Institute of Nanotechnology (Pvt) Ltd.**
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# 5th Research Symposium - Programme

## Day 01: January 29, 2015

### Inaugural Session

**Venue: Main Lecture Theater (MLT)**

| | |
|---|---|
| 08.00 a.m. | Registration |
| 09.00 a.m. | Lighting Oil Lamp<br>National Anthem<br>University Anthem |
| *Chief Guest* | Most Venerable Bengamuwe Sri Dhammadinna Nayake Thero/ Chancellor, Uva Wellassa University |
| *Chairperson* | Dr. G. Chandrasena / Vice Chancellor, Uva Wellassa University |
| 09.15 a.m. | Welcome Address by Dr. A. R. Kumarasinghe<br>Symposium Coordinator/ 5th Research Symposium and Chairman/ Research Committee |
| 09.20 a.m. | Address by Dr. G. Chandrasena<br>Vice Chancellor, Uva Wellassa University |
| 09.25 a.m. | Address by the Keynote Speaker, Prof. Veranja Karunaratne, Associate Director/ Research & Strategic Relations, Sri Lanka Institute of Nanotechnology (Pvt) Ltd. and Senior Professor of Chemistry/ University of Peradeniya |
| 10.10 a.m. | Highlights of the 5th Research Symposium |
| 10.30 a.m. | Vote of thanks by Dr. K. W. Sandya N. Kumari<br>Symposium Secretary/ 5th Research Symposium |
| 10.35 a.m. | Tea |

# Programme Contd.

11.00 a.m. Parallel Technical Sessions

01.00 p.m. Lunch

02.00 p.m. Technical Sessions Contd.

04.00 p.m. Poster Sessions and Tea

07.00 p.m. Symposium Dinner

## Day 02: January 30, 2015

09.00 a.m. Session Keynote Address

09.30 a.m. Parallel Technical Sessions

01.00 p.m. Lunch

02.00 p.m. UWU staff Research Presentation at MLT

**Award Ceremony**

**Venue: Main Lecture Theater (MLT)**

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

03.00 p.m. Overview of the 5th Research Symposium
Dr. A. R. Kumarasinghe
Symposium Coordinator, 5th Research Symposium/ Chairman,
UWU Research Committee

03.10 p.m. Address by Dr. G. Chandrasena
Vice Chancellor, Uva Wellassa University of Sri Lanka

# Programme Contd.

03.15 p.m. Presentation of Awards

03.40 p.m. Vote of Thanks by Dr. K. W. Sandya N. Kumari
Symposium Secretary, 5th Research Symposium

03.45 p.m. Tea

# Acknowledgement

The Vice Chancellor, the Symposium Coordinator

and the Symposium Organizing Committee

extend their sincere appreciation to the following for the support and the assistance

given in numerous ways to make the 5th Research Symposium

a success

- The Chancellor, Most Venerable Bengamuwe Sri Dhammadinna Nayake Thero
- The Authors of the papers and their Research Supervisors
- The Editorial Board
- The Chairpersons and Judges of Technical Sessions
- The Chief Guest
- The Keynote Speakers
- All Activity Coordinators, Degree Programme Coordinators and Committee Members of Sub Committees
- The Academic and Administrative Staff of UvaWellassa University
- Financial support by Bank of Ceylon, all other Sponsors and Contributors
- All the Participants

# Technical Session – Animal Science

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## Oral Session

## Poster Session

# Effect of different aerobic and anoxic time periods on the effluent water quality of a sequence batch reactor in a meat processing plant

K.P.W. Kahandawa, A.M.N.L. Abesinghe, A.M. Samaraweera
*Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka*

and

J.K. Dissanayake
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## Introduction

A large amount of slaughterhouse wastewater is generated during meat product manufacturing. It contains high concentrations of organic matter, oil and grease and nitrogenous compounds. Hence, releasing waste water to the environment causes many environmental problems such as contamination of groundwater and eutrophication of surface waters (Rodriguez *et al*., 2010). The treatment of waste water is especially important in this view. Treatment of wastewater by means of biological process has been widely implemented from urban to industrial wastewater. Sequencing batch reactor (SBR) is a modification of activated sludge process and operates by a cycle of periods consisting of fill, react (alternatively aerobic and anoxic periods), settle, decant, and idle (Mahvi, 2008).

In the SBR process there is no standard time combination for aerobic and anoxic period. It will depend on the effluent waste water components and vary plant to plant. Currently aerobic and anoxic period is operated as 2 hr aerobic and 1 hour anoxic period in the waste water treatment plant of CIC meat processing company. The present investigation was undertaken to study best time combination of aerobic and anoxic time period for simultaneous carbon oxidation, nitrification and denitrification performance of sequencing batch reactor to treat slaughterhouse wastewater.

## Methodology

The current study was carried out at CIC Poultry Farms Pvt Ltd (Processing Plant), Badalgama. Laboratory analysis was done at CIC Processing Plant Laboratory and Uva Wellassa University laboratories. Model structure of aeration tank which has the capacity of 600 L was used to conduct the research experiments. 180 mL of sludge from SBR unit in CIC meat processing plant and 420 mL volume of wastewater was fed to tank each day of the treatment. Air was supplied to the reactor during aerobic phase of react period with the help of diffused aeration system and Anoxic conditions were maintained by switching off the aerators. Eight different combinations of aerobic and anoxic periods were used. Every sequence was operated totally for 20 hrs of react period by alternating the aerobic and anoxic period according to selected different time combinations (Table 01).

Table 01: Selected time Combinations for Aerobic and Anoxic time periods

| | Control T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 |
|---|---|---|---|---|---|---|---|---|
| Aerobic (Hours) | 2 | 2 | 3 | 3 | 4 | 4 | 4 | 4 |
| Anoxic (Hours) | 1 | 2 | 1 | 2 | 1 | 2 | 3 | 4 |

The best combination of aerobic and anoxic time period was determined by analyzing water quality parameters as, COD, BOD, ammonium nitrogen, total nitrogen, TSS, TDS and pH. Complete Randomized Design (CRD) was conducted and data obtained from chemical and physical tests were analyzed using analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS (SAS Institute Inc., 2000). Significant means of treatments were separated using the Least Significant Difference ($P< 0.05$) test.

**Results and Discussion**

There was a significant difference ($P<0.05$) between aerobic and anoxic time combinations regarding COD removal, BOD removal, TN removal and ammonium nitrogen removal. 4 hour aerobic and 2 hour anoxic period showed higher COD removal (95%), BOD removal (90%), TN removal (89%), and ammonium nitrogen removal (92%). There was no significant difference ($P>0.05$) regarding phosphorus removal, TSS removal and TDS removal among different aerobic and anoxic time combinations.

Highest COD and BOD removal occurred in 4 hour aerobic and 2 hour anoxic cycle. Second highest COD removal (92%) was achieved during 4-1 react period. This might be due to during 4-2 hr and 4-1 sequence total aerobic react time is higher than other react cycles. Therefore, longer aeration was achieved. Longer aeration period has been found to be effective in achieving higher degree of nitrification and COD, BOD removal according to the findings of Debsarkar *et al.* (2006).

Due to less total aeration time in 4-3 and 4-4 hr cycles, less COD and BOD removal was achieved. That means one cycle was alternatively operated for 20 hrs totally and in the 4-3 and 4-4 cycles has high anoxic time periods. Therefore, less COD and BOD removal occurred (Kundu *et al*., 2013).

Treatment 6 (4-2) is significantly different from other treatments and also treatment 5 has high BOD removal. This may be due to long aeration time and effective denitrification. According to Kishida *et al*. (2003), BOD concentration of the effluent was relatively high because the oxygen demand by nitrifying bacteria increased the total BOD, when the NH,-N concentration of the effluent was too high (average = 187.1 mg/L). NH,-N concentration of the effluent was high due to partial denitrification. According to this experiment ammonium nitrogen concentration also affect to the BOD removal. And treatment 6 had low level of ammonium nitrogen concentration in effluent water (1.048 mg/L ± 1.07 mg/L).

Longer aeration period (5 hour) has been found to be effective in achieving higher degree of nitrification from Debsarkar *et al*. (2006). But according to preliminary study at the middle of

5th hour pH is reached to 6.9, but optimum pH for nitrification is 8.2. Therefore, in this experiment longest aeration time per one cycle was selected as 4 hr.

According to the statistical analysis, there is no significant difference (P> 0.05) between different aerobic, anoxic time combinations and total dissolved solid and total suspended solids removal. This might be due to activated sludge treatment is not intended to remove dissolved or suspended solids (Sustarsic, 2009).

**Conclusions**

The combination of 4 hours aerobic react period and 2 hours anoxic react period has been found to be optimum from the view point of both nitrification and denitrification, and COD, BOD removal. When total aeration time period is low, removal of COD, BOD is not efficient in 4 hr aerobic – 4 hr anoxic and 4 hr aerobic – 3 hr anoxic time combinations.

**Acknowledgment**

CIC meat Processing plant, Horakandawila is acknowledged for the facilities provided.

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Sustarsic, M. (2009). *Wastewater treatment: understanding the Activated sludge process*, Available at: < www.aiche.org/cep>, [viewed on 4 Aug, 2014].

# Development of Avocado (*Persea americana*) Incorporated Set Yoghurt

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*Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka*

and

L.K.A. Gunawardhane
*Lucky Lanka Milk Processing Company Limited, Sri Lanka*

## Introduction

Yoghurt is one of the best known of all cultured-milk products in the world. According to SLS standards (1989) *Streptococcus thermophillus* and *Lactobacillus bulgaricus* are used to convert lactose in milk in to lactic acid during yoghurt production. Fruit yoghurt is produce by adding fruits and their nectars, jams, marmalade, fruit jellies, fruit drinks, fruit syrups and concentrated fruit drinks to yoghurt or cultured pasteurized milk and fruit yoghurts enhances versatility of taste, color and texture for the consumer (Chandan and Shahani, 1993).

Avocado (*Persea americana*) is a fruit which is having a very good nutrient profile and thus incorporation endorses the healthy image of yoghurts. However, incorporation of avocado in to set yoghurt is limited by enzymatic browning or formation of brown color melaniodins from polyphenol oxidase enzyme in avocado (Bindesh, 2010). Pauker *et al.* (1992) have found incorporation of avocado in to yogurt in the form of fresh avocado pulp is impossible due to enzymatic browning. Therefore, control of enzymatic browning is essential in producing avocado incorporated set yoghurt. Current study was carried out to develop avocado incorporated set yoghurt that is having an adjusted solid content based on sensory properties and controlling enzymatic browning of avocado pulp.

## Methodology

Market available fresh ripened avocados (Fuerte variety) were manually peeled and crushed in to a smooth pulp. It was divided in to seven samples with same weight and preserved using several preserving and enzymatic browning control methods such as 1% citric acid, 1% (w/w) ascorbic acid (Patricia *et al*., 1993), 1% (w/w) citric acid and 1% (w/w) ascorbic acid together (Lopez, 2001), 0.1% (w/w) sodium benzoate (Patricia *et al*., 1993), 0.1% (w/w) potassium sorbate (Singha, 2011), heat treatment at 40 ºC temperature for 30 minutes (Cantwell, 1992) and preparation of avocado pulp as a jam (Connelly, 2013). The best avocado pulp preserving method (least color changing treatment) was selected by conducting a sensory evaluation using 30 untrained panelists.

The selected method of preserving avocado pulp (avocado jam) was used in preparation of avocado incorporated set yoghurt. Yoghurt mix preparation was done according to Pande (2010). Preliminary trials were used to select the appropriate level of ingredients (avocado

jam, sugar and gelatin). Sugar and gelatin levels were finalized after having several sensory trials using 30 untrained panelists. Potassium sorbate 0.03% (w/w) was added to the final mixture as preservative (SLS Standards, 1989) and homogenized using a beater (National™, MK-H100N). Inoculation of lactic acid bacteria culture of YC 350 freeze dried (DVS) was done at 45 °C temperature. Then mixture was poured in to 80 mL plastic yoghurt cups and incubated at 42 ±2 ˚C for 4 hours. Each treatment consisted with three replicates.

Total plate count, coliform bacteria count, yeast and mold count, pH, titratable acidity and peroxide value of selected avocado incorporated set yoghurt and avocado jam was tested at 1$^{st}$, 3$^{rd}$, 5$^{th}$, 7$^{th}$, 9$^{th}$ and 11$^{th}$ day under refrigerated storage. A proximate analysis was done to determine the composition of the avocado incorporated set yoghurt.

**Results and Discussion**

Addition of 50% (w/w) sugar in to avocado pulp showed lowest brown color development ($P<0.05$). Added sugar may have reduced the water activity of the avocado pulp. Enzymes require certain level of water in their structures to maintain their natural conformation, allowing them to deliver their full functionality. Therefore, presence of 50% sugar inhibits the activity of polyphenol oxidase enzyme. Adding more than 50% of sugar, crystalize sugar in the avocado pulp which gives undesirable consistency. Twenty percent of avocado jam incorporation level shows the best results according to the sensory evaluation ($P<0.05$).

Total plate count, yeast and mold and coliform counts of the avocado incorporated set yoghurt were not exceeding SLS standards for set yoghurt during 11 days of refrigerated storage. Titratable acid percentage of avocado jam has increased from 1.22±0.07 to 1.4±0.07 during day 1 to day 11 ($P<0.05$). It may be due to conversion of fermentable sugars in to acids by microorganisms available in avocado jam. Further, titratable acid percentage of avocado incorporated set yoghurt increased from 0.86±0.03 to 0.94±0.03 during 11 days storage period ($P<0.05$). This is due to the presence of live lactic acid bacteria in culture which ferment lactose in milk to lactic acid with the time (Chandan and Kilara, 2013). pH of avocado jam and pH of avocado incorporated set yoghurt was reduced from 3.52±0.06 to 3.35±0.06 and from 4±0.03 to 3.91±0.03, respectively during day 1 to day11. Increasing acidity results in decreasing pH level in the product.

No fatty acid oxidation was detected in the avocado jam during storage period of 11 days. Avocado incorporated set yoghurt started free radicle formation and rancidity development 7$^{th}$ day of storage onwards. Moreover, it shows increasing browning effect. Since, avocado is a fruit with high fat and it contains considerable level of fatty acids, there is a potential to observe oxidation in this product. Statistical analysis showed that enzymatic browning has an influence on the increment of changing rapidity of titratable acidity, pH and peroxide value. Further, it showed fatty acid oxidation and pH are not related. In the view of avocado incorporated set yoghurt and avocado jam, avocado jam is having very low water activity due to saturated sugar solution. Avocado incorporated set yoghurt is having an environment with increasing acidity and decreasing pH with lactic acid fermentation. Water activity of avocado incorporated set yoghurt also very high compared to avocado jam. These factors may have influenced on the observed color change in avocado incorporated set yoghurt.

Proximate analysis of avocado incorporated set yoghurt showed that there is a significant difference with plain yoghurt ($P<0.05$). Fat (3.6±0.42%), fiber (0.3±0.21%), ash (0.9±0.14%), protein (3.5±0.07%) and total solids (16.10±1.31%) in avocado incorporated set yoghurt is comparatively higher than available fat (3.0±0.42%), fiber (00±0.21%), ash (0.7±0.14%), protein (3.4±0.07%) and solids (14.24±1.31%) in plain yoghurt.

**Conclusion**

Avocado incorporated set yoghurt is more nutritious compared to set yoghurt as it has included with more protein, minerals and fiber. There is a relationship between enzymatic browning and fatty acid oxidation. Further studies are required to identify how enzymatic browning and fatty acid oxidation relates with each other and to extend the shelf life of avocado incorporated set yoghurt.

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# Production characteristics and technical efficiency of buffalo farmers in Thanamalwila veterinary division

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## Introduction

At present milk production from large ruminants only meet 17% of the countries requirements (Ministry of livestock and rural community development, 2012). According to Department of animal production and health (2012) *Thanamalwila* Veterinary division (VD) in *Moneragala* district has the highest buffalo population in *Uva* province which is well established over cattle rearing and plays an important role in income generation of rural farm households. Therefore, this study was conducted to identify the important socio-economic determinants of milk production and to estimate the technical efficiency of dairy production in *Thanamalwila* VD.

## Materials and methods

Study was conducted in *Thanamalwila* VD. Fifty buffalo farmers were selected using multi stage sampling technique. Random numbers of buffalo farms were selected from each *Grama Niladhari* division to field survey based on buffalo farm population. Rearing buffalo as primary and secondary income source was the selected criteria for buffalo farmers. Primary data were collected using pre tested structured questionnaire and following models were used in the analysis of stochastic production function and inefficiency model. Then, data were analyzed using Minitab 14 and STATA 11 software packages.

Model 1: Cobb-Douglas model

$$\boldsymbol{ln\,Y_i = \beta_0 + \beta_1 lnX_{1i} + \beta_2 lnX_{2i} + \beta_3 lnX_{3i} + \beta_4 lnX_{4i} + \beta_5 lnX_{5i} + \beta_6 lnX_{6i} + \beta_7 lnX_{7i} + \beta_8 lnX_{8i} + (V_i - U_i)}$$

Where "ln" denotes logarithms to base e, while, $Y_i$= Milk yield (L animal$^{-1}$ day$^{-1}$), $X_1$= Breed, $X_2$= Average birth weight (kg), $X_3$= Condition of the shed , $X_4$= Grazing duration (hours day$^{-1}$), $X_5$= Labor allocation (hour animal$^{-1}$ day$^{-1}$), $X_6$= Frequency of water given (number of times per day), $X_7$= Cost of buffalo farming (LKR per month), $X_8$= Value of feed, $V_i$= Random variable, $U_i$= Non negative random variables.

Model 2: The inefficiency model specification (Battese and Coelli, 1995),

$$\boldsymbol{Ui = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + W_i}$$

Where, $Z_1$ = Age of the farmer (Year), $Z_2$ = Education level (Year), $Z_3$ = Monthly income level (LKR), $Z_4$ = Experience of the farmer (Year), $W_i$ = Unobservable random variables

## Result and discussion

All the buffalo farmers in the sample were male and majority was belonged to 21-30 age category (30%) and a high proportion (62%) of buffalo farmers had education up to grade 10. Only 6% of respondents had the education level beyond GCE ordinary level.

Most of the villages (98%) reared both local as well as exotic river type buffalo breeds and the preferable breed combination was local buffalo and Murrah or Niliravi cross breds. Only 2% of farmers reared solely local buffaloes. Herd size ranged between 2-185 animals and majority of respondents (38%) had a herd size of 21-40. Moreover, the predominant management system (94%) was the extensive management system. Interestingly, one farmer (2%) has practiced the intensive management system. Moreover, 6% of farmers practiced artificial inseminations (AI) in their breeding program. Feed availability, water availability, changes in rainfall pattern, and land availability were the most serious constraints faced by respondents. Elephant attack and illegal smuggling were also critical problems in buffalo farming in the area.

The *maximum likelihood estimates* (MLE) of the parameters of stochastic frontier production function are present in Table 01. The OLS function provided the estimates of the average production function while MLE model provided the estimates of stochastic production frontier. The MLE coefficient for breed, allocation of labour hours day$^{-1}$ animal$^{-1}$ and average birth weight shows a positive and significant contribution to determine the output of stochastic production function. Therefore, by improving these aspects the farmer can enhance the milk output by the given MLE.

Table 01: Estimates of stochastic production function

| Variable | Coefficient | | Standard error | | p value | |
|---|---|---|---|---|---|---|
| | OLS | MLE | OLS | MLE | OLS | MLE |
| Breed | 0.4768** | 0.5830*** | 0.1834 | 0.1428 | 0.013 | 0.000 |
| Birth weight | 0.5367 | 0.6169** | 0.3802 | 0.2856 | 0.166 | 0.031 |
| Shed condition | -0.1626 | -0.2230 | 0.1798 | 0.1375 | 0.371 | 0.105 |
| Grazing duration | -0.0047 | -0.0833 | 0.2994 | 0.2237 | 0.988 | 0.709 |
| Labour hours | 0.0941* | 0.2054*** | 0.0528 | 0.0564 | 0.082 | 0.000 |
| Frequency of water supply | 0.0086 | 0.1461 | 0.1152 | 0.1183 | 0.941 | 0.217 |
| Cost of buffalo farming | 0.0341 | 0.0187 | 0.0275 | 0.0217 | 0.223 | 0.391 |
| Feeding method | 0.0954 | 0.0570 | 0.2038 | 0.1674 | 0.642 | 0.733 |
| Constant | -1.1127 | -0.7375 | 1.5874 | 1.1581 | 0.487 | 0.524 |

OLS= Ordinary Least Square estimation, MLE= maximum Likelihood estimation, *Significant at 10%, **Significant at 5%, ***Significant at 1%

Estimated variables of the inefficiency model are represented in Table 02. Monthly income was the only significant variable of inefficiency model in this study. Therefore, farmers with higher monthly income have the capacity to increase the efficiency of milk production. Moreover, farmers had tendency to invest their money on livestock than cash crop cultivation

because they considered cash crop cultivation as relatively risky business due to dry climatic condition in the area.

Table 02: Technical inefficiency estimates- buffalo farming

| Variable | Coefficient | Standard error | p-value |
|---|---|---|---|
| Age | 0.0459 | 0.039481 | 0.243 |
| Education level | 0.1189 | 0.615439 | 0.846 |
| Monthly income | -0.0005* | 0.000026 | 0.052 |
| Experience | -0.1057 | 0.085551 | 0.217 |
| Contact times of VS/LDI | -0.3871 | 1.024504 | 0.709 |

*Significant at 10% **Significant at 5% ***Significant at 1%

Moreover, mean technical efficiency for buffalo farmers in *Thanamalwila* VD is 86.83, which indicates that the output could be increased by 13.7%, if all farmers achieved the TE level of the best farmer.

**Conclusion**

Coefficients for breed, feed, average birth weight, and level of labor power allocation on dairy industry have significant impact on milk production of buffalo farms in *Thanamalwila* VD. Moreover, by reducing the technical inefficiency by 13.7% the farmers can increase the milk yield without increasing the level of inputs.

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# Development of drinking yoghurt by incorporating corn (*Zea mays*) milk and corn seeds

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## Introduction

Cereal grains are considered as important sources of dietary proteins, carbohydrates, vitamins, minerals and fiber for people all over the world (Chavan and Kadam, 1989). Corn (*Zea mays*) is locally grown cereal that can be purchased at low price from several areas in Sri Lanka. Corn milk is considered as a new innovation, especially in making yoghurt based products. Vegetable based corn milk yoghurt is an alternative to substitute the cow milk based yoghurt. Drinking yogurt is the fastest growing food and beverage category in worldwide (Yasni and Maulidya, 2013). However, still value added drinking yoghurts are rare in Sri Lankan market. Adding cereal grains is a perfect way to upgrade a drink to a nutritious breakfast. Therefore, this study was conducted to develop yoghurt by incorporating corn *(Zea mays)* milk and corn seed to cow milk.

## Methodology

The study was carried out at Lucky Lanka Milk Processing Com. Ltd (LLMP), Matara and Uva Wellassa University. Six experimental trials with different treatments were conducted. In trial I, mature fresh corn seeds, mature boiled corn seeds and germinated corn seeds were separately used to extract corn milk and the best extract of corn milk was evaluated by sensory properties (odor, taste, color and mouth feel) using untrained panelist. In trial II the most compatible sugar (8%, 9% and 10% w/v) and gelatin (0%, 0.2% and 0.4% w/v) levels for different corn milk percentages (5%, 10%, 15% and 20% w/v) were identified. After selection of appropriate combinations of sugar and gelatin levels, trial III was done to select the best corn milk incorporation level by narrow downing the corn milk percentages (6%, 8%, 10%, 12% and 14%). Preserved in sugar syrup and boiled corn seeds were crushed into two sizes (> 3.15 mm and 2 mm –3. 15 mm) to prepare different types of corn seeds. Trial IV was carried out to select best corn seeds particles on the textural basis and trial V was done to assess the consumer acceptability for the presence of corn seeds in the corn milk incorporated drinking yoghurt. Finally three treatments (trial VI) were prepared and evaluated on sensory, chemical and microbiological properties. The sensory evaluation was done using 35 untrained panelists. In chemical analysis, proximate analysis (moisture content, crude fat, total solid, crude protein, ash and crude fiber content) was conducted. pH value and titratable acidity were evaluated and microbiological analysis was done for Yeast and Moulds, and *Escherichia coli* for three weeks in one day interval. The sensory data were analyzed using Friedman

nonparametric test. Complete Randomized Design was conducted and data obtained from chemical and microbiological tests were analyzed by Analysis of Variance using the General Linear Model procedure of SAS. Significant means of treatments were separated using the Least Significant Difference test ($P< 0.05$).

**Result and Discussion**

In trial I, boiled corn seeds (mature) based method was selected to extract corn milk. Other two methods were rejected due to the unpleasant odour and taste which may be due to the activation of various food enzymes and breaking down the higher molecular components to simple molecules during germination.

Eight per cent sugar (w/v) for 5% corn milk (w/v) and 10% sugar (w/v) for other 10%, 15% and 20% corn milk (w/v) incorporation levels were selected due to desirable sweetness. The gelatin level (w/v) was selected as 0% due to the presence of appropriate drinking yoghurt properties including texture, mouth feel, appearance and viscosity. The whey separation has been prevented by stabilizing effect of corn starch in corn milk.

In sensory evaluation, 8% corn milk incorporation level was significantly highly preferred by panelist with respect to mouth feel, taste and overall acceptability ($P<0.05$). However, there is no significant difference in color and aroma of the three treatments ($P>0.05$) (Figure 01). Addition of corn milk had no influence to change colour and aroma of the product.

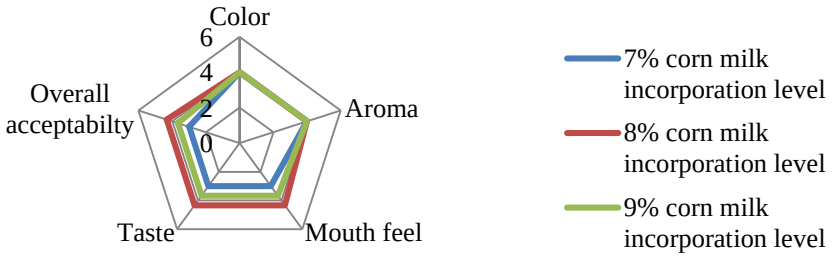


Figure 01. Web diagram for level of corn milk incorporation in sensory evaluation

In trial IV, sugar syrup based method was rejected due to hardness of the seeds and crushed boiled corn seeds were selected. Further, the sensory results revealed that the preference (taste, aroma, mouth feel, color and overall acceptability) for corn seeds >3.15 mm or 2 mm to 3.15 mm particles incorporated drinking yoghurt is less whereas preference for corn milk incorporated drinking yoghurt without corn seeds was high. The observed difference is due to the disturbance for the drinkable property of product by presence of corn seed particles. The composition of the selected corn milk incorporated drinking yogurt is given in Table 01.

There was a significant difference between treatments for change in pH with the storage period ($P<0.05$). pH values of the T8 (with preservative) and control were not changed dramatically. Control of pH by potassium sorbate could be due to inhibition of the activity of starter culture by inhibiting various enzymes in microbial cell (Rajapaksha *et al*., 2013).

There was a significant difference between treatments with respect to acidity ($P<0.05$) and titratable acidity increased significantly with storage period and in treatments without preservatives. According to Rajapaksha *et al.* (2013), titratable acidity of yogurts increased over the time and acidity of yoghurt without potassium sorbate increases drastically than other treatments reflecting the inhibitory activity of potassium sorbate on post fermentation.

Table 01. Composition of select corn milk incorporated drinking yoghurt

| Raw material | Percentage | Quantity (g) |
|---|---|---|
| Milk | 79.54% | 867.03 |
| Dairy cream | 1.03% | 11.33 |
| SMP | 1.42% | 15.49 |
| Corn milk | 8.00% | 87.20 |
| Sugar | 10.00% | 109.00 |
| Total | 100.00% | 1090.00 |

There were no contaminations with Coliform and *Escherichia coli* and thus safe for human consumption. There were no yeast colonies in T8 and control sample. At day 11, yeast colonies were exceed the SLS standards of <1000 only in T7 (without preservative).

Proximate analysis revealed all the physiochemical characteristics of corn incorporated drinking yogurt (protein, fat, ash, fiber and total solid), except moisture significantly higher compared to plain drinking yoghurt ($P<0.05$). Usually drinking yoghurt does not contain fiber. However, due to addition of corn, milk fiber was increased up to 0.5%.

**Conclusion**

Eight per cent corn milk incorporation level with selected sugar (10%) and gelatin (0%) level has best consumer preference with respect to the taste, mouth feel and overall acceptability ($P<0.05$). Moreover, drinking yoghurt without corn seed particles is preferred by the panelists. Shelf life of product without potassium sorbate is around 11 days at 4 ºC with respect to microbiological analysis and physiochemical analysis.

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# Effect of tropical forages on growth performance and carcass quality of rabbits

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## Introduction

Rabbit (*Oryctolagus cuniculus*) is a small mono-gastric animal which has a very small body size and an efficient reproductive ability. Backyard rabbit keeping supplies additional protein with low investment and labor inputs. Rabbit meat has many nutritional benefits which include high protein, low cholesterol and high palatability (Samkol and Lukefahr, 2008).The major problem with rabbit production is high feeding cost (Lebas *et al*., 1997). Feeding cost for rabbits account more than 75% of total cost of production. At present there is a competition for protein sources between man and animals (Jiya *et al*., 2011). Rabbits are herbivores and can be successfully raised on diets with low in grains and high in roughage. Therefore tropical legumes can be used as an alternative for fed rabbits. The objective of this study was to determine the growth performance, carcass quality of weaner rabbits with diet containing forage supplements and commercial layer pellet.

## Methodology

The experiment was carried out at Uva Wellassa University, Badulla. Sixteen (16) weaned cross bred rabbits, mixed sexes were used for the feeding trial which conducted for 45-days. All rabbits selected which were born on same day,a few from same litter. Rabbits were grouped according to Complete Randomized Block Design (CRBD) with four replicates, 2 males and 2 females for each diet group. Ration for all the diets were formulated according to the nutritional requirement of grower rabbit. Maximum inclusion levels for the selected leaves also considered. All animals were kept for an adaptation period during the adaptation period rabbits were fed with only the control diet (Prima layer pellet) with fresh guinea grass (*Panicum maximum*). The experimental diet was introduced gradually for 8 days. Water was supplied ad-libitum for each rabbit. Guinea grass (*Panicum maximum*), Erythrina leaves (*Erythrina indica*), Cassava leaves (*Manihot esculenta Crantz*) and Leucaena leaves (*Leucaena leucocephala*) were harvested from the surrounding environment of the university premises. Guinea grass was harvested one week before feeding to the animals and hay was made by keeping under sun. Erythrina leaves, Cassava leaves and Leucaena leaves were harvested three to four days before feeding rabbits. Those harvested leaves were chopped and wilted until constant weight was gained. Wilted leaves and dried grass were stored under dry condition. Diet 1 = Only layer pellet 100% (control), Diet 2 = Layer pellet 70%, *Erythrina indica* 20%, *Panicum maximum* 10%, Diet 3 = Layer pellet 65%, *Manihot esculenta Crantz* 20%, *Panicum maximum* 15% and Diet 4 = Layer pellet 92%, *Leucaena leucocephala* 7%, *Panicum maximum* 1%. Data were collected on body weight and weight gains, feed intake and Feed Conversion Ratio (FCR).

Two rabbits (one male and one female) from each group were slaughtered for carcass quality evaluation. After 45 days of feeding trial two rabbits (one male and one female) from each treatment group was slaughtered. Hot carcass weight, pH, Length of carcass, dressing percentage was evaluated under carcass quality parameters. Chemical composition of carcasses was analyzed for proximate constituents according to AOAC, 2002 method. Sensory evaluation of boiled meat samples were evaluated using 15 semi trained panelists.

Collected data was analyzed using Analysis of variance (one way ANOVA and two way ANOVA) - Minitab 16 statistical software package. Analysis of variance fallowed by a mean separation procedure using Tukey's test. Sensory analysis was done by using non parametric analysis of Friedman test.

**Result and discussion**

Table 01. Performance of rabbits fed experimental diets

| Performance characteristics | Diet groups | | | |
|---|---|---|---|---|
| | Control (T1) | Erythrina (T2) | Cassava (T3) | Leucaena (T4) |
| Initial body weight (g) | 1981.5[a] | 2062.0[a] | 1818.5[a] | 1836.5[a] |
| Final body weight (g) | 3108.8[a] | 2900.5[a] | 2903.0[a] | 3144.3[a] |
| Daily weight gain (g/head) | 25.62 [a] | 19.06[b] | 18.97[b] | 29.72[a] |
| Feed conversion ratio | 0.2135[a] | 0.1588[b] | 0.1580[b] | 0.2477[a] |

a,b: Values in the same row with different letters are significantly different at $p<0.05$.

Growth performance of rabbits fed diets with various forages is presented on Table 01. However, significant ($P<0.05$) differences was observed in the values of daily weight gain with rabbits in treatment 3 having the highest weight gain, could be as a result of high crude protein content in the diet. It is recommended that for good performance of rabbits, doe or buck, 10% leucaena leaves blended with their feed is good (Lamidi and Akilapa, 2013). Therefore diet containing Leucaena may have provided the required proteins and amino acids for the growth of the rabbits. With respect to FCR, it was observed that significantly ($p<0.05$) higher in the rabbits on fed with diet 4 (0.247) than the other diet groups while diet 3 produced the poorest FCR (0.158) compared to the average. The results were similar to the findings of Okonkwo *et al*. (2010). In addition, the feed conversion ratio recorded in this experiment is poorly compared to the normal feed conversion ratio of rabbits (3:1).

All carcass quality parameters were not significantly different with each other ($p<0.05$) (Data not shown). Treatment 4 showed highest dressing percentage among other treatments. Except treatment 3 other results for dressing percentages were similar to the findings of Chisova *et al*., (2013) which dressing percentage ranged from 55.56 % to 59.72 % for growing rabbits. Lowest dressing percentage in treatment 3 may be due to toxic compounds containing in cassava leaves.

Sensory results showed that *Erythrina indica* incorporated diet fed rabbits meat was much preferred than others. Results of sensory evaluation were same for both male and female rabbits.

When consider proximate composition of rabbit meat, Crude protein content was varying between 81.2 to 88.3 % (dry matter basis). Results were differ when consider male and female animals. There is a less variation in fat content of both male and female animals regarding four diets (6.2% - 7.1%). Results of fat and moisture content were similar to the findings of Zotte (2002).

**Conclusion**

Smaller herbivores can persist on small quantities of food on the condition that the plants are of high nutritional quality. Supplementation of concentrate with forage in the diet of rabbits is cost effective. *Leucaena leucocephala*, *Manihot esculenta Crantz* and *Erythrina indica* forages can be included in rabbit's diet with recommended levels without any adverse effect. Sensory results showed that *Erythrina indica* incorporated diet fed rabbits meat was much preferred than others.

Carcass quality evaluation proved that *Leucaena leucocephala* incorporated diet fed rabbits had highest dressing percentage which showed high weight gain. But proximate composition of rabbit meat was not showed a high variation regarding four diets.

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# Diversity and antibiotic resistance patterns of *Lactobacillus* species in traditional curd in Sri Lanka

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## Introduction

*Lactobacillus* is a genus which comprises of more than 50 species as described in the Bergey's Manual of Systematic Bacteriology (2009) *Lactobacilli* are Gram-positive, non-spore-forming rods or coccobacilli. They are generally considered as apathogenic, fastidious bacteria and one of their main habitats is fermented dairy products.

In their fermentative pathways, main metabolic end product is Lactic acid. The fermentation process of *Lactobacillus* increases the shelf-life of the fermented dairy product, as well as adds the taste and improves the digestibility of milk. There are adequate evidences to prove that traditionally fermented milk products have been produced for a long time in different countries. Curd (Sri Lanka and India), Kefer (Russia), Yakult, Yogurt, Kumisss (Russia), Tarhana (Turkey) are some examples.

There are *Lactobacillus* species that have achieved GRAS (Generally Recognized as Safe) or QPS (Qualified Presumption of Safety) status. However, during the past few decades there has been an emerging concern on spreading the antibiotic resistance in the environment. Due to the increasing use of antibiotics and disposing them in to the environment in a considerably inappropriate manner, concerns have arisen on the possibility and probability of spreading the antibiotic resistance genes to *Lactobacillus* in fermented food (Farthing, 2004). The main threat associated with these bacteria is that they can transfer resistance genes to pathogenic bacteria as well as to the commensal flora in the intestinal tract. A number of initiatives have been recently launched across the globe to address the biosafety concerns of starter cultures and probiotic microorganisms. The European Food safety Authority (2007) considers transferable antibiotic resistances as a safety concern. Many studies have detected the acquired antibiotic resistance in fermented food products. Nevertheless, the tetracycline resistance was shown to be able to transferred *in vitro* to *Enterococcous faecalis* from *Lactobacillus* species isolated from fermented sausages (Gevers *et al*., 2003).

The objective of this study was to find out the diversity of *Lactobacillus* species in curd prepared by small and medium scale producers in Sri Lanka and to detect their antibiotic resistances.

## Methodology

Total number of 32 curd samples representing different areas of the country were collected from small and medium scale produces (SMS) who do not use starter cultures directly for the process. Samples were enriched in modified Man Rogosa Sharpe broth at $37^0$C at room temperature for 24 h, under anaerobic conditions and plated on modified MRS agar medium

using agar overlay technique and incubated at $37^0$C, for 24-36 h under anaerobic conditions. *Lactobacillus delbrueckii subsp. bulgaricus* was used as the positive control. Morphologically different colonies were isolated. Identification of the different strains were carried out using morphological and biochemical tests according to the Bergey's Manual of Systematic Bacteriology. For the detection of antibiotic resistances, agar overlay disc diffusion method (Charteris *et al*., 1998 ) was followed. The bacterial cultures used for this test were grown overnight in modified MRS broth and the densities were adjusted to $OD_{590nm}$ = 0.1 using spectrophotometer in order to obtain consistent growth. Penicillin G(P10),Tetracycline (TE30), Erythromycin (E15), Bacitracin (B10), Rifampicin (RD30) Nalidixic Acid (NA30), Vancomycin (VA30) and Polymixine B (PB300) were selected as the test antibiotics.

**Results**

For morphological characteristics, shape and colour of the colonies, Gram's reaction, shape and arrangement of cells, motility and endospore formation were observed. For the biochemical characteristics, reaction in the Gibson's medium, oxidase test, catalase test, Arginine utilization, sugar fermentation tests (Arabinose, Cellobioose , Esculin, Galactose, Maltose, Mannose, Melibiose, Raffinose, Ribose, Sucrose, Trehalose, Xylose, Salicin, Sorbitol, Mannitol, Rhamnose, Lactose ) were detected.

A total Number of 51 *Lactobacillus* isolates were obtained in this study and all the 51 isolates were comprised with 16 different bacterial species. *Lactobacillus fermentum* (35%) *Lactobacillus acidophilus* (11.11%), *Lactobacillus plantarum* (5.55%) and *Lactobacillus amylolyticus* (8.33%) represented majority. When compare the antibiotic resistance patterns (Table 01), Polymixine B was reported to have 94.44% overall resistance. All the 51 isolates were reported to score 100% of overall resistance for both Vancomycin and Nalidixic Acid. Minimum percentages of antibiotic resistances were observed for Tetracycline (22.22%) and Erythromycin (27.78%).

**Discussion**

Considering the prevalence of different *Lactobacillus* species, the results obtained in this study correlate to a significant extent to some research carried out on traditional fermented dairy products (Yu, 2011). Conversely, several research studies have been *disclosed that L. delbrueckii subsp. bulgaricus is the most abundant Lactobacilli in* traditionally fermented milk products (Tendakyi *et al*., 2001) and this species was not identified in this study.

Though the present study reveals less abundance of Tetracycline and Erythromycin resistance compared to that of most other countries it can be considered as an important finding. Correlate with the Tet- resistant species identified in this study, R-plasmids encoding Tet-resistance have been reported in *L. fermentum L. planatarum* and *L. amylolyticus.* Because the Tet-resistance has been transferred from *Lactobacillus* to *E. faecalis* in vitro it shows the possibility of in vivo process. Further studies can be aimed at determining the transferability of the Tet-resistance from *Lactobacillus* to commensal flora *in vitro*.

Table 01: Antibiotic resistance patterns of some selected *Lactobacillus* isolates.

| Isolate No | Species | Tet | Ery | Bac | Rif | Pen | Poly | Nali | Van |
|---|---|---|---|---|---|---|---|---|---|
| L43 | *L. planatarum* | R | S | S | R | R | R | R | R |
| L3 | *L. planatarum* | S | S | R | MS | R | R | R | R |
| K1 | *L. amylolyticus* | R | R | R | R | R | R | R | R |
| K2 | *L. amylolyticus* | R | R | R | R | R | R | R | R |
| L25 | *L. fermentum* | R | R | R | R | R | R | R | R |
| M2 | *L. fermentum* | R | R | R | R | R | R | R | R |
| L11 | *L. fermentum* | R | R | S | R | R | R | R | R |
| L8 | *L.frintoshensis* | R | R | R | R | R | R | R | R |
| L29 | *L. gastricus* | S | R | R | R | R | R | R | R |
| Tcb | *L. acidophilus* | S | S | R | R | R | R | R | R |

S; Sensitive, R; Resistant, MS; Moderatly sensitive
Tet; Tetracycline, Ery; Erythromycin, Bac; Bacitracin, Rif; Rifampicin,
Pen; Penicillin G, Poly; Polymixine B, Nal; Nalidixic acid, Van; Vancomycin

**Conclusions**

16 different Lactobacillus species were isolated. *Lactobacillus fermentum* was the most abundant organism. Minimum percentages of antibiotic resistances were observed for Tetracycline and Erythromycin while maximum percentages of resistances were observed for Nalidixic Acid and Vancomycin. The relatively high percentage of vancomycin resistance (85%) is due to the fact that the majority of the lactobacilli are intrinsically resistant to this glycopeptide.

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# A preliminary study on Milk Urea Nitrogen values of the Ambewela farm

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## Introduction

Feeding management is a key factor in profit maximizing of a dairy farm. Milk Urea Nitrogen (MUN) is a tool that measures the efficiency of protein and carbohydrate feeding to milking cows (Jonker *et al*., 1999). Implementing routine use of MUN on dairy farms could reduce nutrient loading to natural environments and improve farm profitability (Jonker *et al*., 2002). According to Kohn (2007) dairy herds should have MUN concentrations between 8 to 12 mg $dL^{-1}$. However, the MUN values could be affected by many factors such as environment, breed, feed, season, etc. (Godden *et al*., 2001). Hence the use of 8 to 12 mg $dL^{-1}$ MUN values to evaluate the dairy herds in the Sri Lanka would be inappropriate, since there were no studies carried out in to determine the baselines of MUN values in Sri Lanka. Therefore, this study has been carried out as a preliminary study, to study about the prevailing MUN values of one of the commercial dairy farm in Sri Lanka.

## Methodology

The study was conducted at Ambewela farm and Veterinary Research Institute, Sri Lanka. Four groups of the milking herd in the Ambewela farm (treatments) which have been made based on the production levels of the cows were used to collect milk samples. Samples from each group were taken once in fortnight during three months' experimental period. During each sample collection, 15 cows were selected randomly from each group and 50 mL of milk from each cow was obtained after complete milking. Milk from five cows belonging to each group was pooled. Hence, each treatment consisted with three replicates. Milk fat was analyzed using the Gerber method. Solids-non-fat (SNF), protein, salts and lactose contents were measured using a portable ultrasonic milk analyzer (Lactoscan MCC, Milkotronic Ltd., Bulgaria). Lacto meter was used to measure the milk specific gravity. The urea content in milk was estimated according to the method described by Malik and Sirohi (1998) and the optical density of the sample was measured at 450 nm using the spectrophotometer (Cary 50 Conc - 10069600, Agilent Technologies, Australia). In the statistical analysis, according to the normality of the sample data test by Anderson-Darling test, the relationships were evaluated using multiple regression analysis or Spearman Rank Correlation Coefficient. STATA® S/E 11.2 and Minitab® 17 software were used in statistical analysis of the data. The MUN levels were interpreted based on the current recommended levels of Kohn (2007).

**Results and Discussion**

The results revealed that the milk fat%, SNF%, protein%, lactose%, and specific gravity does not have a significant relationship with MUN ($P>0.05$). Similarly Godden *et al.* (2001) have stated that there is no association between MUN and either milk fat or true protein percentages. Broderick and Clayton (1997) also confirm that there is no significant relationship between milk SNF% and MUN values. Therefore, it can be stated that MUN values are not related with fat%, SNF%, and protein% in dairy cow milk.

The variation of MUN values of each group in the selected weeks of experimental period are shown in Figure 01.

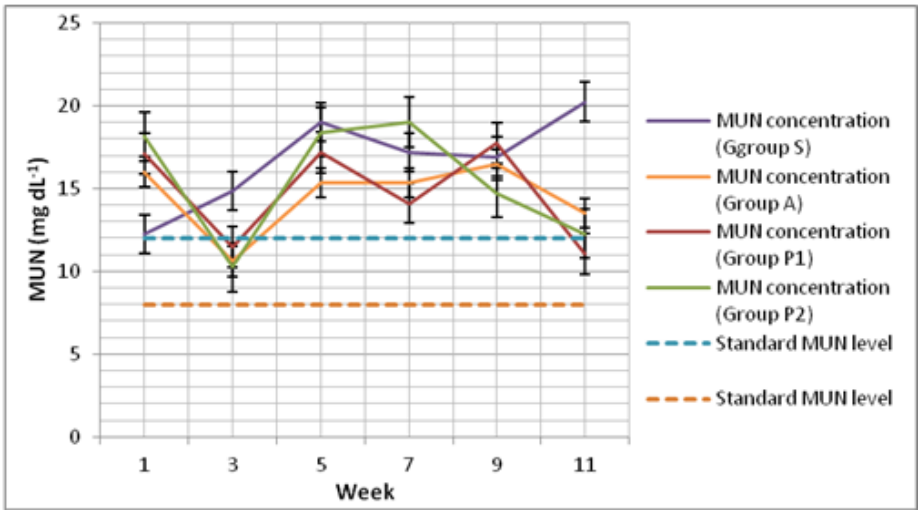


Figure 01: Average MUN concentrations of different groups during the experimental period

All the groups showed higher MUN values during the experimental period except in 3$^{rd}$ and 11$^{th}$ weeks. On the 3$^{rd}$ week, all groups and on the 11$^{th}$ week, group P1 and P2 showed MUN values close to the upper limit of Kohn (2007). However, on 11$^{th}$ week also group S and A showed higher MUN values than the reference range. Moreover, the analysis of mean MUN values of each group during the experimental period also revealed mean MUN values of each group is higher than the recommended levels of Kohn (2007) (Table 01).

The highest mean MUN value is recorded in Group S consisting highest producing cows. High levels of MUN are generally interpreted as an indication of inefficient utilization of protein, which is economically unfavorable. However, high MUN values could be found in high producing cows due to high protein provided with their rations. (Godden *et al*., 2001).

Feed formulation records of the farm did not indicated any higher deviations from the standard NRC recommendations for dairy cattle feeding. Therefore, the higher mean MUN values cannot be strictly interpreted along with inefficient utilization of protein. Hence, establishment of MUN reference range for Sri Lankan dairy herds for evaluation of efficient dietary nutrient utilization is an essential.

Table 01: Mean MUN values of different groups during the experimental period

| Group | Mean MUN ± SEM (mg $dL^{-1}$) | Standard deviation | Max (mg $dL^{-1}$) | Min (mg $dL^{-1}$) |
|---|---|---|---|---|
| S | 16.75 ± 1.17 | 2.87 | 20.24 | 12.25 |
| A | 14.53 ± 0.89 | 2.17 | 16.43 | 10.59 |
| P1 | 14.77 ± 1.23 | 3.01 | 17.72 | 11.04 |
| P2 | 15.46 ± 1.49 | 3.64 | 19.02 | 10.24 |

SEM- Standard Error of Mean

**Conclusion**

The mean MUN values of each milking cow group were higher than the recommended range indicating the inefficient utilization of protein in the ration given to these groups. However, the feed formulation records did not indicated higher deviations from the recommended nutritional requirements of these animals. Therefore, further research is needed to make the baseline levels of MUN to farms of Sri Lanka.

**Acknowledgement**

All the staff members of the Ambewela farm are gratefully acknowledged.

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# Comparison of broiler chick performance in single stage incubation and multi stage incubation

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## Introduction

Among livestock industries, poultry sector is widely spread throughout Sri Lanka. Chickens raised for meat purpose are broilers. In current broiler market, the competition is high. To face this competition, companies need to have strong production line with the companies. The main input of the broiler industry is day old chicks. The commercial operations depend on the hatcheries for the supplying of day old chicks. Hence, the hatchery should have considerable capacity to produce required amount of chicks to fulfill the demand using artificial incubation. Currently, the commercial markets have Single Stage (SS) and Multi Stage (MS) incubators. According to the specialists in the industry, the SS machines are more effective and efficient than the MS machine. To meet the competition successfully company need to establish an efficient machine type in incubation procedure. Therefore, the primary objective of this research is to compare the performance of broilers incubate in SS and MS incubators and to investigate the effect of SS and MS incubation on chick quality.

## Methodology

The hatching eggs were obtained from Cobb 500 female × Cobb 500 male broiler breeders at 54 and 64 week old age. The collected eggs were graded using egg grading machine. The eggs weighing 63 g – 80 g were selected in present study. The setter trays were taken from top, middle and bottom positions from both SS and MS machines. Setter trolleys were set in the Petersime® SS setter machine and Petersime® MS setter machine. After 18 days, incubated eggs were transferred to the hatcher baskets. At the transferring, the weight was measured and recorded. Weight loss was calculated. The hatcher trolleys were placed in Petersime® hatcher machines.

Chick pullout (hatch-out) was obtained at the 21 day of incubation. Live hatched chicks were counted and recorded separately. Thirty newly hatched chicks were selected randomly from the hatcher baskets. The hatch residuals were collected separately, stocks in egg trays and tagged them for break out analysis. Death chicks were recorded separately. Chick weight was measures separately in the replications by using weighing scale and recorded. Chick length was measured using standard chick ruler and recorded in centimetres. Pasgar© scoring method was done to analysis chick quality. Breakout analysis was done using hatch residuals. Then chicks were sent through the chick grading and counting machine. Chicks were packed in

paper laid plastic chick boxes as 50 sets and 100 sets.

Chicks were vaccinated with IB, ND and IBD vaccines. Chick boxes were stock in chick room separately as SS and MS. Then chicks were transported to the boiler farm. Chicks were brooded at the closed housed using gas brooder. All chicks were given similar environmental condition, same floor space, feed, and water. Brooding, feeding and watering were automated. Weekly body weight gain, Feed conversion ratio (FCR) and weekly mortality data were collected at the broiler farm level. At the farm level, data were collected from SS - close house and MS - close house.

**Results and Discussion**

There was no significant difference between initial eggs set for the two machine types. The eggs set for the SS were had $69.73\pm 4.26^{a}$ g of weight and $69.59\pm 3.93^{a}$ g of eggs were set for the MS machine. Hence, there was no significant effect of machine type to the results obtained throughout the experiment. Yet, there was a significant relationship between machine type and weight loss. The highest weight loss was shown in eggs set in MS machine. Weight loss in SS machine was $9.1\pm 3.7^{b}$ and MS was $11.5\pm 3.5^{a}$. The results obtained for the weight losses can be between 9 – 11% (Metzer, n.d.). The weight loss from SS and MS machines were lined within 9 – 11%. There was a significant different between two means ($P < 0.05$) of the chick weight. The MS incubated Day old chicks were shown a higher chick weight of $48.4\pm 3.5^{b}$ g than SS incubated chicks (Table 01).

According to a study, the chicks have divided in to three groups and they were 18.0 – 18.3 cm as middle group, higher than 18.3 cm as large group and less than 18 cm as small group (Table 01). A positive correlation between chick Length and chick weight was observed at day zero of age (Petek, *et al.,* 2010). The SS incubated chicks have lower FCR with compared to the MS incubated chicks in days 7 and days 14. There was a similar mortality percentage (1.3%) in SS and MS incubated chicks in the first week and no mortality in the second week at the brooding. Table 1 showed there was no significant difference between hatchability and fertility.

Table 01: Effect of incubation type on Weight loss, Day old chick weight, Chick length, Hatchability, Fertility and Average feed conversion ratio

| Parameter | Incubation Type | |
|---|---|---|
| | Single-stage | Multi-stage |
| Weight loss (%) | $9.10\pm 3.7^{b}$ | $11.50\pm 3.50^{a}$ |
| Day Old Chick weight (g) | $47.10\pm 3.5^{b}$ | $48.40\pm 3.50^{a}$ |
| Chick length (cm) | $19.20\pm 0.58^{a}$ | $19.10\pm 0.59^{a}$ |
| Hatchability (%) | $81.67\pm 2.21^{a}$ | $82.08\pm 2.63^{a}$ |
| Fertility (%) | $92.50\pm 1.48^{a}$ | $92.00\pm 3.57^{a}$ |
| Average Feed conversion ratio | 0.92 | 0.98 |

Means not labeled with letter a are significantly different from control level mean ($P<0.05$)

There was a significant different ($P<0.05$) in broiler weight gain. SS incubated chicks have been obtained higher body weight gain than the MS incubated chicks (Figure 01). It was a 19.23 g of body weight increment compared with the MS incubated chicks.

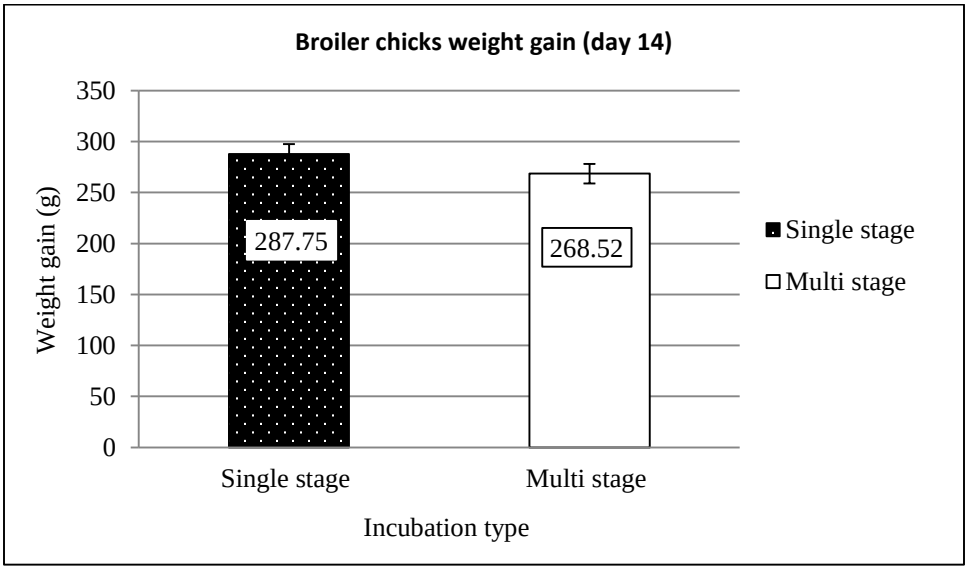


Figure 01: Bar chart of the broiler weight gain versus incubation

**Conclusion**

Multi stage incubated chicks have higher chick weight and incubation has effect on the broiler performances. Single stage incubated chicks show high quality than multi stage incubated chicks and incubation has effect on quality. Single stage incubated broilers show higher weight gain at the brooding time and incubation has affect to the broiler performances.

**Acknowledgement**

The hatchery of the Bairaha Farms PLC, Pasyala and Opathalla Boiler Farm, Opathalla are gratefully acknowledged.

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# Potential to use extracts from *Lawsonia inermis* (Marathondhi) leaves and *Emblica officinalis* (Nelli) fruits as tannin agents in leather manufacturing

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## Introduction

In Sri Lanka mainly mimosa bark powder and chesnut powder are used to produce vegetable tanned leather. However, these tannin agents can produce limited number of colors and are imported to Sri Lanka with high import cost. As a result, final vegetable tanned leather products become high in price. Thus, it is necessary to find out locally available, low cost tannin agents to produce vegetable tanned leathers. *Emblica officinalis* (Nelli) fruits and *Lawsonia inermis* (Marathondi) leaves are two such locally available tannin agents with considerably high tannin content (nelli fruits-18-35 % (Pushpakumara and Heenkenda, 2012) and Marathondi leaves- 11.12% (Musa, 2012). Therefore, the objective of the present study was to assess the quality of leather prepared using locally available tanning agents, Marathondhi leaves and Nelli fruit extracts.

## Methodology

3.6 kg of marathondi leaves and 1.2 kg of nelli fruits were first crushed and ground separately. Then it was mixed with 3 L of water and was filtered into separate containers. Same tannin concentration (5 backometer value) was maintained in all containers. Further, a mimosa solution with same concentration was prepared as the control.

Then, the buffalo hides were, soaked, dehaired and delimed and partial pickling was also done prior to the tanning according to the leather manufacturing procedure of Ceylon Leather Products PLC. Then, nine hide pieces with 6 x 7 inch was selected from same area of these buffalo hides. Weight and thicknesses of each piece was measured and recorded. After that, solutions were added into separate containers and three pieces of hide were dipped in each container.

After hides were dipped, concentration of each solution was increased by 5 backo every four days up to four weeks. Tannin penetration was also measured until it obtains 3 mm. After finishing process, physical parameters, mean penetration rate (mm/day), thickness, mean yield of the leather (%) and mean tensile strength was measured in all treatments and was compared with control. Completely Randomized Design (CRD) was used to allocate treatments and data

analysis was done using Minitab 15 software. Analysis of Variance (ANOVA) was used for comparison of data at (significance level of 95%) and. Dunnet's procedure was used for mean separation. Sensory evaluation was conducted to select the best tannin agent based on the appearance, hardness, fullness and overall acceptability of finished leather using 10 trained panelists and results of the sensory evaluation after analysis by Friedman test.

**Result and Discussion**

During tanning of hides Nelli tannin media was seen as light cream color whereas control (Mimosa) and Marathondi media were darker in color. Though, Nelli and Mimosa media had pleasant smell, Marathondi had an unpleasant smell. Nelli was more acidic (pH 3.2) and pH values of Mimosa and Marathondi were pH- 4.6 and pH 4.3, respectively. After the tannin process, loose grain was observed on the Nelli treated hides. Mean penetration rate, yield, thickness reduction and tensile strength were measured as physical parameters (Table 01).

Table 01: Mean values of physical parameters of leather treated with tannin agents, Mimosa, Nelli and Marathondi

| Treatments | Mean values | | | |
|---|---|---|---|---|
| | Penetration rates ($mmday^{-2}$) | Yield of the leather (%) | Thickness reduction (mm) | Tensile strength of the leather ($Nmm^{-2}$) |
| Mimosa (Control) | $0.29\pm0.02^{a}$ | $51.27\pm3.84^{a}$ | $0.17\pm0.06^{a}$ | $270.00\pm6.00^{a}$ |
| Nelli (Treatment 1) | $0.20\pm0.00^{b}$ | $44.15\pm4.35^{a}$ | $3.43\pm0.25^{b}$ | $517.33\pm54.86^{b}$ |
| Marathondi (Treatment 2) | $0.13\pm0.00^{b}$ | $43.45\pm3.82^{a}$ | $1.23\pm0.15^{b}$ | $262.33\pm7.37^{a}$ |

$^{a,b}$ means with same letter are not significantly different

According to Dunnet's mean separation procedure, highest mean penetration rate was recorded in Mimosa compared to other two treatments ($P< 0.05$). The studies indicated that tannins first approach the surface of collagen fibers by hydrophobic bonding, and then combine with collagen fibers by multi-hydrogen bonding (Zhongbing, 2003). However, the other components of plant extracts, including polyphenolic compounds with small molecular weight, are not able to form multi-hydrogen bonding with collagen fibers due to the fact that they have no enough phenolic hydroxys or are lack of structure of ortho-phenolic hydroxys (Zhongbing, 2003). Therefore, they have relatively weaker adsorption capacity on collagen fibers. Thus, molecular weights of tannin agents are important for tannin penetration into the hides. Nelli and Mimosa have tannins with higher molecular weight compare to Marathondi. Molecular weight of tannin agents in Mimosa and Nelli are 1250 and 782.52, respectively (Pushpakumara and Heenkenda, 2012). However, molecular weight of tannin agents in Marathondi (gallic acid) is 170.17 (Musa and Gasmelseed, 2012). Therefore, these can be reasons for low penetration rates of tannin in to hides.

Yield of the vegetable tanned leathers is important since it determines the price of the leather. However, there is no any significant difference (P>0.05) between mean yields of the leather. Thickness of the hide needs to be lowered after drying. Lowest mean thickness reduction was observed in Mimosa (P< 0.05).

Highest mean tensile strength was observed in Nelli followed by Mimosa and Marathondi. According to these results, mean tensile strength of Nelli is significantly different (P<0.05) from other two treatments. Nelli contains hydrolysable tannins whereas Mimosa and Marathondi mainly contain condensed tannins (Pushpakumara and Henkenda, 2012). Since, hydrolysable tannin agents give more strength to leather compare to condense tannin type of tannin agent present in Nelli can be the main reason for the results obtained.

When measuring qualitative parameters best appearance was recorded in Nelli treated leather whereas fullness, hardness and overall best leather were reported in mimosa treated leather (Figure 01).

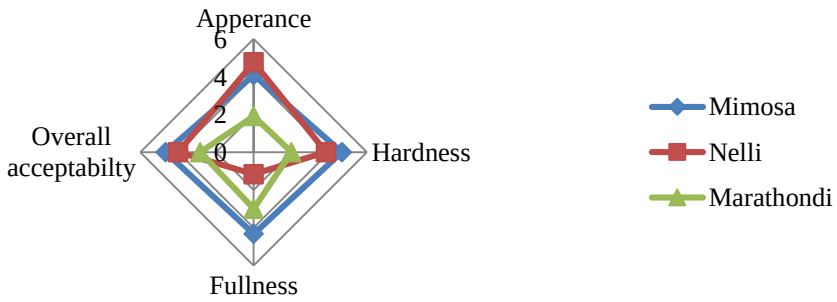


Figure 01: Sensory evaluation for all qualitative parameters

**Conclusions**

Mimosa is the best tannin agent to produce sole leather compare to other two treatments, Nelli and Marathondi.

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# Performance evaluation of different broiler strains under environmental controlled broiler house in Sri Lanka

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## Introduction

Broilers are bred and rose specifically for meat production. Hubbard breed is mainly used to produce meat in large scale farms. They are imported from Europe. CIC farm is one of the large scale farms in Sri Lanka and they are rearing two different strains; Hubbard Flex and F 15 under environmental controlled broiler house system. The aim of this study is to compare and find the best strain in assessment of body weight, growth rate, mortality and feed conversion ratio between Hubbard Flex and F 15.

## Methodology

The experiment was conducted in closed house at C.I.C. poultry farms (Pvt.) during 2nd May to 14th June 2014. Five hundred day old broiler chicks (Hubbard Flex and F 15) from hatchery were used in the total experiment. Each (250 Flex + 250 F 15) were considered as two treatments. Each treatment was divided into 5 subgroups as replicates as fifty birds per each. Separation was made without including automated feeder line by using plastic boxes.

Before placing, initial weight of the premium category birds were recorded and then adequate amount of feed was given separately. According to the space requirement feeders and waters were used to each separation. Unlimited feeding was done throughout the study period (42 days). All the birds were vaccinated through drinking water against Newcastle disease and Gumboro disease. Same conditions and feed were maintained for each group.

Group feed intake, Average body weight were measured daily until slaughtered at 42nd day. Average weight gain and Feed Conversion Ratio (FCR) of bird was calculated during period of growing birds. Mortality, if any, during the rearing period was recorded. Feed intake was calculated as the difference between the amount of feed supplied and the amount of feed that remained at the end of each feeding period. Feed conversion (feed: gain ratio) was calculated as the ratio between feed intake and body weight gain every day. The experimental data were processed and analyzed using Microsoft Office Excel (2007) and Minitab16 software. Performances of two groups were compared using two sample t tests. Mean comparison was used to find the best strain in performance.

## Result and Discussion

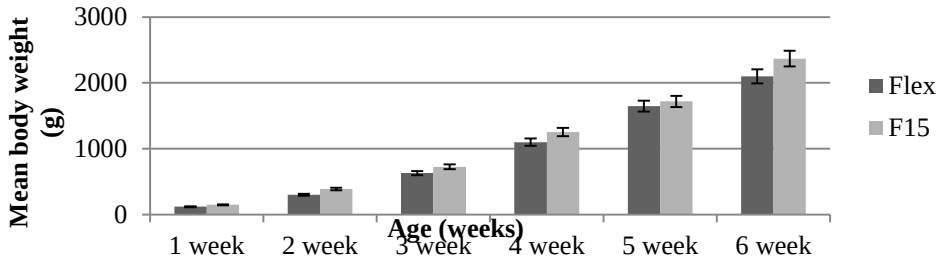


Figure 01: Body weight of Hubbard Flex and F15

When consider the body weight of the broilers there was significant (P<0.05) difference among the treatments in first week, second week, third week, fourth week and sixth week. However, there was no significant (P>0.05) difference among the treatments in fifth week (Figure 01). Average body weight of Flex and F 15 was increased throughout the rearing period. However, F 15 was shown the highest mean body weight than Flex broiler chicken throughout the rearing period.

When consider the feed intake of the broilers in weekly basis, there was no significant (P>0.05) difference among the treatments in third week, fourth week, fifth week and sixth week. However, there was significant (P <0.05) difference among the treatments in first and second week. Mean value of F 15 was shown the highest mean of feed intake with in 1st and 2nd week. Mainly the first two weeks were considered as brooding period which was helped to increase the performance throughout the rearing period.

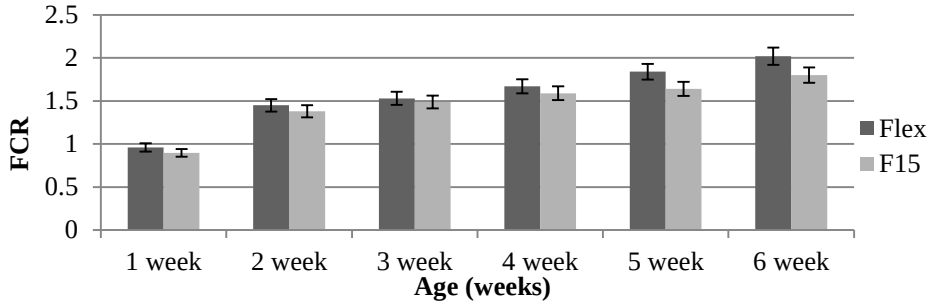


Figure 02: Feed Conversion Ratio of Hubbard Flex and F15

According to the Figure 02, feed conversion ratio was shown significant (P<0.05) difference between two treatments within 2nd, 5th and 6th week with that highest mean of feed conversion ratio was recorded in Flex treatment. F15 broiler chicken was shown higher feed conversion efficiency than flex broiler chicken throughout the rearing period. Feed Conversion Ratio was increased with increasing age of birds in both treatments.

According to the analyzed data weight gain was shown significant (P<0.05) difference between the Hubbard flex and F15 commercial broiler chicken with in first, second and sixth weeks. (Figure 03) Weight gain did not show significant (P>0.05) difference among the

treatments with in third ,fourth and fifth week throughout the production period, The highest mean values in weight gain was shown in F 15 in last week of the production which is the most important traits because that will give high profit to the farm.

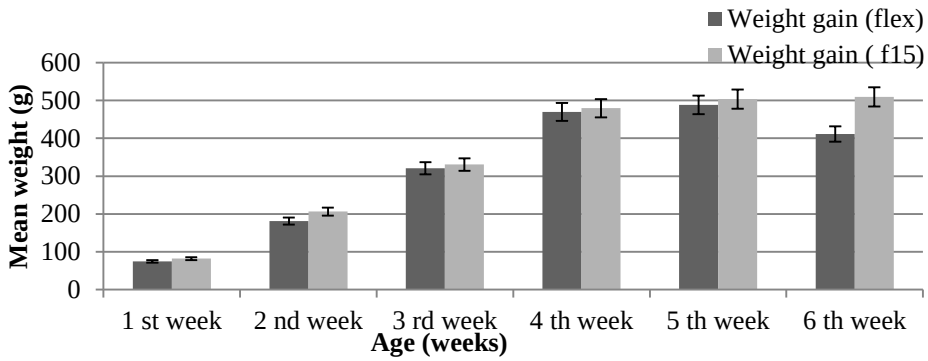


Figure 03: Weight gain of Hubbard Flex and F15

Flex group was shown the highest mortality percentage than F15 group. Mortality during the whole rearing period was higher in Hubbard Flex. The number of deaths in Hubbard F15 chickens was lower, which may indicate that these birds had better immunity. Mikulski *et al.* (2011) observed a similar tendency and have found mortality to be higher in fast-growing Hubbard F15 compared to slow-growing Hubbard JA 957 chickens (6.03 vs. 2.50%).

**Conclusions**

It can be concluded that F15 commercial broiler strain was superior in body weight and weight gain during the study. The feed efficiency and FCR were related negatively. Strain F15 was adjusted good and profitable because the strain had the highest mean values in body weight and feed efficiency coupled with the lowest FCR at maturity. Strain F15 could be recommended to poultry farmers in study zone for highe productivity and maximum profit.

**Acknowledgement**

Management staff of CIC poultry farm (PVT) Ltd is gratefully acknowledged.

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# Development of Fishmeal using Knifefish *Chitala ornata*

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## Introduction

Knifefish (*Chitala ornata*) is a freshwater fish introduced to Sri Lanka as an aquarium ornamental fish in 1980's (Gunawardena, 2007). They were introduced to wild habitats by accidental release and now found in the rivers and lakes in Colombo and Kalutara districts (Sriyananda, 2004). The predatory nature of the knifefish and its ability to spread fast has posed a threat to native aquatic animals in Sri Lanka, especially to endemic species. At present, knifefish is listed as one of the invasive alien species in Sri Lanka (Gunawardena, 2007). Due to their large size and predatory nature, they have lost demand as aquarium fish and they have no demand as food fish. Hence, in order to eliminate these fish from wild habitats a new use should be introduced which would encourage the fishermen to catch them. In this research the possibility of using knifefish to produce fishmeal which could be used as a protein source in fish feed was evaluated.

## Methodology

Knifefish for the experiment was collected from Kalutara area. Large bones and skin were removed and flesh was sun dried for 4-5 days. Dried flesh was ground and sieved to produce fishmeal powder. Two experimental diets were prepared as treatment 1 (containing Peliyagoda fishmeal) and treatment 2 (containing knifefish fishmeal) using the trial and error method. Other ingredients used were wheat flour, soyabean meal, rice bran and fish oil. Both diets were formulated to contain 30-35%. Proximate analysis was done for the ingredients and the two diets. Feeding trial was conducted for 20 days using guppies (2.34 ±0.24 cm), male and female separately. Three replicates were used for each treatment. Length and weight of the fish were measured weekly. At the end of the experiment Feed Conversion Ratio (FCR), Specific Growth Rate (SGR), weight gain and protein efficiency ratio (PER) were determined. Production cost of 1 Kg of each diet was calculated and compared. Statistical analysis was done using two-way ANOVA using minitab16 software.

## Results and Discussion

Proximate compositions of the two diets are shown in Table 01. As shown by table 2 there was no significant difference between mean values of the two treatments with respect to FCR, SGR, weight gain or the PER. There was also no effect of the interaction between the sexes and the treatments on the above parameters ($P>0.05$) according to the results of the two-way

ANOVA. Therefore, it is possible to use knifefish fishmeal as a substitute for Peliyagoda fishmeal in fish diets.

Table 01: Proximate composition of experimental diets

| Component | Treatment 1 (%) | Treatment 2 (%) |
|---|---|---|
| Protein | 33.30±0.34 | 35.29±1.74 |
| Lipid | 7.98±0.22 | 4.25±0.43 |
| Moisture | 2.34±0.42 | 2.27±0.16 |
| Ash | 22.05±0.10 | 15.82±0.23 |

Treatment 1- diet with Peliyagoda fishmeal, Treatment 2- diet with Knifefish fishmeal

Table 02: Mean values of the parameters

| Treatment | Sex | FCR | SGR | WG | PER |
|---|---|---|---|---|---|
| Treatment 1 | Male | 3.46 ±0.40 | 1.82 ±0.41 | 0.05 ±0.01 | 2.3 ±0.29 |
| Treatment 1 | Female | 2.00 ±1.30 | 1.71 ±0.52 | 0.05 ±0.01 | 1.8 ±0.11 |
| Treatment 2 | Male | 2.61 ±0.33 | 2.28 ±0.33 | 0.06 ±0.01 | 2.2 ±0.98 |
| Treatment 2 | Female | 2.00 ±1.10 | 1.95 ±0.06 | 0.05 ±0.00 | 2.7 ±1.14 |

FCR- feed conversion ratio, SGR- specific growth rate, WG- weight gain, PER- protein efficiency ratio

When the production costs of 1 Kg of each diet were compared, it was more expensive to produce the diet with knifefish fishmeal than with Peliyagoda fishmeal. This was due to the high cost incurred on the production of knifefish fishmeal. If the whole fish was used for the production of fishmeal instead of using only the flesh, cost of production could be reduced. However results of the proximate analysis showed higher ash content in Peliyagoda fishmeal (26.6±0.25) which shows that it contained higher amounts of impurities in contrast to the composition of knifefish fishmeal (7.55±0.07) which contained only the flesh of the fish.

**Conclusion**

Knifefish fishmeal and Peliyagoda fishmeal have similar protein efficiency ratios and similar effect on growth of guppy. Therefore it is suitable to be used as a protein source in guppy feed. Domestic production of feed using knifefish fishmeal by fishermen could be encouraged.

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# A study on microbial contaminations, sources and preventive measures in salted butter production in a commercial dairy plant

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## Introduction

Dairy fat spreads are milk products relatively rich in fat in the form of a spreadable emulsion principally of the type of water-in-milk fat that remains in solid phase at a temperature of 20 °C (Codex Standard for Dairy Fat Spreads, 2006). There are two kinds of butter as sweet cream and ripened-cream. Sweet cream butter may or may not contain salt (Fernandes, 2008). To overcome the high demand of butter, a reputed dairy company in Sri Lanka engages in manufacturing salted butter. However, finish product frequently contain high microbial load before releasing to the packing which leads to quick rancidity. Consequently, it has become a problem to the company to obtain a profit. Therefore, this research was carried out to assess microbiological quality at different production steps to determine the sources of microbial contamination in salted butter production.

## Methodology

A preliminary study was carried out to identify possible sample collection points including swab sampling points during production process. Samples were collected from raw cream, before and after pasteurization, after aging, during churning, final product, and wash water of butter granules and the churner. Swab samples were collected from cream and aging vats, hands of permanent workers (randomly), and inside and outside of the churner. Time and temperature during storage of cream in the cream vat, pasteurization and aging were recorded. Sample collection procedure was repeated for every batch up to identification of the contamination points. Quality of samples was evaluated by performing microbiological tests (total colony count, Coliform and fecal Coliform). According to the test results, contamination points were identified and microbiological (*E. coli*, yeast, and moulds), chemical (free fatty acid level of the final products) and physical (foreign matter observed from naked eye) properties were further analyzed. Entire tests were conducted in triplicate according to the analytical testing procedure of company. Data were finally analyzed by mean value comparison using Microsoft Excel 2013. Further, analyzed data were compared with the standards (SLS 279:1988).

## Results and Discussion

According to the preliminary analysis, raw cream was stored for 4-5 hours at 7-8 °C in a cream vat. Mean total colony count in raw cream of seven batches was ranged from $110\times10^6$ to $127\times10^6$ cfu/g and Coliform and fecal Coliform bacteria were detected in all samples tested. After pasteurization (95 °C, 20 minutes), mean total colony count of all samples were lower than $10^4$ cfu/g and after aging (5-7 °C, 12 hours) (Table 01). *Coliform* and fecal *Coliform*

bacteria were detected in all samples tested however, after pasteurization and aging, *Coliform* and fecal *Coliform* bacteria were not detected in any of the samples.

Table 01: Average total colony counts (cfu/g) of raw cream

| Batch no. | B. P ($\times 10^6$) | A.P ($\times 10^3$) | A.A ($\times 10^3$) |
|---|---|---|---|
| A | 111±9.07 | 66±7.37 | 65±3.21 |
| B | 124±7.00 | 49±14.98 | 52±5.69 |
| C | 129±2.52 | 49±16.29 | 52±9.50 |
| D | 131±3.05 | 57±8.39 | 59±2.00 |
| E | 118±12.34 | 41±8.19 | 44±3.05 |
| F | 119±2.08 | 34±3.00 | 40±2.08 |
| G | 126±3.00 | 46±3.51 | 53±6.03 |

B.P-Before Pasteurization, A.P-After Pasteurization, A.A-After Aging

Before churning, the mean total colony counts in aged cream were ranged from $44\times10^3$ to $67\times10^3$ cfu/g in all samples. However, after washing, the mean total colony count was decreased to a range of $19\times10^3$ to $53\times10^3$ cfu/g. Before churning, *Coliform* bacteria were not detected in samples tested (except B). However, "before washing" *Coliform* bacteria were detected in the four samples (A, C, D and G). Furthermore, products after washing and final products from these four batches contained *Coliform*. *Coliform* bacteria were not detected in chilled pasteurized water samples (0-2 °C). However, *Coliform* was detected in swabs taken from inside of churner in A, B, C, D and G batches. Swabs obtained from outside of churner and random swab samples of the permanent workers' hands were negative for *Coliform.* Thus, churning process was identified as the contamination point of *Coliform* during salted butter production and samples collected from contamination points from new four batches were further analyzed.

The mean total colony counts in four batches were ranged between 30 × 103 – 64 × 103 cfu/g. During churning, the mean yeast counts ranged from 137 to 670 cfu/g and mould counts ranged between <10 and 50 cfu/g in samples of tested batches. However, before washing, Coliform bacteria were detected in the samples of A1, B1, D1 batches. Further, Coliform was detected after washing and in final product of same batches. Coliform bacteria were not detected in chilled pasteurized water samples (0-2 °C) used to wash the butter granules in all four batches during churning. In swabs analysis; Coliform was detected in swabs taken from inside of churner in A1, B1, D1 batches. However, swabs obtained from outside of the churner were negative for Coliform. This confirms the results of the preliminary analysis which was due to improper sanitary conditions of the churner inside. Hence, water used to wash the churner (before production) was also analyzed. Results showed that this water (27-30 °C) contained Coliform in batch A1, B1, and D1.

To prevent the contamination, hot water and steam cleaning implementation was done during washing. According to the Robinson and Tamime (2002), hot water and steam were the best sanitizers against gram-positive and gram-negative bacteria and yeast. Cords and Dychdala (1993) reported that combination of hot water and steam are more efficient than dry heat. Therefore, samples from four batches; A2, B2, C2, and D2 of salted butter were analyzed after the implementation of hot water (70-75 °C, 15 minutes ) and steam (80-85 °C, 5 minutes)

cleaning. Further, samples from six batches; A3, B3, C3, D3, E3, and F3 of salted butter were analyzed after implementation of hot water and steam treatment as above. In wash water analysis; Coliform bacteria was not detected in both samples. In swabs analysis; Coliform bacteria was not detected in swabs taken from the inside and outside of churner. With the increasing water temperature, the mean total colony count was reduced in both tested batches. Yeast and moulds counts were within the standard level except B2. After implementation of hot water and steam treatments, samples of tested batches were within the standard level. Coliform were not detected in all samples tested. White (1996) stated that, Coliforms were destroyed by pasteurization therefore according to the analysis; product had not been contaminated after pasteurization, due to implementation of hot water and steam.

In chemical analysis; before implementation of the hot water and steam, the mean free fatty acid level of the final products were ranged between 0.22 and 0.52 and only one batch was within the standard level among the tested batches. After implementation of hot water (70-75 °C) and steam, it was ranged between 0.29 and 0.40 and after implementation of 75-80 °C hot water and steam; it was ranged between 0.24 and 0.30. Accordingly eight batches (among ten batches) were within the standard level. Moreover, with the temperature increment of the wash water, free fatty acid level of the final product was lower than the previous. Furthermore, no physical contaminants were observed in all tested batches.

**Conclusion**

Water used to wash churner was the main contamination source of Coliform in salted butter production. Microbiological and chemical quality of salted butter can be improved by using hot water (75-80 °C, 15 minutes) and steam (80-85 °C, 5 minutes) for cleaning the churner.

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# A Study on Crocodile Behavior (*Crocodylus palustris*) and Public Value Orientation in Ethimale of Monaragala District

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## Introduction

Mugger crocodile (*Crocodylus palustris*) is principally restricted to Indian subcontinent and the highest number is recorded in Sri Lanka (Da Silva and Lenin, 2010). *Crocodylus palustris* is categorized as a vulnerable species in IUCN red list (2011). Furthermore, due to destruction of their natural habitats, illegal hunting, fishing activities and crocodile attacks during sand mining, bathing and washing, there is an emergence of this interaction as a human-crocodile conflict. Though the existence of considerable number of *C. palustris* is recorded in Uva less literature is available on their status in Uva Province of Sri Lanka. Therefore, this study was conducted to understand people's attitudes, risks, believes and practices towards human crocodile conflict and to study the behavior of crocodile in Ethimale area.

## Methodology

The study was conducted in villages surrounding eight perennial and seasonal tanks (Doser tank, Wattarama tank, Kotiyagala tank, Heekaduwa tank 1 and 2, Karadandara tank, Karakolagaswewa tank and Vila oya) at Ethimale of Monaragala district from May to August 2014. Ninety four individuals were interviewed using a pre-tested structured questionnaire including farmers, fishermen and villagers to determine their awareness, knowledge, practices, believes and attitudes regarding *C. palustris*. The information on purpose, frequency and duration of water body usage by the villages, crocodile population, their approximate size, migration and their availability throughout the year in the area was gathered through the questionnaire. Moreover, the practices of the people and attitudes regarding crocodiles were identified by gathering information on crocodile attacks, financial damages, people's reaction when seen crocodiles, offending actions, benefits/uses of crocodiles and threats face by crocodiles. Presence of fecal pellets, footprints, smashed vegetation and cleared basking areas were observed to study the migration and basking behavior. Data analysis was carried out by Microsoft Excel and map was created using ArcGIS software including crocodile migration paths.

## Results and Discussion

### Awareness of the people

The main water sources of Ethimale were tanks and Vila oya. Therefore, around 97% of the respondents used tanks for their needs daily. Moreover, most of households are by or close to the tanks which explains their close relation with the crocodiles.

### Knowledge of the people regarding crocodiles

Sixty eight percent of the respondents considered that crocodiles were useful and 32% of respondents believed that crocodiles were not useful or did not know the ecological roles played by the crocodiles. According to them, consumption of crocodile meat and egg are the major uses. Around 53% of the respondents have eaten crocodile meat while 5.3% have consumed crocodile eggs. Though few had heard the uses of crocodile hide they have not done any hide processing.

Though the respondents have seen crocodiles throughout the day, crocodiles were common on tank sides especially in the morning (6.00 to 8.00 a.m.) and evening (5.30 to 7.00 p.m.). Based on the observations of the respondents, highest crocodile number was reported from Kotiyagala tank (20 to 25), followed by Heekaduwa tank-1 (15 to 20) and Heekaduwa tank-2 (10 to 15). Regarding the approximate length of the largest crocodile seen by the respondents, majority (62%) of has seen largest crocodile in between 2-3 m in length.

Nesting season, i.e., from June to August of *Crocodylus palustris* coincides with the dry season in Monaragala (June to September) (Department of meteorology statistics, 2014). Therefore, the hatching of eggs takes place with the beginning of the rainy season. Around 45% of the respondents have seen crocodile nesting sites at tank bunds, Vila oya sides, canal sides, Vila oya anicut and jungle area which close to tanks.However, 11% of respondents have seen Water Monitors (*Varanus salvator*) and Land Monitor (*Varanus bengalensis*) as main predators of crocodile eggs.

Among the crocodile deaths observed by the respondents, most of the recorded crocodile deaths were due to human actions such as shooting and hitting when the crocodiles attack to the fishing nets (Specially for hatchlings). Two crocodile attacks to the fishermen while fishing were reported. However, 37% of the respondents have faced some financial damages from the crocodiles as damage to livestock (especially to calves) (37%), loss of fish yield (29%), fish net damage and damage to pet animals. Among them damage to livestock and damage to net and loss of fish yield were common. Moreover, threat from crocodiles was reported as one reason to refrain youngsters from fishery.

**Attitudes regarding crocodiles**

Though 77% of the respondents have agreed that the crocodiles have become threat to fishery or daily uses of the water body, 73% of the respondents still believe that conservation programs for crocodiles are essential, since they believe that the number of crocodiles are depleting annually. Moreover, they have suggested translocation of crocodiles (to large tanks, national parks and zoo) and ecotourism to minimize the human crocodile conflict may be due to the ethical reasons since all the respondents are Buddhists.

**Crocodile migration and basking behavior**

Crocodiles were migrated during the dry season and they were returned to their original habitats at the beginning of the rainy season. Therefore, crocodile migration was highest during August where all most all the seasonal tanks were dried and low water level was observed in perennial tanks. With the beginning of rainy season in September, crocodiles were returned to their original habitats.

Crocodiles were basked commonly during 6.00 am to 9.30 am under direct sun light (average 33°C daily temperature) in open areas such as dead trees in water, on the Vila oya river bank, tank sides/bund and surrounding rocks. With the high day time temperature, they were moved to the tank bottom and come to the top only for breathing meanwhile some crocodiles were moved to burrows.

**Recommendations to solve human crocodile conflict and conservation**

To minimize human-crocodile conflict conducting awareness program to villagers including conservation and laws related, installation and maintenance of crocodile excluding areas at bathing places, installing warning sign boards and translocation of crocodiles which trap to fish nets can be done. The crocodile conservation can be done to some extent by sharing conservation and management responsibility among local community. The crocodiles can be an attraction of visitors and create employment opportunities for the local community. Eco-tourism may be a good solution for involving people with their traditional knowledge about crocodile conservation and will be helpful to uplift the local socio-economic conditions. Other than eco-tourism, protection of nesting habitats, initiation of crocodile parks or sanctuary, conservation education and public awareness also can be practiced.

## Conclusion

Majority of the villagers have sound knowledge regarding crocodile population, behavior, migration patterns and availability. Since almost all the people were engaged with the tanks for their daily needs and majority was farmers and fishermen. Though there are several livestock attacks and economic losses from crocodiles no fatal attacks recorded to people. Therefore, majority of the people in Ethimale was having a positive attitudes regarding conservation of crocodiles.

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# Development of Tomato (*Solanum lycopersicum*) Incorporated Fish Nuggets

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## Introduction

Modern consumers prefer processed foods and the changes in consumer life styles have resulted in increasing demands for ready-to-eat and ready-to-cook seafood products (Venugopal, 2005). But due to high post-harvest losses and busy life style fish consumption has reduced gradually in Sri Lanka. Therefore value added fish products have become familiar among most consumers (Sri Lanka Fisheries Year Book, 2009). Fish nuggets are formed meat product in ready-to-cook form and it is a good substitute for above situations.

Most of the people nowadays concern more about their health and prefer to have healthier diets. Tomato is considered as one of the healthiest vegetable and fruit in the world (American Cancer Society, 2014). Tomato contains carbohydrates and several vitamins such as Vitamin A, Thiamine, Niacin, Vitamin B6, Vitamin C and Vitamin E. In addition, tomatoes possess one of the most powerful antioxidants, lycopene (Choski and Joshi 2007; Kavanaugh et al., 2007). It has shown a wide variety of positive health benefits, including a reduced risk of cancer (American Cancer Society, 2014). Therefore tomato incorporated fish nuggets contain more health benefits and deliciousness due to incorporation of tomato. On the other hand, the production of value added fish products using locally available resources is important for the wide range of consumers and manufactures and it is also important to fulfill the market gap by production of healthier fish based formed meat product in ready-to-cook or ready-to-eat forms. The objective of this research is to develop a tomato (*Solanum lycopersicum*) incorporated fish nugget with higher levels of antioxidants.

## Methodology

Initially, the basic composition of fish nuggets was determined. The ingredients for fish nuggets were identified and new recipes were formulated based on different fish percentages (30%, 35%, 40% and 45%). After production fish nuggets, a sensory evaluation was carried out using 10 trained panelists to find the best combination. For selection of the best heat treatment for tomatoes, keeping qualities (pH, titratable acidity, moisture content and salt content) and sensory qualities of different heat treated tomato pastes were evaluated. Boiling (10 min, 100 $^{o}$C), microwave-cooking (50 s, 800 W) and steaming (10 min) were selected as the best heat treatments (Kamiloglu *et al*., 2013). After selecting the best heat treatment for tomatoes, the best level of tomato paste to be incorporated in to the selected fish nugget recipe

was determined by a sensory evaluation. Tomato paste was incorporated at 5%, 8%, 12% and 15% (w/w) (Deda *et al*., 2007).

Tomato incorporated fish nugget and fish nugget without tomato incorporation (control) were further analyzed for its physicochemical properties and microbiological quality. Proximate composition, pH value and water holding capacity of the final product were determined. Microbiological analysis was done for *Escherichia coli, Staphylococcus aureus*, Total Plate Count (TPC) and Yeast and Moulds. Sensory data were analyzed according to the Friedman test using MINITAB 15 software package. Data obtained from melting tests were analyzed by analysis of variance using MINITAB 15 software package.

**Results and Discussion**

45% fish incorporated fish nugget sample was selected as the best sample. According to the sensory evaluation, there was significant difference ($p<0.05$) among treatments. Then 45% fish incorporated fish nugget sample was used as the control. According to another sensory evaluation and keeping quality evaluation, boiling (10 min, 100 $^{o}$C) was selected as the best heat treatment for tomato paste. The results of the above mentioned sensory evaluation showed that there was significant difference between different heat treatments of tomato paste related to the quality parameters such as appearance/ color, aroma flavor/ taste and mouth feel ($p<0.05$). According to the results (Figure 01), there was significant difference between fish nugget samples with different tomato incorporation levels related to the organoleptic properties such as appearance, color, taste, texture and overall acceptability ($p<0.05$). Finally 12% tomato incorporated fish nugget sample was selected as the best.

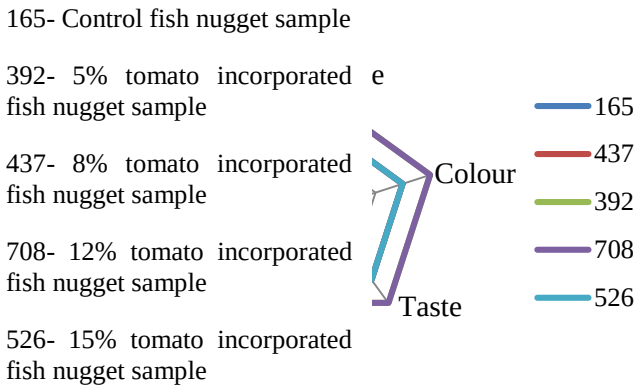


Figure 01: Web diagram of sensory evaluation on different levels of tomato incorporation in fish nugget

The composition of tomato incorporated fish nuggets is given in Table 01. The total solid, organic non-fat, moisture, crude protein and ash contents of the samples were significantly different ($P<0.05$). But crude fat content of the samples were not significantly different ($P>0.05$). Tomato incorporated fish nugget sample was contain high amount of crude protein and moisture. This may be due to the incorporation of tomato paste in the fish nuggets.

Table 01: Proximate composition of the samples

| Test Parameters % | Fish nugget sample | Tomato incorporated fish nugget sample | Standard Limits |
|---|---|---|---|
| Total Solids | 49.01±0.05 | 45.96±0.1 | 45% (min) |
| Crude Fat | 10.05±0.14 | 9.70±0.16 | 15% (max) |
| Organic Non Fat | 36.30±0.21 | 33.79±0.12 | 32.5% (min) |
| Ash | 2.66±0.06 | 2.47±0.04 | 2.7% (max) |
| Moisture | 30.99±0.05 | 34.04±1.0 | 40% (max) |
| Crude Protein | 27.37±0.14 | 27.71±0.04 | 25% (min) |

Microbiological analysis revealed, though the microbial count was increased with the time, microbe count of tomato incorporated fish nuggets were within the SLSI requirements. There was a positive effect on reduction of microbial count by frying of fish nuggets. Cost analysis indicated that cost of 1 kg of tomato incorporated fish nuggets is Rs.325.00.

**Conclusion**

12% (w/w) is the best level for the incorporation of tomato in to fish nuggets. The analysis of the chemical composition in tomato incorporated fish nuggets showed high values for total solids, crude fat, organic non-fat and ash. Boiling is the best heat treatment for tomato paste to retain the sensory qualities, keeping qualities and nutritional value.

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# Analysis of Consumer Food Safety Knowledge and Practices in Rathnapura

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## Introduction

Food safety is a scientific discipline describing handling, preparation, and storage of food in ways that prevent food borne illness. Unsafe food is the likely vector of multiple biological, chemical or physical hazards and certainly of several nutritional problems. Consumers are the end-users of food chain. With their attitudes, knowledge, age, sex, income level and social status food safety knowledge and practices are different. According to the World Health Organization (WHO), up to 30% of the population of developed countries are affected by food borne illness each year; more than 75 million people get sick from food related illnesses in the USA resulting in 325,000 hospitalizations and 5,000 deaths annually (WHO, 2007). The problem is expected to be even more severe in developing countries.

Now Sri Lanka is more concern about food safety and handling practices. There are many rules and regulations. Food Act No. 26 of 1980: This Act controls, manufacture, importation, transport, sale, distribution, advertisement labeling of food. Sri Lankan food & beverage products comply with international standards such as ISO 9000, ISO 22000, HACCP, Halal, Kosher, Organic etc. In Sri Lanka also have many of food borne diseases, but they are not reported often. But mainly diarrhoeal diseases are the prominent. This study assesses the consumer food safety knowledge and the practices among the Rathnapura households.

## Methodology

A survey strategy was used in the research. Target population was the entire household in Rathnapura district 301,876 .Thought it was large to do an investigation within limited time period and inadequate financial budget, multi stage random sampling technique was employed to select appropriate sample to evaluate the objectives of this study. Eventually 120 household were selected as the sample size where can meet 95% confidential level.

Five key principles of Food safety by WHO, are used to find out consumer knowledge level in food safety. The association between socio economic characteristics and knowledge on food safety was revealed by applying chi-square test. Prevailing food safety measures were identified by using significant measures like smell, appearance, special package, and price and quality certificates. Consumer food safety knowledge was evaluated with household experiences of physical symptoms associate with food borne illness. And also food preparation, purchasing and storage practices were used to identify food safety knowledge and practices of consumers. Analysis was done by using Minitab 14.0 software package and Microsoft Excel.

## Results and Discussion

Descriptive statistics for the sample were produced using descriptive statistical analysis. The purpose of generating descriptive statistics was to describe the demographic characteristics of the sample.56% females and 44% males are in the sample. To prevent contamination of food with pathogens spreading from people, pets and pests, separate raw and cooked foods to prevent contaminating the cooked foods, cook foods for the appropriate length of time and at the appropriate temperature to kill pathogens, store food at the proper temperature, do use safe water and cooked materials. Majority of consumer's (58%) food safety knowledge level was low. 30% of consumers were had high food safety knowledge level.12% had medium level knowledge on food safety.

Food safety measures were identified by the study as smell, appearance, special package, and price and quality certificates. Among them 12% considered price, appearance and smell as important factors.7% were merely concern about one factor of them. Smell, package and special offer were identified by 10% of consumers. And also 10% of them were concerned about all measures. Among respondents 63% selected food items without considering about quality certification. The association between socio economic characteristics and knowledge on food safety was analyzed by using chi-square analysis. Income level had significant association with food safety knowledge of consumers. Education level did not show any association on food safety knowledge.

95% of respondents had experienced with any of the food borne illnesses. This shows that consumers have low confident on food safety and how to protect their family from food borne illnesses. Daniels (1998) verified that consumers who considered themselves knowledgeable make food handling errors.

By considering food safety practices on storage and preparation, 53% of consumers agreed that peeled and chopped fruits and vegetables kept in open air for long time cause contamination. But 23% strongly agreed that before using vegetables and fruits, they should be soaked in salt water. Only 10% kept cooled vegetables and fruits in open air more than one hour. In purchasing fish, 8% of consumers observed red color gills, discoloration and brightness of eyes. Majority were concerned on one factor. And also 48% were concerned about cleanliness of preparation and operator. Storage period of fish and usage were not concerned by consumers of 36%.some consumers never keep cooked meat and raw meat at the same place in refrigerator (34%). Cleaning of food preparation area with soap and water was practiced by only 6%. Washing the cutting board with water, used to chop vegetables or cut raw meat was practiced by 8% of consumers (Table 01).

Lack of knowledge is likely to lead to inappropriate food handling behaviors. Generally, consumer's knowledge has been found to be inadequate to ensure that food preparation in the home minimizes the risk of food borne illness. Personal hygiene and cleanliness of surfaces where food is prepared were identified as practices that have to be developed. Nearly 48% consumers were concern on personal hygiene highly,

Table 01: Descriptive on Food preparation practices

| Practices | Always | Sometimes | Rarely | Never |
|---|---|---|---|---|
| Wash hands before prepare foods. | 42% | 27% | 16% | 15% |
| Before prepare food clean hands and equipment with soap and water. | 6% | 25% | 19% | 39% |
| Using cutting board to cut without cleaning after cutting meat. | 8% | 28% | 35% | 18% |
| Keep leftover food at room temperature for more than 2 hours. | 47% | 11% | 18% | 18% |
| Check cleanliness of surfaces where you prepared food. | 33% | 20% | 29% | 7% |

47% of respondents were unaware on keeping leftover food at room temperature for more than 2 hours can cause contamination. 42% of consumers wash hands before preparing meals. However some respondents were say always if leftovers were safe. 53% of consumers thought that vegetables open up to air cause contamination. Although that 40% of consumers were not aware on cleaning procedure of vegetables and fruits.

**Conclusion**

Consumers in Rathnapura district express low level of self-related confidence and awareness on food safety. Information and low understanding of food bone illness issues. However, findings also reveal gaps in consumer's knowledge of safe food handling practices. For instance many of them believe they can tell food borne illnesses by its appearance, smell, and price.

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# A study on shelf life of export oriented fresh chilled Yellowfin tuna loins in relation to histamine content

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## Introduction

Sri Lanka has become a leading country which produces Yellowfin tuna (*Thunnus albacores*) and other large pelagic species in the Indian Ocean. (Indian Ocean Tuna Commission, 2011). To meet export market, maximum histamine content of the product should not exceed 50 ppm (Food and Drug Administration, 1998). Seafood processing factories guarantee a shelf life of 14 days for the product fresh chilled Yellowfin tuna loin, even though shelf life of different Yellowfin tuna loin batches is varied. Shelf life can be exceeded or not exceeded 14 days in different batches. These batches represent Yellowfin tuna received from different fishing harbors in different proportions. According to the fishing harbor environmental factors and practices followed by fishermen can be varied. There is evident that depending on the nature of the environment, different proportions of decarboxylase positive bacteria would be present in water and external fish tissue, and therefore the level of histamine and other toxigenic amines formed in fish tissue would not be uniform (Yoshinga and Frank, 1982). This research is to identify whether these fishing harbors have an effect on the shelf life of fresh chilled Yellowfin tuna loin in relation to histamine content.

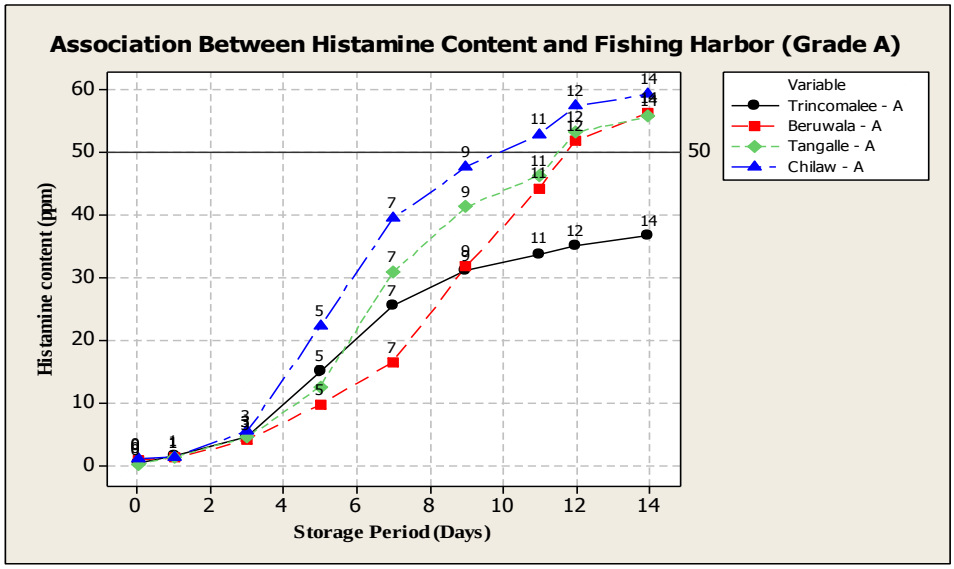
## Methodology

The study was carried out at SGS Lanka (Pvt) Limited, Colombo 02. The sample collection and background study of fresh chilled Yellowfin tuna loin exportation was done at Global Seafoods (Pvt) Limited. Three repeated experimental trials on histamine analysis of Yellowfin tuna loin samples were conducted during a time period of 42 days. Storage time period of each set of samples for an experimental trial was 14 days. Selected fishing harbors were Beruwala, Tangalle, Chilaw, and Trincomalee. Yellowfin tuna loins of Grade A and B were selected from each fishing harbor. All collected samples had an on-broad freezing time period, which was varied between 18 - 22 days. Labeled and vacuum packed samples were stored at 0 $^0$C, in the fresh chilled condition. Histamine analysis was carried out from the time period of zero day of storage to 14 days of storage. Histamine was analysed using flurometric method according to the AOAC official methods of analysis. Data collected from the three experimental trials were analysed using Minitab 14 statistical software. Descriptive statistics of means, Standard deviation, two-way ANOVA and one way ANOVA with tukey's pairwise comparison was applied in analysing the results. A significance level of 5 % was used.

**Result and Discussion**

Histamine content was increased with storage time period in each and every sample. The increment pattern of Yellowfin tuna loins received from four selected fishing harbors of Grade B did not show any significant difference (P>0.005). It was concluded that there was an effect from fishing harbor on average histamine content of Yellowfin tuna loins within fish grade A (P<0.005). Further analysis of one way ANOVA with tukey's pairwise comparison revealed that Trincomalee fishing harbor had the least contribution for histamine formation.

Figure 01: Association between the average histamine content of Yellowfin tuna loins and




fishing harbor (Grade A – Histamine analysis experiment 1)

According to Figure 01 the shelf life of Yellowfin tuna was varied between 10 to 14 days. Figure 2 revealed a Shelf life of 9 to 10 days in Yellowfin tuna loin samples of Grade B. Higher bacterial loads seemed to be associated with the formation of higher amines in storage (Koutosomanis *et al.*, 1999). Thus this study reveals due to high microbial contamination in Grade B, a significant difference cannot be identified in the pattern of histamine formation of the loin samples received from four different fishing harbors. Furthermore due to high microbial contamination histamine formation was happened at an alarming rate. Fish grading A with the least microbial contamination had shown a difference in histamine formation according to the fishing harbor. It was proven Yellowfin tuna loins received from Trincomalee fishing harbor had the best shelf life in relation to the histamine content with in the "A" grade fish. The reason behind this is histamine formation is highly affected with the amount of microflora and the microbial load that could contaminate a fish would not uniform from place to place, due to factors like environmental conditions, post harvest practices followed by fishermen and fish catching methods.

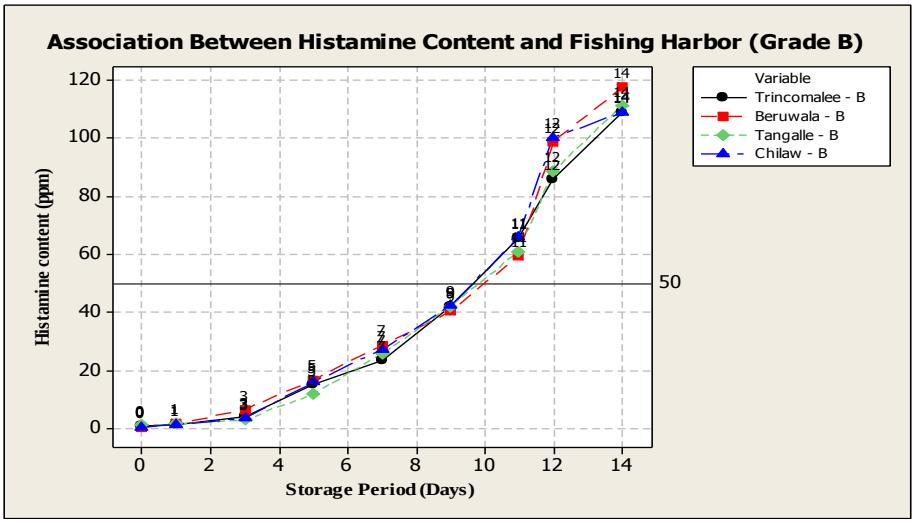



Figure 02: Association between average histamine content of Yellowfin tuna loins and fishing harbor (Grade B - Histamine analysis experiment 1)

**Conclusions**

Shelf life of fresh chilled Yellowfin tuna loins, in relation to histamine content was highly dependent on the fish grading rather than the conditions of the fishery harbor.

**Acknowledgement**

Laboratory facilities provided by the SGS Lanka (Pvt) Limited, Colombo are acknowledged.

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# Development of Finger millet *(Eleusinecoracana)* incorporated symbiotic drinking yoghurt

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## Introduction

Sri Lankan yogurt market is characterized by intense competition prompting leading players to differentiate themselves by focusing on health benefits, branding, and incorporation of different ingredients. Yoghurt is a popular fermented dairy product due to its health benefits as a functional food in addition to its nutritional benefits (Robinson and Tamime, 1999). High calorie yogurt drink that contains any kind of a cereal powder is completely a new product concept to the Sri Lankan market. Therefore, the objective of the current study was to develop a health beneficial probiotic drinking yoghurt by incorporating finger millet as a cereal which can be used as a breakfast food, sport supplement and also as a weaned food for toddlers. Nutritionally, finger millet is used as a whole grain, it is higher in protein and minerals in comparison to all other cereals and millets. Accroding to previous studies, finger millet is also known for several health benefits such as anti-diabetic, antitumerogenic, atherosclerogenic effects, antioxidant and antimicrobial properties which are mainly attributed due to its polyphenol and dietary fiber contents (Dykes and Rooney, 2007; Chethan, 2008). Therefore this study was conducted to develop a cereal based probiotic yoghurt drink which can be promoted as a natural source of high calorie that can be consumed as an alternative for the imported, artificial and expensive sport nutrition's and weaned foods.

## Methodology

The study was conducted at the research and development and quality assurance laboratories in Ceylon cold stores PLC, Ranala, Kaduwela. In the preliminary trial 1 most compatible sugar percentages for different incorporation levels of finger millet flour from the three experimental forms (roasted flour, germinated flour and raw slurry) were selected. Then preliminary trial 2 was carried out using ranking method to select the best finger millet incorporation levels (4 %, 5 %, 6%, 7% and 8 % (w/w)) for each incorporation form. The best sugar percentages and incorporation levels of finger millet from preliminary trials were used in next steps of

experiments. Sensory evaluation 1 was carried out to select the best form/type of finger millet flour to incorporate out of three forms. In second sensory evaluation, the most suitable stage for finger millet incorporation was determined by using two treatments. Each sensory evaluation was conducted with 30 untrained panellists and color, taste, aroma, mouth feel and overall acceptability were considered as sensory properties. Finally proximate analysis, physico- chemical and microbial analysis were conducted for the selected final probiotic drinking yoghurt by comparing with a control sample. Probiotc lactic acid bacteria enumeration was carried out using the selected final product by pour plating on MRS media to find out the effect of finger millet incorporation on the viability of probiotic lactobacilli. Selected final product was compared with a control sample and enumeration was done at 1, 7 and 14 days interval.

The sensory data were analyzed using Friedman non-parametric test with 95% significance by using Minitab 16 software. Complete Randomized Design (CRD) was conducted and data obtained from chemical and microbiological tests were analyzed using analysis of variance (ANOVA) using the SAS 9.0 software. Significant means of treatments were separated using the Least Significant Difference test (LSD) ($P< 0.05$).

**Results and Discussion**

According to the results of the series of preliminary trials 5% (w/w) was selected as the best incorporation level from each three finger millet forms and 8 % (w/w) sugar as the compatible sugar percentage. In the first sensory evaluation for selecting best form/type of incorporation out of three experimental forms, germinated /malted flour incorporated yoghurt was selected as the best due to higher preference than other two. There was a significant difference ($P<0.05$) between treatments regarding and overall acceptability. Second sensory evaluation revealed, 5 % (w/w) germinated (malted) finger millet flour incorporated (Addition before fermentation) drinking yoghurt have the higher preference compared to the other treatment with respect toall the sensory parameters considered ($p<0.05$). The selected composition of synbiotic drinking yoghurt is given in Table 01.

Table 01. Composition of the selected final product

| Ingredient | Percentage (w/w) |
|---|---|
| Raw milk | 84.54 % |
| Sugar | 8 % |
| Stabilizer | 0.25 % |
| Finger millet (Germinated flour ) | 5 % |
| Skim milk powder | 0.83 % |
| Dairy cream | 1.37 % |

In the shelf life evaluation of the final product, there was a significant difference ($p< 0.05$) in lactic acid development (Titratable acidity) during cold storage between control drinking yoghurt sample and germinated finger millet flour incorporated yoghurt.

During the 21 days of storage period, titratable acidity of the selected final product was between 0.68% ± 0.08 to 0.89% ± 0.08. During the storage period of 21 days, pH of the control yoghurt sample reduced from 4.58± 0.09 to 4.25±0.09 and pH of germinated finger millet flour incorporated yoghurt reduced from 4.62±0.09 to 4.38±0.09. The pH drop of both treatments is due to the acid development as a result of the activity of lactic acid bacteria (Tammie and Robinson, 1999).Yeast andmold and *E.coli*, Coliform counts of the both germinated finger millet flour incorporated drinking yoghurt and control were not exceeding SLS standards for yoghurt during 21 days of refrigerated storage.

The probiotic *lactobacilli* count in both experimental and control yoghurt samples have decreased over the storage period (Figure 1). Reason for that may be the low pH (high acid development with the time) levels.Low pH level of the fermented milk products was directly affected the survival of probiotic bacteria. However, as shown in the figure probiotic *lactobacilli*population in germinated finger millet flour incorporated drinking yoghurt is higher compared to the control sample. Finger millet contains prebiotic substances such as resistant starch, oligosaccharides, crude fibers and also it acts as fermentable substrates for growth of probiotic microorganisms (Dykes and Rooney, 2007; Chethan, 2008). There is a significant difference in probiotic bacteria population over the storage period between control and germinated finger millet flour incorporated yoghurt sample ($p < 0.05$).

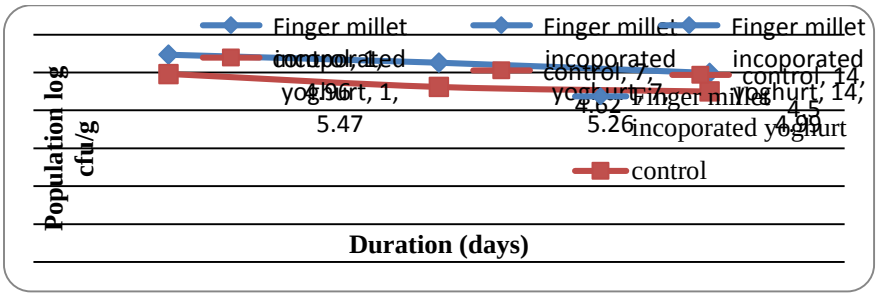


Figure 01: Changes of probiotic lactobacilli population during refrigerated storage

## Conclusions

5 % (w/w) finger millet flour incorporation level was selected as the best and germinated/malted flour was selected as the best form of incorporation while addition of finger millet before fermentation was determined as the most suitable stage of incorporation. Further, the incorporation of finger millet into the yoghurt has enhanced the survival of probiotic *lactobacilli* during refrigerated storage.

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# Development of soursop pulp (*Annonamuricata)* incorporated fermented sweet cream buttermilk beverage

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## Introduction

In Sri Lankan context buttermilk removed from the dairy processing plants considered as a dairy waste and utilization of dairy by product is considerably low compared to other countries. Sri Lankan market is still having a market gap for locally produce fermented flavored milk base beverages. Buttermilk could be used to produce fermented milk beverages replacing milk which would result in differentiated products. Buttermilk is also considered a nutritious dairy ingredient that is saturated in milk fat globule membrane (MFGM) components (Sodini *et al*., 2006). Addition of fruit juices or pulps is an attractive avenue for the utilization of buttermilk. Soursop is one of the fruit spp. which can be incorporated to manufacture beverages with good consumer demand. The fruit is rich in vitamin B, potassium, fructose and vitamin C (**Pamplona-Roger, 2005** cited in Ekaluo *et al*., 2013). Soursop fruit is a proven cancer remedy for cancers of all types and broad spectrum antimicrobial agent for both bacterial and fungal infections, antiparasitic activity, lower high blood pressure and is used for depression and stress (Camiel *et al*., 2008).

## Methodology

The current study was carried out at Pelwatte Dairy Industries Limited, Pelwette and laboratory analysis was done at Pelwatte Dairy Indusries Limited and Uva Wellassa University laboratories. Soursop pulp was prepared by flowing method. Fresh fully ripped Soursop fruit was washed by chlorinated water and disinfected by using 70% of ethanol. Then fruit was cut it to halves by using a sharp knife and seeds and blemishes were removed. After that, flesh was scooped out using a clean stainless steel spoon and blended it using an electric blender. Initially incubation time was standardized for the buttermilk base by incorporating different levels of Skim Milk Powder. Several preliminary studies were done to select the best

Soursop pulp and Sugar incorporation level for the final product. Sensory evaluation was done using 30 untrained panelists for the final three treatments (12%, 13% and 14% of Soursop). The pH value and acidity were evaluated in one day intervals for thirteen days in both Potassium Sorbate added sample and without preservative sample and microbiological analysis was done for *Escherichia coli*, Coliform and Yeast and Molds. The sensory data was analyzed using non- parametric procedure, according to the Friedman test with 0.05 levels of significance in Minitab 16 software package. Complete Randomized Design (CRD) was conducted and data obtained from chemical and microbiological testes were analyzed using analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS software.

**Results and Discussion**

Skim Milk Powder was added to buttermilk to increase the total solid content. The increase of total solid content has reduced the incubation time by influencing the growth and activity of starter culture (Figure 01). Incubation time was reduced to 4 hours by adjusting Skim Milk Powder level to 6 grams/100 mL. Eight grams of Skim Milk Powder addition level was not selected as it can increase the cost of production.

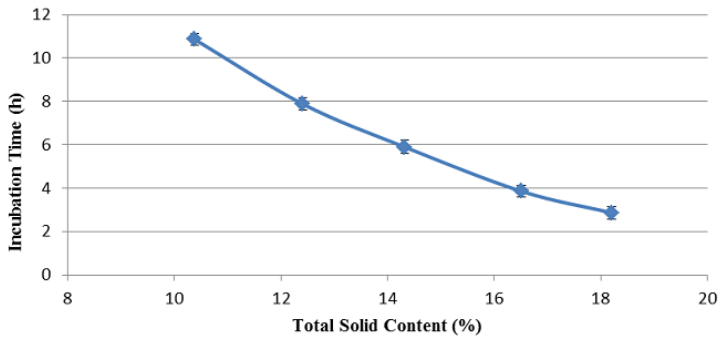


Figure 01: Incubation Time variations with the Total Solid Content

According to the sensory evaluation, formulation with 13% Soursop incorporation level has shown higher preference than the other formulated treatments (Figure 2). According to above results mouth feel and taste were overlapped in all three treatments. 13% Soursop level was not significantly masking the milky flavor of the beverage this might be a reason for higher preference.

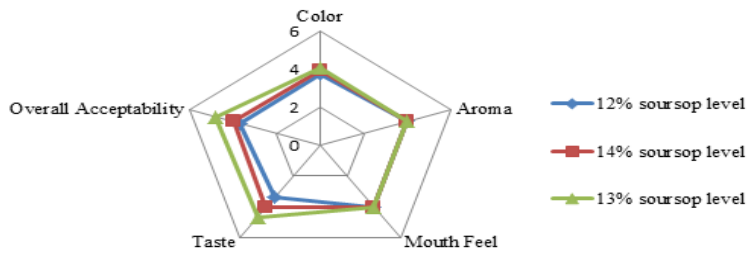


Figure 02: Sensory attributes of the different Soursop incorporation levels

Titratable acidity of the Soursop incorporated sweet cream buttermilk beverage has increased while the pH of the beverage was decrease with the days of storage. The decrease of pH during the storage is common in fermented dairy foods and can be attributed to the growth of bacteria and lactic acid production (Lucey, 2004). The pH reduction in the beverage with preservatives was in a higher pH range than beverage without preservatives. Buttermilk beverage without preservatives was having a significantly higher mean acidity than the buttermilk beverage with preservatives ($P<0.05$). Fermentable sugars in the product produces lactic acid this lactic acid may increase with storage time period. It may lead to increase the acidity of the product.

Negative results for *E. coli/* Coliform could be a result of good hygienic practices conducted during processing of beverage. Beverage without preservatives was positive for yeast and mold count after the $5^{th}$ day of storage and beverage with preservatives was negative for yeast and mold count during 13 days of storage. Thus Potassium sorbate is an effective preservative for the beverage.

**Conclusions**

Starter culture multiplication was not harmed by use of sweet cream buttermilk for the production of fermented beverage. Further, incubation time was reduced to favorable level with increase of total solid content in sweet cream buttermilk base. 13% Soursop incorporation level and 12% sugar incorporation level were selected as the best incorporation level according to the sensory attributes. Potassium sorbate can be used as a preservative for the Soursop incorporated sweet cream buttermilk beverage. The crude protein level of the most preferred sample was 3.6% while its ash content was 0.8%. Its also had a fat content of

0.6%.Further studies should be done on the shelf stability of the Soursop incorporated sweet cream buttermilk beverage.

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# Development of fruit (*Musa* spp.) puree incorporated synbiotic stirred yoghurt

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## Introduction

Yoghurt is one of the most nutritious fermented milk products that can be used to enhance the nutrition condition of people. It is obtained by introducing specific strains of Lactic acid bacteria. The Lactic acid micro flora reduce risk of colon cancer (Foissy, 1983 cited in Huma, 2003), reduce the serum cholesterol level (Anderson and Gilliland, 1999 cited in Huma, 2003) and also maintain the intestinal ecosystem (Saarela *et al.*, 2002 cited in Huma, 2003). Prebiotics are non-digestible food ingredients that improve the host health by selectively stimulating the growth of certain beneficial microorganisms. Fructo-oligosaccharide is prebiotic source that can be found in ripe banana around 2 mg/g. By incorporating banana with yoghurt is best way to improve the health benefits and taste of the yoghurt. Stirred type fruit yoghurt is one of the best products that can be used to gain consumer preference. Therefore, this study was conducted to develop a Banana puree incorporated symbiotic stirred yogurt.

## Methodology

The current study was carried out at Ceylon Cold Stores PLC (CCS), Ranala, Kaduwela. Laboratory analysis was done at CCS and laboratories in University of Kelaniya. First, yoghurt base and the banana puree were prepared according to the predetermined recipe after various preliminary trials. For final sensory evaluation, three treatments were used with three replicates. The incorporation levels of fruit puree with yogurt base is given in table 01.

Table 01: Incorporation levels of fruit puree with yoghurt base

| Treatment | Yoghurt % (w/w) | Fruit puree % (w/w) |
|---|---|---|
| 1 | 86 | 14 |
| 2 | 85 | 15 |
| 3 | 84 | 16 |

Table 02: Composition of the Final stirred yogurt base

| Ingredient | % | Weight (g) | Fat (g) | MSNF (g) |
|---|---|---|---|---|
| **Raw Milk** | 92.67 | 1010.00 | 35.40 | 85.90 |
| **Fresh Cream** | 0.70 | 7.80 | 2.80 | 0.30 |
| **SMP** | 3.20 | 35.10 | _ | 33.90 |
| **Sugar** | 0.40 | 4.40 | _ | _ |
| **Gelatin** | 3.00 | 32.70 | _ | _ |
| **Total** | 100.00 | 1090.00 | 38.20 | 120.10 |

Table 03: Composition of Final Fruit puree

| Ingredient | Amount (w/w) |
|---|---|
| **Banana ('Anamalu')** | 45% |
| **Pineapple** | 15% |
| **Cane sugar (white)** | 40% |
| **Ascorbic acid** | 500 ppm |

Then the best incorporation of fruit puree was determined by using five point hedonic scale with 30 sensory panel. Physicochemical and microbiological properties were observed in the selected best sample. Chemical composition (Moisture &crude fat) was tested. Titratable acidity and pH were evaluated for 14 days period and microbiological analysis was done for *E.coli* and Yeast and mould content. Also probiotic bacterial count was determined using Man Rogosa Sharp Media. In addition effectiveness of the Potassium sorbate against yeast and mould count was evaluated. The sensory data were analyzed using non-parametric procedure, according to the Friedman test using Minitab 15 software programme. The data obtained from physicochemical and microbiological tests were analyzed using analysis of variance (ANOVA) using SAS 9.0 software programme. Significant means of treatments were separated using Least Significant Difference ($P<0.05$).

**Results and Discussion**

The sensory evaluation with Friedman test revealed all sensory parameters were significantly difference except color ($P<0.05$). The 15% incorporation level of fruit puree was obtained higher estimated median value for taste and overall acceptability. After analysis, 15% incorporation level of banana puree was selected as the best percentage for stirred yoghurt. The composition of the final selected final stirred yogurt and composition of final fruit puree is given in table 2 and table 3; respectively.

The microbilogical analysis revealed that the *E. coli*/ Coliform and yeast and mould count were in acceptable range according to the SLSI standards. Preservative treatment was significantly difference with without preservative treatment ($P<0.05$). Sorbic acid and/ or

sorbic acid salt prevent the growth of yeast by blocking their dehydrogenase system. Potassium sorbate is very effective against *Saccharomyces* spp., *Debaryomyces* spp., *Candida* spp. (Mihyar, Yamani and Al-Sa'ed, 1994 cited in Yildiz, 2010).

The probiotic activity of banana stirred yoghurt was significantly different from plain stirred yoghurt ($p<0.05$) (Figure 1). It may be due to the prebiotic (FOS) compounds that present in ripe bananas. The highest FOS content was found in ripe bananas, which contained 2.0mg/g of FOS (Environ International Corporation, 2000).

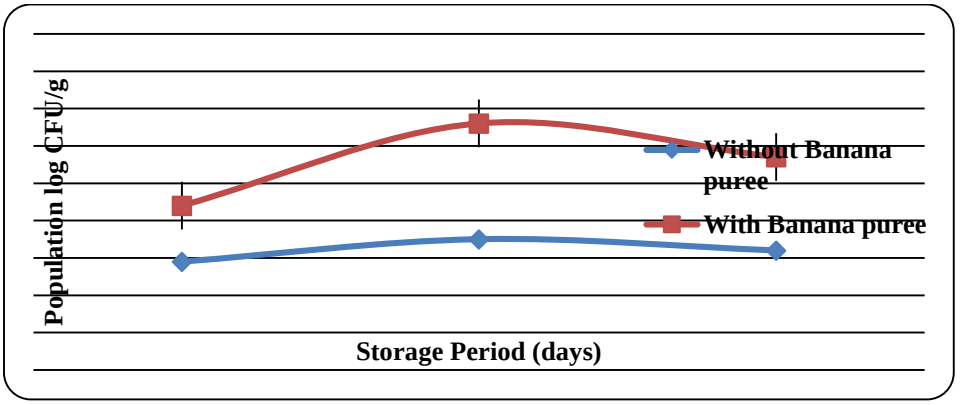


Figure 01: Viability of probiotic lactobacilli with storage life

**Conclusion**

The best incorporation level of fruit puree for the stirred yoghurt was 15%. Ripe banana contains prebiotic source that enhance the probiotic lactic acid bacteria. Potassium sorbate is an effective preservative against yeast and mould count.

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# Quail egg consumption: patterns, preferences and perceptions among consumers in Galle district, Sri Lanka

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## Introduction

Owing to the changing life style and food availability, Quail egg is being used as analternate potential and acceptable egg source in many parts of the world. Regular consumption of quail eggs helps fight against some diseases such as digestive tract disorders, tuberculosis, asthma, diabetes and stomach ulcers, strengthen the immune system, promote memory health, increase brain activity and stabilize the nervous system. Nutritional value of quail eggs is higher than those offered by other eggs and contain high amount of antioxidants, minerals, and vitamins and less amount of cholesterol (Tanasorn*et al.*,2013).Compared to chicken eggs, there is a limited body of scholarly literature in related to consumer behavior of quail eggs. Most literature to do with quails and their eggs has focused on production and processing issues, not consumer market studies. Therefore, present study was aimed to determine the quail egg consumption patterns, preferences and perception among consumers in Galle district, Sri Lanka.

## Methodology

Ten Divisional secretariats (Akmeemana, Ambalangoda, Baddegama, Balapitiya, Bope-poddala, Elpitiya, Galle four gravates, Habaraduwa, Thawalama and Yakkalamulla) in Galle districts were purposively selected as the research area. 200 consumers, who toured to local markets and supermarkets in those areas were purposively selected and interviewed.Information related to consumers' age, sex, education, occupation, income, consumption pattern and attitude towards quail eggs were collected using a pre-tested questionnaire with havingboth open and closed form questions. Primary data were processed and analyzed using the Microsoft Office Excel (2003) and SPSS 20 package. The association between demographic data and egg consumption pattern was tested using chi square, with a p-value of less than 0.05 considered statistically significant.

## Result and Discussion

As to present study produced data it is revealed that majority of the respondents (57%) did not consumed quail eggs, while 43% consumed. Table 01, shows the relationship between

demographic data with the quail egg consumption. These demographic indices did not significantly ($p>0.05$) influence the quail egg consumption, except gender, with female respondents consuming less eggs. Findings of the study is revealed that purchasing frequency is not satisfied, because most of the respondents who consume quail eggs (81%) rarely purchasedeggs every month. Most of them had purchased quail eggs once or twice during the past year. Findings revealed, quail eggs were not a regular food item in their diet.

Boiled eggs were most preferred (61%) as egg serving method than any other preparations (Figure 01). This can be expected because of the small size of quail eggs,it is inconvenient to prepared comparing withother poultry eggs especially chicken eggs. Consumers had purchased quail eggs from Food Cities (34%), from Farm shops (30%), from grocery stores (20%) and directly from farms (11%). 5% of consumers had supplied quail eggs by home production.

When the quail egg consumers were asked about the major factors that limit their consumption of quail eggs, it was found out that the most common limiting factor was the low of availability of quail eggs (54%) in the accessible markets, the high price of the quail eggs became the second factor (23.3%) and less preference of other family members was the third factor (16.3%).

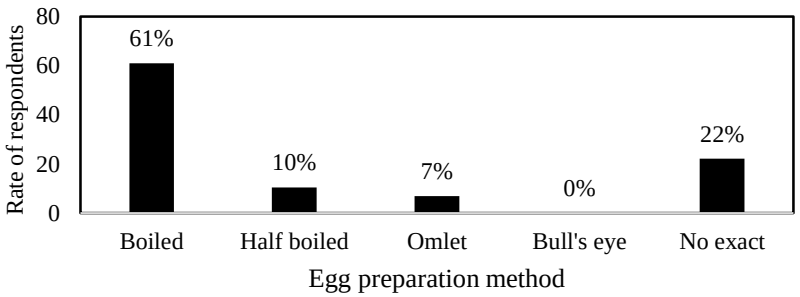
| Variable | Frequency | Percentage (%) | $\chi^2$ | p-value |
|---|---|---|---|---|
| Gender (n=200) | | | | |
| Male | 119 | 59.5 | 9.929 | 0.002* |
| Female | 81 | 40.5 | | |
| Age (Years)(n=200) | | | | |
| Less than 30 | 47 | 23.5 | 0.166 | 0.920 |
| 30-50 | 121 | 60.5 | | |
| >50 | 32 | 16 | | |
| Religion (n=200) | | | | |
| Buddhist | 179 | 89.5 | 0.998 | 0.607 |
| Catholic | 5 | 2.5 | | |
| Islam | 16 | 8 | | |
| Educational level (n=200) | | | | |
| Below secondary | 68 | 34 | 5.475 | 0.065 |
| Secondary | 81 | 40.5 | | |
| Tertiary | 51 | 25.5 | | |
| Income (per month) (Rs.) | | | | |
| <20,000 | 62 | 31 | 4.231 | 0.124 |
| 20,000-50,000 | 102 | 51 | | |
| >50,000 | 36 | 18 | | |

| | | | | |
|---|---|---|---|---|
| Egg consumption (n=200) | | | | |
| Yes | 86 | 43 | | |
| No | 114 | 57 | | |

Table 01:Demography and egg consumption among respondents
*Relationship with the egg consumption is significant at 0.05 level.

Table 02 revealed that, awareness on the nutritional and health benefits of quail eggs among the people had significant influenced on egg consumption. Majority of egg consumers had knowledge that quail eggs are better for asthma and have a low level of cholesterol.

Respondents who did not consume quail eggs mentioned their reasons as follows: a) they are




not used to eat quail eggs as a food (50%), b) do not like the appearance of the egg (17.5%), c) not available where they usually shop (14.9%) and d) do not like taste and odour of eggs.

Figure 01: Way of preparation of quail eggs for consumption

Table 02: Awareness of nutritional and health benefits of quail eggs among respondents

| Consumption of quail eggs | Awareness about the qualities of quail eggs | | $\chi^2$ | p-value |
|---|---|---|---|---|
| | Yes | No | | |
| Yes | 74 | 12 | 45.626 | <0.0001 |
| No | 44 | 70 | | |

It is recommended to keep cholesterol level below 200 mg per day for whom with cardiovascular diseases, diabetic patients, those with hypercholesterolemia and serious risk factors and those with a history of familial early atherosclerosis (Cengizhan, 2012). Hence, there is a potential to increase the quail egg consumption within the society due to its low level of low density lipoprotein cholesterol ((Polate*et al.*, 2013; Tanasorn*et al.*, 2013).

## Conclusions

Quail egg consumption is low in the society. But there is a potential to enhance it as an alternative egg source among the people. Effective promotion and advertising campaign about the nutritional and health benefits for a healthy society should be organized to create well-informed consumers. As well as quail egg production should be promote to increase the availability of them.

## Acknowledgement

I would like express my thanks to Director General of Sri Lanka Institute of Advanced Technological Education for approving the research allowance to conduct this study.

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# Technical Session - Aquatic Resources Technology

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## Oral Session

## Poster Session

# Determination of a suitable growing medium and a commercial fertilizer for *Echinodorus parviflorus* 'Tropica' in the nursery level

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## Introdution

Aquatic Plant varieties have unique morphology and habitats as commercially important aquatic plants. Dissanayake*l*., 2007). The most popular ornamental aquarium plants genera are *Anubias, Cryptocoryne, Echinodorous, Aponogeton, Hygrophyla, Bacopa, Hydrilla, Cabomba, Myriophyllum, Lagenandra, Vallisneria* and *Elodea.* Among these plant genera *Cryptocoryne, Lagenandra, Aponogeton* and *Echinodorous have* important characteristics as aquarium plants in Sri Lanka. *Echinodorus* species have attractive green to mid green submerged leaves arranged in a rosette with beautiful, white flowers occurring in an inflorescence (Muhlberg, 1982). Aquatic plants play a significant role in the freshwater ecosystems worldwide. With time ecosystem may collapse without aquatic plants due to wild collection. Therefore growing plants is solution for that. An aquatic plant growing medium was essential for that. The growing mediums contain sand, silt and clay proportion according to the ratio of the medium. Four different ratios were used as treatments (T). T1- Boggy soil: Bricks particles T2- 3:1, Boggy soil 3: Sand 1, T3-Boggy soil: Top soil -3:1, T4-Top soil were treatments. Growing medium should balance the aeration and water for maximum root growth and physically support for the plant. Practical size of the growing medium should be with adequate pore spaces between the particles (Bilderback*l*., 2005)

Nutrition is a major factor for the plant growth. Therefore nutrient should be supplied in optimum level at the correct time as fertilizers.

## Methodology

The present study was carried out to investigate the effect of growing medium and fertilizer for the growth of *Echinodorus parviflorus*'Tropica' National Aquaculture Development Authority (NAQDA) Ornamental Fish Breeding and Training center in Rambadagalle Sri Lanka. Experiment one was conducted to find out a suitable nursery medium for the *E.parviflorus* 'Tropica' plant. Boggy soil, brick particles, sand and top soil were used. Using those growing substrate four types of media used as treatments (T), T1- Boggy soil: Bricks particles T2- 3:1, Boggy soil 3: Sand 1, T3-Boggy soil: Top soil -3:1, T4-Top soil were treatments. Experiment two four fertilizer mixture used as four treatment of fertilizer, T1-N: P: K -4:2:1, T2- N: P: K -5:2:3,T3- N: P: K -3:1:1and T4- N: P: K -20:20:20 were used during this study.

Uniform *Echinodorus parviflorus* 'Tropica' about 4.5 cm -6.5 cm heights, same age plants were selected for the experiment. Old and rotted leaves were removed; leaving 5- 6 laves to remain. Old and rotted roots also were trimmed, leaving the only healthy roots. Initial weights between 0.5 g - 1.5 g of plants were selected.Experiment one and two results were analyzed by using Minitab 16 computer package and significant differences between treatments were identified using Analysis Of

Variance (ANOVA) produce at 5% probability level. In experiment one T4-Top soil and experiment two T4- N: P: K -20:20:20 were used as control of the both experiments.

**Results**

According to experiment one, Boggy soil 3: sand 1(T2) growing medium was most suitable growing medium among other used media for the *E.parviflorus* 'Tropica'.In the experiment one, there was significant difference ($P< 0.05$) among four treatments regarding increment of plant height, weight, dry weight and root length. As indicated Table1, the maximum growth was observed in T2.

Table 1. Influence of growing medium on Tropica plant growth

| Substrate | Plant height difference (cm) | Plant weight difference (g) | Dry weight difference (g) | Root length difference (cm) |
|---|---|---|---|---|
| T1 | 4.2500 | 1.5503 | 0.0265 | 1.5633 |
| T2 | 4.7767 | 1.623 | 0.0211 | 4 |
| T3 | 3.6833 | 1.6993 | 0.02167 | 1.6667 |
| T4 | 2.8367 | 0.6407 | 0.02517 | 1.5833 |

According to experiment two N: P: K -4:2:1(T1) fertilizer ratio was the suitable fertilizer ratio for *Echinodorus parviflorus* 'Tropica' plants.In the experiment two there was significant difference ($P< 0.05$) among four treatment regarding increment of plant height, weight, dry weight and root length. As indicated Table 2, the highest growing was observed in T1.

Table 2. Influence of fertilizer Tropica plant growth

| Fertilizer | Plant height difference (cm) | Plant weight difference (g) | Dry weight difference (g) | Root length difference (cm) |
|---|---|---|---|---|
| T1 | 6.3693 | 2.2598 | 0.05697 | 4.6897 |
| T2 | 4.0967 | 1.7111 | 0.05184 | 1.9496 |
| T3 | 4.0332 | 1.5896 | 0.03873 | 1.8693 |
| T4 | 3.9166 | 1.3958 | 0.02767 | 1.5703 |

**Discussion**

Based on the results obtained from the present study, it can be concluded that the parameters which measured the growth of the *Echinodorus paviflorus* variety Tropica. Considering the analyses carried out separately with four parameters, both experiments one and experiment two were able to found out a suitable growing medium and a suitable fertilizer mixture for enhancing the growth of *Echinodorus parviflorus* 'Tropica*'.*

**Conclusions**

Most suitable fertilizer ratio for growth of plant is N: P: K- 4: 2: 1 and most suitable growing medium is the medium consist of Boggy soil: Sand- 3: 1.for *Echinodorus parviflorus* 'Tropica'.

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Bilderback T. E., 2005. Healthy substrates need physicals, HortTechnology. vol. 15, p. 747–751.

# Development of a suitable culture media for mass culture of *Moina macrocopa*

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## Introduction

Live food organisms contain of all the nutrients such as essential proteins, lipids, carbohydrates, vitamins, minerals, amino acids and fatty acids (Das *et al.*, 2012). Mostly, *Artemia naupli* is cultured as live feed in large amounts in Sri Lanka. However, the high cost is a problem. In Sri Lanka, brine shrimp can be replaced by *Moina macrocopa*. It is a cost effective live feed and important to find out a cost effective culture medium to get the highest production of *Moina macrocopa*. Therefore, this research was carried out to develop a suitable culture medium for mass culture of *Moina macrocopa*.

## Methodology

Two experiments were conducted to develop a suitable method for culturing *Moina macrocopa* in National Aquaculture Development Authority (NAQDA) at Rambadagalla. Experiment 1 was conducted to find out possible culture media and to determine its concentration for mass culture. Experiment 2 was conducted to find out the best culture medium and its concentration for mass culture of *Moina macrocopa*. All bottles and tanks used in experiments were cleaned, drained and sun dried for two days and then filled with water, left for two days before using. *Moina macrocopa* for all experiments were taken from stock culture developed in NAQDA Centre at Rambadagalla. Pure culture of *Chlorella vulgaris* ($1\times10^4$ cells per 1 ml) was acquired from NAQDA Centre at Rambadagalla. Filtered tap water was used in both experiments. In experiment 1, five culture media; mineralized cow dung, steamed cow dung, 15 min. boiled chicken manure, 30 min. boiled chicken manure, and 1 hr. boiled chicken manure were prepared with four different concentrations such as 5 g $l^{-1}$, 10 g $l^{-1}$, 15 g $l^{-1}$and 20 g $l^{-1}$. Different concentrations with various media tested with and without adding *Chlorella* into the medium. As control, a medium only with *Chlorella* and water was maintained. Three replicates from each treatment were maintained during experiment. Five individuals of *Moina macrocopa* were inoculated into each bottle. After that, top of the bottles were covered with a mosquito net to prevent entrance of undesired insects. They were allowed to stay 10 days and after that data were collected. Three samples from every tank were collected using 3 ml of fine dropping pipette. Samples were taken from the surface to bottom at three random points. Collected data (number of *Moina macrocopa* ) were analyzed using Minitab 16 software with ANOVA, general linear model. According to the results of experiment 1, the positive culture media and their concentrations were used in experiment 2.

Selected treatments were prepared as same as in experiment 1. 150 individuals of *Moina macrocopa* were introduced into each tank. After ten days, 25 ml samples were taken as earlier and preserved using two drops of 1.007 g $cm^{-3}$ Lugol's solution. Values of all tanks were recorded. Data were analyzed as in experiment 1.

**Results and Discussion**

According to the preliminary experiment, there was a significant relationship between number of *Moina macrocopa* and culture medium ($p<0.05$). There was a significant relationship between medium and concentration to the number of *Moina macrocopa* ($p<0.05$). There were no results of *Moina macrocopa* in both 15 g $l^{-1}$ and 20 g $l^{-1}$ of mineralized cow dung media. There were no results of *Moina macrocopa* in 15 g $l^{-1}$ and 20 g $l^{-1}$ of steamed cow dung media. Those media may be not favorable for growth of *Moina*. There were no results found in 15 min. boiled chicken manure and 30 min. boiled chicken manure media. The major reason for boiling chicken manure is to prevent the *Salmonella* effect. Low time duration for boiling might be not enough for destroy the undesirable pathogens. There may be not a favorable environment for growth of *Moina macrocopa* in both of those media. Fig. 1 shows the possible culture media to be developed for experiment 2.

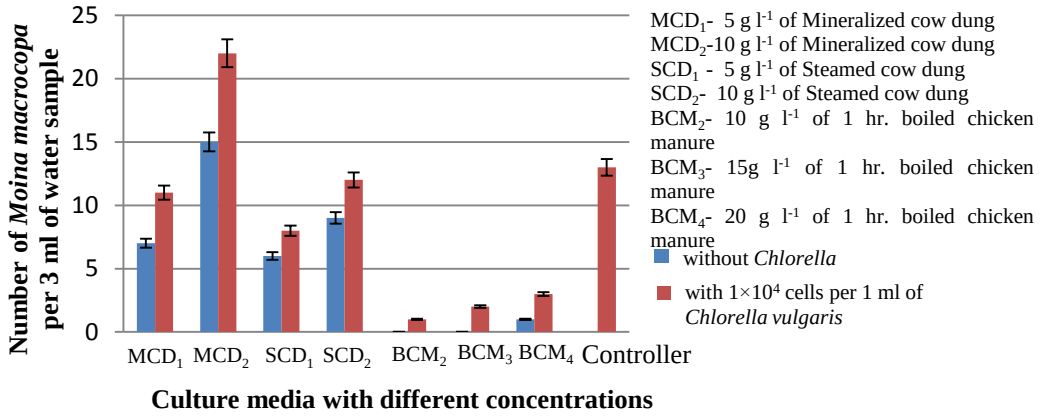


*Figure 1: Suitable culture media and it's concentrations for culturing Moina macrocopa*

In experiment 2, according to ANOVA, general linear model, there was a significant relationship between total number of *Moina macrocopa* and medium ($p<0.05$). Table 1 shows the mineralized cow dung media and steamed cow dung media had higher results than the 1 hr. boiled chicken manure media. According to Begum *et al*., (2013), the survival rate of individuals in cow dung is higher than chicken manure and nutritional composition of cow dung compare to the chicken manure is higher**.** This would be the reason for higher total number of *Moina macrocopa* in cow dung media than the chicken manure media. According to Table 1, mineralized cow dung media was better than steamed cow dung media and that results were better than the controller. Nutritional deficiency and destruction of favorable microbes which can convert complex compounds into simple absorbable minerals due to steam can be the reason for lower results in steamed cow dung. Cow dung is freely available in Sri Lanka and it is low in cost in Sri Lanka. According to the analyzed data, there was no significant relationship between total count and *Chlorella* ($p>0.05$). It means the selected culture media can be used with *Chlorella* or without *Chlorella*. But, Table 1 shows all positive resulted culture media gave higher yield with *Chlorella* than without *Chlorella*. *Chlorella* is a major food for *Moina*.. Finally, it can enhanced the available food for *Moina*.

Table 1: Relationship of different concentrations of media and availability of *Chlorella* to the total number of *Moina macrocopa*

| **Medium** | **Concentration** | **Availability of $1\times10^4$ cells per 1 ml of *Chlorella vulgaris*** | **Mean ± SE Mean** |
|---|---|---|---|
| **Mineralized cow dung** | 5 g $l^{-1}$ | With *Chlorella*<br>Without *Chlorella* | 090.00 ± 0.33<br>084.22 ± 0.22 |
| | 10 g $l^{-1}$ | With *Chlorella*<br>Without *Chlorella* | 140.00 ± 0.50<br>129.78 ± 0.28 |
| **Steamed cow dung** | 5 g $l^{-1}$ | With *Chlorella*<br>Without *Chlorella* | 065.00 ± 0.41<br>050.11 ± 0.35 |
| | 10 g $l^{-1}$ | With *Chlorella*<br>Without *Chlorella* | 099.89 ± 0.35<br>072.00 ± 0.29 |
| **1 hr. boiled chicken manure** | 10 g $l^{-1}$ | With *Chlorella* | 007.89 ± 0.26 |
| | 15 g $l^{-1}$ | With *Chlorella* | 007.89 ± 0.35 |
| | 20 g $l^{-1}$ | With *Chlorella*<br>Without *Chlorella* | 017.00 ± 0.23<br>007.78 ± 0.22 |
| **Controller** | | With *Chlorella* | 100.78 ± 0.47 |

## Conclusion

10 g $l^{-1}$ of mineralized cow dung with *Chlorella vulgaris* can be used as a best culture medium to obtain highest total number of *Moina macrocopa* among the tested culture media.

## Acknowledgement

I wish to express my gratitude to all the lecturers in Uva Wellassa University, Sri Lanka and all the members in Ornamental Fish Breeding and Training Centre, Rambadagalla, Sri Lanka.

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Das, P., Mandal, S.C., Bhagabati, S.K., Akhtar, M.S. and Singh, S.K. 2012, Important live food organisms and other role in Aquaculture, Narendra publishing house, Mumbai.

# Evaluation of the attitude and awareness of the international resolution on responsible fishing: a case study on the multiday fishermen of Matara

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## Introduction

Sri Lanka is an island, situated in the Indian Ocean between 6 – $10^0$ N latitude and 80 – $82^0$ E longitudes. This island has approximately 1700 km long coastline and sovereign power for the 21,500 $km^2$ territorial sea and an Exclusive Economic zone (EEZ) of 517,000 $km^2$ (MFAR, 2013). Therefore fisheries industry significantly contributes to the food security and the foreign exchange earnings of Sri Lanka. This IUU fishing is a serious threat to the sustainability of fisheries in both national jurisdictions and high seas. Therefore regional resolutions are implemented by the Indian Ocean Tuna Commission (IOTC) to reduce these IUU fishing activities. Although there are laws and regulations, many problems in the fisheries sector are caused due to lack of awareness of fishermen regarding these implemented national and international laws. Therefore identification of awareness of fishermen on these laws and regulations are very important before the implementation of awareness programs. This study was done with the objectives of investigating international resolutions which highly impact to Sri Lankan fisheries sector, investigate responses of fishermen on international resolutions, identify and suggest procedures which can improve the awareness and behaviors of fishermen on international resolutions.

**Keywords**: Illegal Unreported Unregulated (IUU) fishing, Indian Ocean Tuna Commission (IOTC), International Resolutions

## Methodology

Matara fisheries district was selected as the research area. The sample for the case study was selected from multiday boat owners, crew members, skippers and other service providers of Matara fisheries district through the Stratified random sampling. The sample size was determined using "Moving average method". Data was collected from both primary and secondary sources. Primary data was collected from selected sample, through the questionnaire and interviews. The questionnaire was prepared using international resolutions which developed by the IOTC. Both open ended questions and closed ended questions were included in the questionnaire. Secondary data was collected from sources of Department of Fisheries and Aquatic Resources and IOTC web site. Collected data was analyzed using "Likert method" (Likert, 1932) and one way ANOVA (Analysis of Variance) at 95% significant interval. "Minitab 16" software was used for analyzing all the collected data.

## Results and Discussion

The sample size was selected as 105. According to the finalized results of the study, total mean of awareness and attitude regarding these international resolutions is 3.38 ± 1.58. It means that the level of awareness and attitude of fishermen of Matara fisheries district on these international resolutions are medium. The statements used for the questionnaire have derived from the IOTC resolutions (IOTC, 2013). The current awareness of stakeholders on these international resolutions is helped to keep the Sri Lankan fishermen under the international resolutions. It helps to enhance the acceptance for Sri Lankan fish and fish products in the international market. Not only that but also the awareness on some resolutions are directly influenced on the management of fishery resources.

The community has a high level of knowledge ($3.67 \leq$ Mean Likert scale $\geq 5.00$) on the statements of importance of registration of fishing vessel, importance of having a flag in the fishing vessel, importance to mark vessels according to the regulations (Resolution 01/02 relating to control of fishing activities), importance of establishing a vessel monitoring program (Resolution 06/03), idea about prohibition of bottom trawling and crossing sea boundaries without proper permission, requirement of permission from the department for landing harvest at another country or for exchanging harvest with the foreign vessels at sea (Resolution 12/05 on establishing a program for transshipment by large scale fishing vessels), prohibition of catching endangered shark species and sea turtles (Resolution 12/09 on the conservation of Thresher sharks and Resolution 12/04 on the conservation of marine turtles) and preference of carrying equipment in the vessel which was used for catching sea birds and sea turtles. The registration of fishing vessel and vessel marking according to the regulations are already in place in the national regulations (1980). Therefore all of them have to comply with the registration of fishing vessel and marking them according to the regulations for having other subsidies and insurance.

The awareness was medium ($2.34 \leq$ Mean Likert scale $\geq 3.66$) on the statements of importance of maintaining a log book on board (Resolution 01/02), the requirement of providing information about harvest to the Department of Fisheries, willingness to support the government officers, agree to carry a department officer as an observer when they request, importance to inform navigation path for the department or harbor (Resolution 05/03 and Resolution 10/11). According to the attitude of some stakeholders, it is difficult to carry a department officer as an observer due to the limitation of space in the vessel and several other difficulties. The idea of some skippers was important to maintain a log book to have an idea in future regarding places and time of high densities of fish. It was considered as an additional trouble for their hard occupation by others. According to the responses of stakeholders, there are some people who unable to keep records on this log book due to inability of writing.

The overall awareness was very low ($1.00 \leq$ Mean Likert scale $\geq 2.33$) on the statements of international trade barriers which are occurred to Sri Lankan fisheries sector due to the ignorance of international resolutions, prohibition of large scale driftnets on the high seas in the IOTC area (Resolution 12/12), closed area (Resolution 12/13). With the high sea fishing operation license, printed material including the statements regarding the Resolution 12/12 has received by the boat owners. Therefore regarding the prohibition of large scale driftnets on the high seas, there was awareness among some people specially with the boat owners and skippers. But even the response of these people was not agreed with the idea. According to them, 2.5 km length gill nets are not enough to recover their fuel cost. The awareness of fishermen was very low regarding the closed area (Co-ordinates $0^0$ - $10^0$ North, $40^0$ - $60^0$ East in the Indian Ocean during February month) for fishing (Resolution 12/13 for the conservation and management of Tropical Tunas stocks in the IOTC area of competence). Therefore the overall response for a closed area was seriously disagreed. But some of the stakeholders believe it is necessary to have a closed area for the sustainability of fishery resources.

Regarding six statements, there was a significant difference of the responses according to the types of stakeholders. The identified major reasons for this significant difference are difference of the participation level for the awareness programs and different attitudes among types of stakeholders. Compared to the crew members, the awareness of boat owners and skippers were high. The reason for this was identified as the high level of participation for the awareness programs while others are engaging in fishing activities. The awareness of other service providers was very low. Because they just consider on their occupation. It is better to use a media such as newspapers, television and mostly the radio which is much closer to them. Other than using the mass media for the awareness programs, it is better to display posters regarding these resolutions in the harbor premises, maintain a continuous dialogue between the stakeholders and the government. It is identified the necessity to improve their knowledge and literacy on new devices such as electronic means of communication.

The overall knowledge of fishermen of Beruwala is relatively in positive level (3.61± 1.28) about the international resolutions (Madhushani, *et al*., 2013). But knowledge level of fishermen of Matara fisheries district regarding international resolutions is medium. Therefore the level of implementing awareness programs should be different from Beruwala to Matara. The required level of awareness programs is high for the Matara fisheries district than for the Beruwala. Although there was awareness regarding some resolutions in both Beruwala and Matara, they do not act according to them. Their negative attitude regarding these resolutions is the reason for this. Therefore while improving awareness regarding international resolutions, developing positive attitudes is very important. It is necessary to improve the common knowledge of stakeholders regarding the international resolutions and importance of these resolutions.

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# Toxicity effects of trace metals on Zebra fish (*Danio rerio*) embryo

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## Introduction

Water quality deterioration is a major problem in the most of the countries, due to organic and inorganic contaminants. Among all the toxicant trace metals are threaten to the aquatic ecosystem and organisms. Metals are natural component of aquatic ecosystem. Trace metals such as Copper (Cu), Zinc (Zn) and Chromium (Cr) are important for the metabolic and other biological activities of lives whereas Mercury (Hg), Lead (Pb), Cadmium(Cd) are biologically non-essential metal that can be toxic to biota even at very low concentration. High concentration of some essential trace metals can be toxic when it exceeds the limits(Ebrahimi and Taherianfard, 2011).High accumulation of trace metal in both biotic and abiotic components causes serious health consequences. Thus, assessment of their toxicity has become an important component of water pollution monitoring. Now in most of the toxicity studies Zebra fish (*Danio rerio*) embryo used as an alternative model for the fish acute toxicity to determine the toxicity of pollutants. Therefore this study was focused on determination of the acute toxicity of Cu, Zn, Cd, As, Pb and Hg that produce lethal effect on zebra fish embryos during four day period.

## Materials and Methodology

Zebra fish breeding was carried out and eggs were collected using a small pipette. The stock solution of 1000 ppm of selected Cu, Zn, Pb, Cd, As and Hg were prepared a day before the test by dissolving Copper sulfate ($CuSO_4.5H_2O$), Zinc sulfate ($ZnSO_4.\ 7H_2O$), Lead nitrate ($Pb(NO_3)_2$, Arsenic pentoxide ($As_2O_5$), Cadmium chloride ($CdCl_2.\ ½\ H_2O$) and Mercury chloride ($HgCl_2$) in deionized water. The working treatment solution was prepared daily by serial dilution of the stock solution. Initially a range finding test was carried out in the nominal concentrations of (1000, 100, 10, 1 and 0.1 $mgL^{-1}$) for 96 hours. Ten eggs per concentrations were used. Deionized water was used as a negative control. Each treatment had three replicates. Acute Cu, Zn, Pb, As, Cd and Hg toxicity experiments were performed for a 4-day period using *Danio rerio* embryo. Ten test concentrations of Cu, Cd (0.025, 0.05, 0.1, 0.2, 0.4, 0.8, 1.6, 3.2, 6.4 and 10.0 $mgL^{-1}$), Zn, Pb, As (2.0, 4.0, 8.0, 16.0, 32.0,64.0, 125.0,250.0, 500.0 and 1000.0 $mgL^{-1}$) and Hg (0.002, 0.004, 0.008, 0.016, 0.032, 0.064, 0.125, 0.250, 0.500 and 1.0 $mgL^{-1}$) were prepared by diluting the stock solution in deionized water. Deionized water was used as negative control and as internal plate control. As a positive control concentration of 15% ethanol(Hassan *et al*., 2008) was used with each embryo batch for testing. Fertilized zebra fish embryos were immersed in the test solutions before cleavage, by the 16 cell-stage. At least twice the number of eggs needed per treatment group (40 eggs) was randomly selected and transferred into the respective concentrations and controls within the 90 minutes of post fertilization. 24-well plates were filled with 2 mL per well freshly prepared test solutions. In each plate twenty wells were used for test concentrations and four were used as internal plate control. Another plate was used as positive control. The eggs in standard 24- well plate were covered by shelf adhesive foil and maintain at a temperature to 26 ± 1 °C. The mortality of the fish eggs were recorded at 24, 48, 72 and 96 hours of exposure using a stereo microscope with the indicator of lethality; coagulation of fertilized egg, lack of somite formation, lack of detachment of the tail and lack of heart beat as described in OECD/ OCDE 236, 2013; guideline for the test of chemical, Fish Embryo Acute Toxicity (FET) tests. Dead eggs were removed immediately. Three replicates were performed individually. In this study the acute toxic effect of each metal on the *Danio rerio* embryo was

determined by Probit Analysis $LC_{50}$ determination method. Data analysis was performed by using statistical software SPSS15.

**Results and Discussion**

According to the analysis in the range finding test, minimum concentration that can cause 100 % mortality was recorded. Based on the result obtained, range for As, Pb and Zn is below the 1000.0 $mgL^{-1}$, for Cd and Cu less than 10.0 $mgL^{-1}$ and for Hg less than 1.0 $mgL^{-1}$ . The relationship between the metal concentration and mortality rate of each trace metal was recorded based on the four apical endpoints. It shows that mortality rate is increasing with the increasing concentration and time of exposure. Acute toxicity of As, Cd, Hg, Pb, Cu and Zn showed that mortality is directly proportional to the concentration of the trace metals. The probit analysis revealed that there is a significance difference between the trace metals and control group ($P< 0.05$).According to the analysis of median lethal concentration ($LC_{50}$), Hg is highly toxic to the *Danio rerio* embryo and followed by the Cu, Cd, Zn, As and Pb. The toxicity trend of $LC_{50}$ 96 hrs observed was Hg (0.0217 $mgL^{-1}$) < Cu (0.099 $mgL^{-1}$) < Cd (0.407 $mgL^{-1}$) < Zn (14.021 $mgL^{-1}$) < As (34.840 $mgL^{-1}$) <Pb (41.697 $mgL^{-1}$). $LC_{50}$ and upper and lower confidence limits revealed a decreasing trend from 24 to 96 hrs(Table 1). Fish embryo stage is highly sensitive to metal pollution. The chorion does not fully protect the embryo against metal penetration. In this study, the most toxic trace metal to *Danio rerio* embryo is Hg. The $LC_{50}$values of Hg at 24, 48, 72 and 96 hrs wereless than 0.04 $mgL^{-1}$.It shows that even at lower concentration it can cause high mortality rate on *Danio rerio* embryo.

Table 2: Summarized $LC_{50}$ value of trace metals on *Danio rerio* for a period of 24 – 96 hrs

| Trace metals | $LC_{50}$ (95% confident limits – lower, upper) | | | |
|---|---|---|---|---|
| | 24hrs | 48hrs | 72hrs | 96hrs |
| Hg | 0.0397 (0.0324,0.0488) | 0.0229 (0.0245,0.0367) | 0.0218 (0.0182,0.0263) | 0.0217 (0.0180,0.0260) |
| Cu | 0.1735 (0.1498,0.2011) | 0.1306 (0.1128,0.1512) | 0.0991 (0.0844,0.1157) | 0.0991 (0.0844,0.1157) |
| Cd | 0.5660 (0.4339,0.741) | 0.464 (0.3505,0.613) | 0.418 (0.3152,0.550) | 0.407 (0.3072,0.536) |
| Zn | 23.083 (18.871,28.13) | 17.080 (13.936,20.801) | 14.021 (11.347,17.147) | 14.021 (11.347,17.147) |
| As | 42.915 (36.223,50.97) | 38.313 (32.007,45.98) | 34.840 (28.903,42.08) | 34.840 (28.903,42.08) |
| Pb | 113.8 (88.5,149.6) | 63.90 (50.81,81.0) | 43.75 (35.75,53.71) | 41.70 (33.97,51.34) |

In *Danio rerio* embryo toxicity test several sub- lethal and teratogenic endpoints were observed. In control no deformities were observed. Growth retardation, Shrinkage of chorion, Scoliosis, Pericardial edema, Yolk sac edema, Lack of pigmentation, Tail deformities, Heamorrhages, missing formation of lens and Lack of otoliths are the major deformities observed during the study. Growth retardation is mainly caused by growth inhibitorsofCd and Cu (Sikorska and Wolnicki, 2006). Skeletal deformities in fish are good bio indicators of pollution (Bengtsson, 1979; Lemly, 1997; cited in Curtis, 2004). Damage of the vertebral column expressed as curvature of the larval body axis is

caused by all heavy metals toxification (Jezierska *et al.*, 2000; Nguyen and Janssen, 2002; Hallare *et al.*, 2005; cited in Osman, 2007). The tail deformities genetically resulting from the inability of treated embryos to expresses the *evenskippid* gene (Osman, 2007).Pigmentation is controlled by Melanocyte Stimulating Hormone (αMSH) and Melanin-Concentrating Hormone (MCH). Pigmentation changes in fish are often due to stress induced (Nguyen and Janssen, 2002; cited in Osman, 2007).

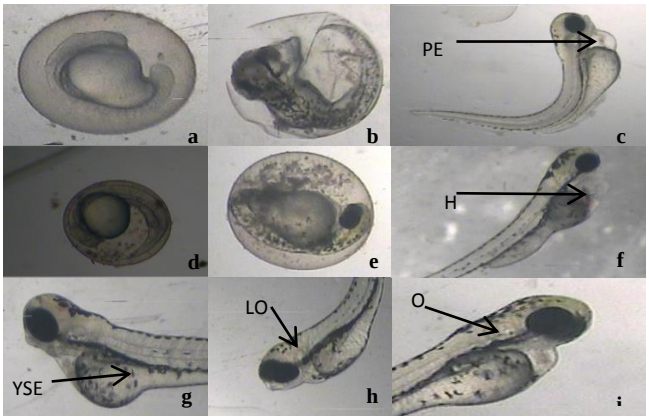


Figure 2: Sub-lethal and terratogenic endpoints ; Growth retardation (a),Shrinkage of chorion (b), Scoliosis and Pericardial edema (c), Lack of pigmentation (d), tail deformities (e), Heamorrhages (f), Yolk – sac edema (g), Lack of otolinths (h), Normally developed *Danio rerio* embryo after 96 hpf

## Conclusion

In the present study, a comparison of $LC_{50}$ values, sub-lethal and teratogenic effects indicated that Hg is highly toxic to *Danio rerio* embryo followed by Cu, Cd, Zn, As and Pb. The $LC_{50}$ value of each trace metal is increasing with increasing concentration and time of exposure. This study indicates that *Danio rerio* embryo is a potential indicator for trace metal pollution.

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# Development of micropropagation protocols for two aponogeton species of Sri Lanka (*Aponogeton crispus* and *Aponogeton natans*)

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## Introduction

Sri Lanka being a tropical country contributes for a highly diversified flora and fauna. These climatic conditions have become a critical factor for the occurrence of highly diversified aquatic flora as well. *Aponogeton* is genus of aquatic plants which belongs to the family Aponogetonaceae. According to Bruggen there are four *Aponogeton* species occur in Sri Lanka (Dassanayake and Fosberg, 1987). Among these species *Aponogeton jacobsenii and A. rigidifolius* are endemic to Sri Lanka while *A. natans* and *A. crispus* are native plants (Wijesundara and Shantha Siri, 2004).They are having a high demand as an aquarium decorative plant in the export market. This study was carried out to develop a micropropagation protocol for mass production of *A. crispus* and *A. natans* and *A. jacobsenii* species.

## Methodology

The study was carried out at tissue culture laboratory of Royal Botanic Gardens, Peradeniya. Mother plants were collected from different areas of Sri Lanka. Experiments were done to determine hormonal effect on shoot initiation and multiplication using rhizomes of *Aponogeton crispus* and *A. jacobsenii*; leaf and leaf stalks of *A. natans* and *A. jacobsenii* and seeds of *A. crispus* and *A. natans.* For the Sterilization of *A. crispus* and *A. jacobsenii* rhizomes were kept under running tap water for 3 hours and dipped in a fungicide for 30 minutes. Then disinfected using 20 % NaOCl (Clorox) with 2 drops of Tween twenty for 10 minutes and washed with 0.1 % $HgCl_2$ for 7 minutes. Finally rhizomes were washed 5 times thoroughly with distilled water per 5 minutes. For seeds sterilization seeds were kept under running tap water for 10 minutes, disinfected using 5 % Clorox with 2 drops of Tween twenty for 15 minutes and washed 3 times with distilled water. Three sterilization procedures were carried out for leaves and leaf stalks. Firstly leaves kept under running tap water for 1 ½ hours and dipped in fungicide (topsin) for half an hour. Then washed with 5 % of NaOCl (Clorox) for 10 minutes and washed with 0.1 % $HgCl_2$ for 3 minutes. Finally leaves washed 3 times with distilled water. Again sterilization procedure was tested by using 5 % NaOCl for 5 minutes and 0.1 % $HgCl_2$ for 2 minutes. As the final method leaves were sterilized with 2 % of NaOCl for 2 minutes 0.1 % $HgCl_2$ for 1 minute. Basal full strength MS medium supplemented with 20 $mgL^{-1}$ of sucrose and 7 $gL^{-1}$ of agar was used. pH was adjusted to 5.6. Different levels of BAP and IAA hormones were tested for the experiments (Figure 1, 2, 3). Cultures were maintained under controlled condition of 26 $^0$C +/- 2 $^0$C temperatures and white fluorescent light with 16 hour photoperiod for shoot regeneration. Ten replicates per each treatment were maintained and media without adding hormones used as the control. Experiment was arranged in factorial Complete Randomized Design (CRD). Data analyzed using ANOVA and Tukey's Test using MINITAB 17 software.

**Results and Discussion**

In the study only rhizome culture of *Aponogeton crispus* and seed culture of *A. crispus* and *A. natans* were succeeded. Shoot initiation was not observed in rhizome culture of *Aponogeton jacobsenii* within six week time period. Leaf and leaf stalk culture was unsuccessful due to over sterilization. The effects of the hormone concentration on shoot regeneration of *Aponogeton crispus* had shown a significant difference ($p < 0.05$). Maximum mean number of shoot initiation was observed in culture medium T6 (Figure 1). Minimum number of shoot initiation was observed in T7 (Figure 1). Shoot regeneration was not observed in hormone free MS medium. There was a significant different between T1, T4 and T6 (Figure 1).

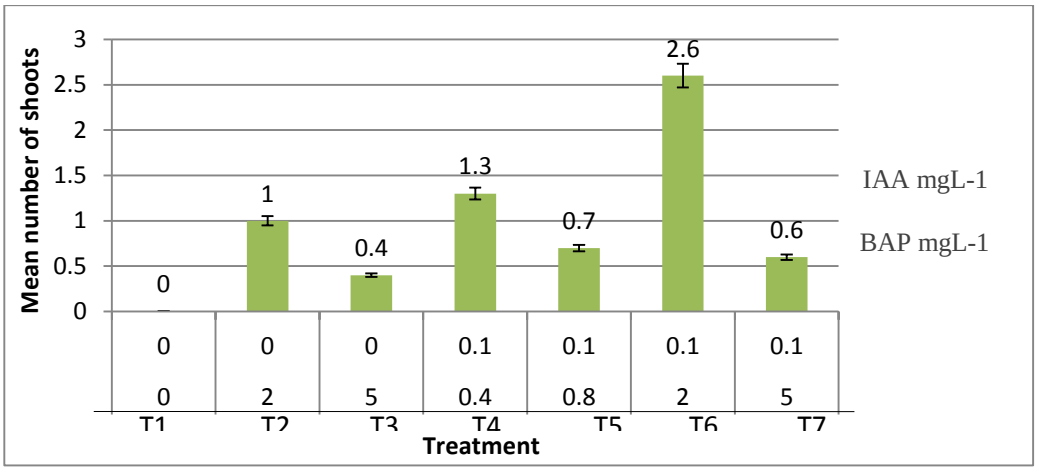


Figure 3 : Effect of hormone concentration on shoot initiation of *Aponogeton*

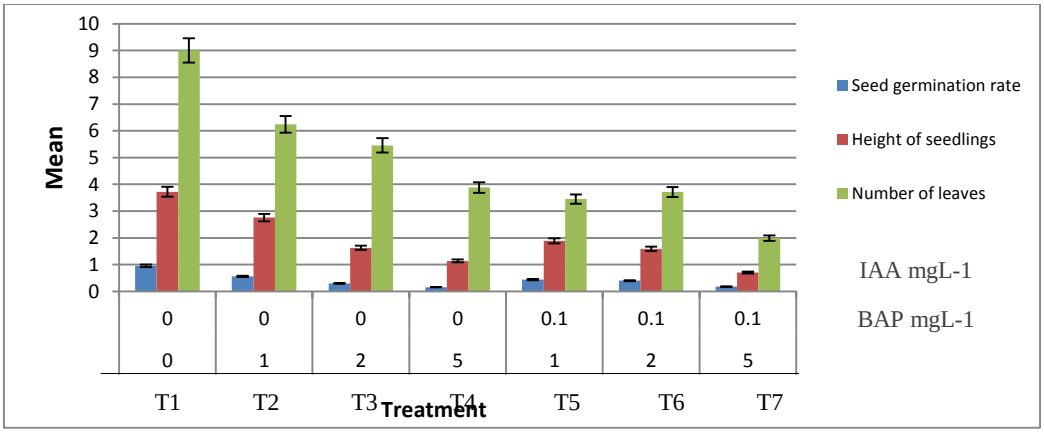


Figure 4: Effect of different hormone concentration for Seed culture of *Aponogeton natans*

Seed culture of *Aponogeton natans* and *A. crispus* were succeeded. The data analysis of *Aponogeton natans* seed culture had shown a significant difference ($p < 0.05$) in mean of seed germination rate, mean height of seedlings and mean number of leaves. Highest mean of seed germination rate was observed in hormone free MS media (T1). Minimum mean number of seed germination was observed in medium supplemented with 5 $mgL^{-1}$ of BAP. There was a significant difference among T1, T2 and T4. The maximum mean height of seedlings and the maximum mean number of leaves were observed in hormone free MS medium followed by T2, T3, T4 and T6 (Figure 2). The minimum height of

seedlings and the minimum mean number of leaves were observed in T7 medium which was supplemented with high concentration of BAP (5 $mgL^{-1}$) and IAA (0.1 $mgL^{-1}$). (Figure 2)

There was a significant difference in treatments for seed germination ($p < 0.05$) of *A. crispus*. The maximum seed germination was recorded in hormone free MS medium (T1). The minimum seed germination was observed in T4 medium which was supplemented with 1 $mgL^{-1}$ of BAP and 0.1 $mgL^{-1}$ of IAA. The maximum mean height of seedlings and the maximum mean number of leaves were observed in hormone free MS medium (T1). The minimum mean height of seedlings and the minimum mean number of leaves were observed in medium which contained 1 $mgL^{-1}$ of BAP and 0.1 $mgL^{-1}$ of IAA. (Figure 3)

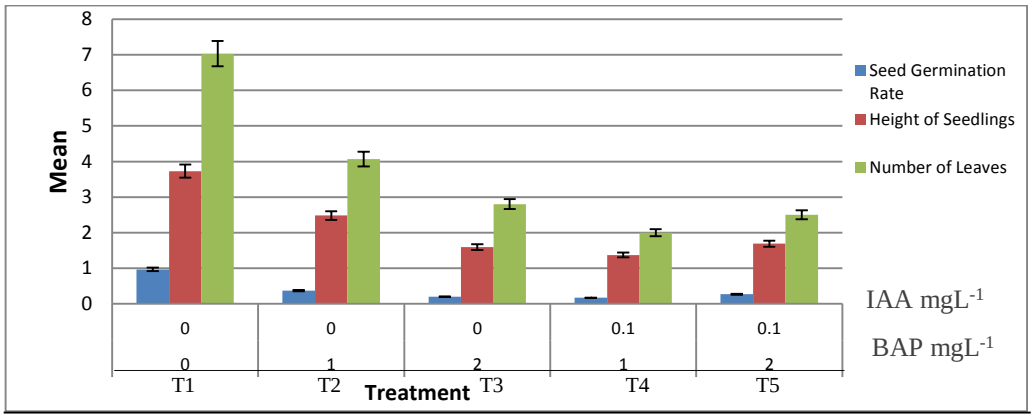


Figure 3: Effect of different hormone concentration for Seed culture of *Aponogeton crispus*

Medium supplemented with 2 and 5 $mgL^{-1}$ of BAP were used for shoot multiplication. Data analysis of *A. crispus* and *A. natans* had shown a significant difference ($p < 0.05$) among hormone treatments. Maximum was obtained in the medium supplemented with 2 $mgL^{-1}$ of BAP. The toxicity caused by an excess of growth regulators in the culture medium, or the extended period of time in which the culture was exposed to them, might lead to genetic, physiological and morphological changes, resulted in a reduction of the proliferation rate in vitro (Narayanaswamy, 1977). It is therefore important to evaluate their effects on plant regeneration.

## Conclusion

Among selected hormone concentrations 2 $mgL^{-1}$ of BAP and 0.1 $mgL^{-1}$ of IAA is the most suitable combination for shoot regeneration of *A. crispus*. MS medium without hormones is more effective for seed culture of *A. crispus* and *A. natans*. Culture medium supplemented with 2 $mgL^{-1}$ of BAP is more suitable for multiplication of seedlings of *A. natans.*

## Acknowledgement

I'd like to convey my sincere gratitude to Dr. S. A. Krishnerajah, Deputy Director of Floriculture Research and Development. Also to all the staff members of Tissue culture laboratory at Royal Botanic Gardens, Peradeniya.

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# Consumption pattern of fish among households in Batticaloa District

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## Introduction

Fisheries sector in Sri Lanka provides livelihood for more than 2.5 million coastal communities as well as providing more than 50% of animal protein requirement of people in the country (NARA, 2012). The fact that fish is relatively cheap compared with meat, beef, mutton, poultry, and pork, which also contains protein of high biological value tends to make it preferred to other sources of animal protein (Adeniyi *et al*., 2010). In Batticaloa District presence of a long seacoast and the mile long lagoon provides a good fishing environment. It leads to high availability and production of both inland and marine fish (Dist. Planning Secretariat, 2013). About 85% of people in Batticaloa District consume fish as their major protein food (Devadawson and Jayasinghe, 2014). Therefore, this study was designed to determine the quantity of fish consumed, expenditure on fish and preferences for various fish varieties by households in Batticaloa District.

## Methodology

Data related to frequency of fish purchases, price of different fish varieties, preference of fish varieties and other fish purchasing details were collected from 120 respondents at 3 rural and 3 urban markets in 6 DS Divisions in the Batticaloa District. Purposive sampling technique was used to select the respondents and a pre tested and well-structured questionnaire was used to collect data. The data was analyzed using SPSS Ver.22.0 software.

## Result and Discussion

The data revealed that the majority of the respondents (66%) were consuming both marine and inland fish varieties, while 24% of the respondents consume marine fish only and 10% consume inland fish only. It was also evident from the data that about 34% of the respondents had some specific reasons for the avoidance of certain fish types in their meal. Avoidance of marine fish varieties in fish purchase occurs only due to the high market price compared to inland fish. In case of inland fish avoiders, 82% of them avoid due to the unfavorable odor emanating during the cooking process, 62% of them avoid due to polluted and unsatisfactory sanitary conditions prevalent in fishing areas and rest (13%) avoids inland fish due to unpalatable taste.

In purchasing fish about 26% of the consumers considered only the desirable characters of fish, around 68% considered both price of fish and fish characters equally and only 6% considered the price of fish in purchasing decisions. Freshness of fish is the important fish character considered in fish purchasing. Around 97% of consumers were very specific about the freshness of fish they purchase. About 60% consumers were concerned about taste of the fish they purchase and 43% of consumers concerned about the allergic condition of fish to their family members and a quarter of the respondents (28%) pay attention to the appearance of the fish which include firmness of flesh, bone content and thickness of skin.

Table 1: Consumption pattern of Marine Fish Varieties (N=108)

| **Fish varieties** | **Percentage of Consumers purchasing** | **Frequency of purchases per month / family** | **Quantity purchased (Kgs/visit) )** | **Mean Price (Rs./kg )** | **Preference (% of consumers )** |
|---|---|---|---|---|---|
| *1. Arukula (Scomberomorus cavalla)* | 36.11 | 1.23 | 0.56 | 1026.15 | 26.9 |
| *2. Kelawalla (Tuna sp.)* | 38.89 | 2.10 | 0.58 | 775.00 | 32.4 |
| *3. Paarai (Carangoides malabaricus)* | 66.67 | 2.47 | 0.60 | 673.75 | 37.0 |
| *4. Balaya (Thunnus albacores)* | 39.81 | 2.23 | 0.58 | 349.77 | 13.0 |
| *5. Soodai (Sardinella sp.)* | 45.37 | 2.06 | 0.62 | 245.51 | 2.8 |
| *6. Thalapath (Istiuphorus platypterus)* | 20.37 | 1.10 | 0.51 | 718.64 | 13.0 |
| *7. Keeri (Amplicaster sp.)* | 58.33 | 2.66 | 0.57 | 372.38 | 13.9 |
| *8. Neththali (Anchoviella sp.)* | 61.11 | 2.50 | 0.56 | 350.30 | 28.7 |
| *9. Sura (Chaenogalus sp.)* | 7.41 | 1.38 | 0.69 | 593.75 | 6.5 |
| *10. Seela (Sphyraenabarracuda.)* | 56.48 | 2.40 | 0.58 | 320.98 | 18.5 |
| *11. Kumbula (Rastrelliger sp.)* | 54.63 | 2.94 | 0.56 | 419.83 | 25.9 |
| *12. Thirukkai (Dasyatis sp.)* | 15.74 | 2.41 | 0.66 | 457.65 | 6.5 |

According to Table 1, in Batticaloa District, popular marine fish variety was *Carangoides malabaricus*. About 67% of the consumers purchased *Carangoides malabaricus* fish for their meal at an average of about 2-3 days per month. Fish purchased at high frequency in a month by respondents was *Rastrelliger sp.* (55% at 3 days/ month interval). The data clearly showed that no appreciable changes were observed on mean consumption of fish varieties and it was very independent with the quantity purchased and variety selected. The mean consumption of marine fish varieties at a single visit in study area was 0.59 kg. Data revealed that the high priced marine fish variety *Scomberomorus cavalla*, and mean market price was Rs.1,025 per kg. Cheapest marine fish variety in the study area was *Sardinella sp.* (Rs. 245 per kg). In the study area the respondents mostly preferred varieties of fish were 37% *Paarai (Carangoides malabaricus*), 32% Kelawalla *(Tuna sp.)* and 29% Neththali *(Anchoviella sp.).*The mean expenditure on marine fish purchases per family per month was Rs.3,042.

As shown Table 2, in the consumption pattern of inland fish varieties, about 72% of the consumers consumed *Oreochromis mossambicus*, 65% of them consumed *Etropluss uratensis* at an average of 3 times per month. The average quantity of inland fish variety purchased was more or less similar to all varieties. The mean quantity of inland fish variety purchased was 0.57 kgs per single visit.

According to the data, the high priced inland fish variety in the study area was *Ophicephlaus sp*. (Rs.511 per kg) followed by *Cyprinus carpio* (Rs.504 per kg). In the study area, consumers most preferred varieties of fish were 44% *Oreochromis mossambicu (Tilapia)*, 25.3% *Seththal (Etropluss uratensis)* and 24% *Otti (Siganus sp.)* due to their reasonable prices and frequent availability. It was found that the mean expenditure on inland fish purchases per family per month was Rs.1,077.

Table 2: Consumption pattern of Inland Fish Varieties (N=91)

| **Fish varieties** | **Percentage of Consumers purchasing** | **Frequency of purchase / mth. Per family** | **Quantity purchased (Kgs/visit)** | **Mean Price (Rs./kg)** | **Preference (% of consumers)** |
|---|---|---|---|---|---|
| *1. Tilapia (Oreochromis mossambicus)* | 72.53 | 3.27 | 0.59 | 284.09 | 43.96 |
| *2. Keluthi (Arius sp.)* | 29.67 | 2.33 | 0.69 | 236.48 | 8.79 |
| *3. Viral (Ophicephlaus sp.)* | 14.29 | 1.08 | 0.63 | 511.54 | 6.59 |
| *4. Seththal (Etropluss uratensis)* | 64.84 | 3.00 | 0.61 | 283.39 | 25.27 |
| *5. Kayal (Liza sp.)* | 26.37 | 1.71 | 0.53 | 346.67 | 12.09 |
| *6. Koduwa (Ephinephalus sp.)* | 19.78 | 1.56 | 0.57 | 383.89 | 6.59 |
| *7. Otti (Siganus sp.)* | 40.66 | 2.05 | 0.58 | 398.65 | 24.18 |
| *8. Sallal (Etroplus aculates)* | 20.88 | 3.00 | 0.51 | 242.11 | 3.30 |
| *9. Kanayan (Cyprinus carpio)* | 13.19 | 2.33 | 0.52 | 504.17 | 10.99 |
| *10. Manalai (Mugil cephalus)* | 13.19 | 2.17 | 0.44 | 281.67 | 3.30 |

## Conclusions

Majority of the households were consuming both marine and inland fish varieties in the study area and they mostly consider the price of fish and desirable fish characters together during purchases. Price, freshness, allergic content and taste of fish were considered in purchasing decisions while freshness of fish was the important fish character considered in fish purchasing. Average quantity of fish purchased at a single market visit did not differ significantly between marine and inland fish varieties and was about 0.57 kg per household /visit. While the expenditure by households on marine fish purchases was almost three times higher than that on inland fish purchases. Hence promotion of sales of both marine and inland fish varieties could help households meet their consumption demands. Especially the promotion of inland fish culture or aquaculture could enhance production of inland fish and the level of fish protein intake among households at a cheaper cost.

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# Isolation and incorporation of Nitrogenous compounds from Yellow Fin Tuna (*Thunnus albacares*) to produce a fish flavored vegetable burger

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## Introduction

Fish processing industry is increasing continuously in the world *Thunnus albacares* is a one of the major fish used bymany processing companies. Value added products are produced using tuna which include tuna steaks, tuna loin, tuna fillets, tuna blocks and canned tuna. At processing, trimmings are resulted as waste and discharged without any utilization. Hence, maximum utilization of fish waste is important. There are many nitrogenous compounds present in fish flesh. Nitrogenous compounds play an important role in flavor and taste of fish. Fish flavor components are non-protein-nitrogen compounds such as ammonia, monomethylamines, dimethylamines, trimethilamines, trimethilamonia bases (trimethylamine oxide and betaines), and guanidine derivatives such as creatine and argenine (Teerasuntonwat and Raksakulthai, 1995).Soya bean and chick pea can be used to produce vegetable burger sinceboth contain high amounts of protein. Soya bean contains 38% to 42% protein (Balasubramaniyan and Palaniappan, 2004). Chickpea has significant amounts of all essential amino acids and is rich in nutritionally important unsaturated fatty acids such as linoleic and oleic acid (Jukanti, 2012).The objectives of this study was to find out the ways to maximize the utilization of fish waste generated in fish processing industry and to use them to extract flavor compounds in order to incorporate it in to a vegetable burger.

## Methodology

Vegetable burger was prepared using soya and chick pea as the main ingredients. Dried soya bean was steamed at 80°C for 20 minutes and ground using a grinder (IS 4250,Jaipan family mate, India). Weighed ingredients were mixed and the pulp was made. Prepared mixture was then cooked in a steamer (WP5525, WIPRO, China) at 80°C for 20 minutes. Ingredients level of the burger was determined by preliminary sensory evaluations keeping soy and chick pea flour levels constant.

For determination of best combination of soya and chick pea flour, 5 recipes of vegetable burger were prepared by decreasing the soya level from 100% to 0% and increasing the chick pea level from 0% to 100% while keeping the other ingredients constant. Thirty untrained panelists were used to select the best formula for the burger. Fish flavor was extracted according to the method of Teerasuntonwat and Raksakulthai (1995) with some modifications. Yellow fin tuna trimmings were cut in to small pieces and ground using the grinder (Jaipan family mate) with 1% (w/v) NaCl (Fluka, England). Blended samples were transferred in to a 1000 mL beaker (PYREX, England) and heated at 60°Cfor 15 minutes using a stirrer (SR No:67702, VELP® SCINTIFICA, Europe). Heated samples were filtered using Whatman No: 4 filter papers. Filtration was dialysised to remove salt. Extracted fish flavor was kept under freezing condition and used instead of water (28%) in vegetable burger preparation.

For determination of best concentration to extract volatile compounds series different concentrations (w/v) of NaCl (0.1%, 1%, 5% and 10%) were prepared. Vegetable burger was prepared using the recipe developed and separated dialysis solutions. Best NaCl concentration was determined by a sensory evaluation test using 30 untrained panelists. Sensory evaluation data were statistically analyzed using non parametric Friedman test in Minitab 16. Lipid oxidation, pH value and proximate composition were determined in triplicate during 30 days of storage at 4°C.Microbiology tests were

done for *Escherichia coli, Salmonella, Staphylococcus* and total plate counts. Crude protein, crude fat, moisture and ash contents of fish flavored vegetable burger were analyzed using AOAC standard methods (2002) with some modifications. The cost of product was calculated for the best treatment selected from the final trial.

**Results and Discussion**

Majority of the panelist did not accepted the chick pea containing recipe ($p<0.05$). Therefore, only soya flour was selected as the plant protein source of the vegetable burger. At the same time cost analysis results showed that 100% soya containing recipe was cheaper than chick pea containing recipe. Hence, vegetable burger recipe was finalized. Finalized vegetable burger recipe containing 55% (w/w) of soya flour, 5% (w/w) of wheat flour, 1.5% (w/w) of chili powder, 1% (w/w) of pepper, 2% (w/w) of garlic, 1.6% (w/w) of salt, 5.9% (w/w) of vegetable oil, and 28% (w/w) of water. Then several trials were carried outto determine the best dilution series. Then NaCl:fish= 1:1 ratio was selected as the best dilution series by sensory evaluation tests.

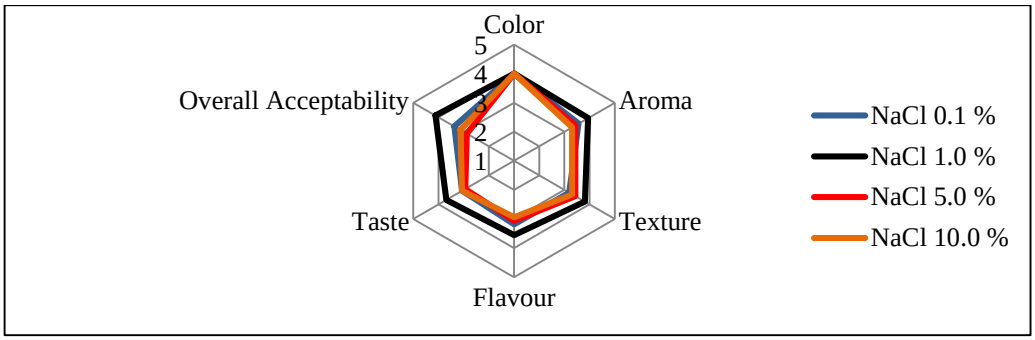


Figure 1: Sensory evaluation for determination of best NaCl concentration

According to Figure 1; 1% (w/v) of NaCl gave the highest organoleptic properties compared to rest of treatments ($p<0.05$). Therefore to separate protein and other volatile compounds 1% (w/v) with 1:1 dilution can be considered as the best NaCl concentration.

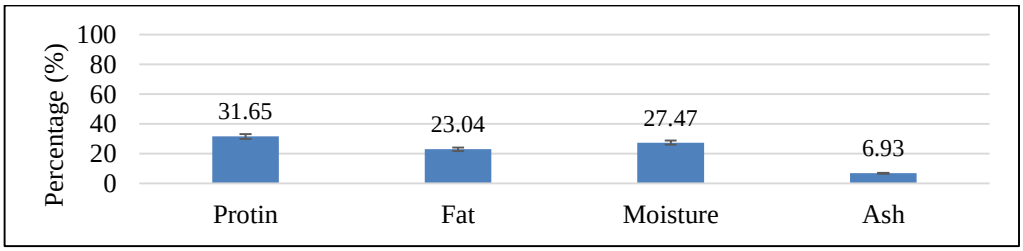


Figure 2:Proximate composition of the developed vegetable burger

According to the proximate analysis results, the fish flavored vegetable burger is rich in protein and fat content. Vegetable oil such as soy bean, nuts and rapeseed containing poly unsaturated (ω 3) fatty acids (Linolenic acids). Soy bean containing 7 % of α-linolenic acid and 18 carbon omega-3 fatty acids with 3 double bonds. ω-3 fatty acids prevent from the cardio vascular disease and ω-3 fatty acids such as docosahexaenoic acid are incorporated in to neural tissues, notably brain and retina. Hence poly unsaturated fatty acids are healthier than saturated fatty acids such as animal fat(Nettleton, 1995). It proved that this fish flavored vegetable burger is healthier than a meat origin burger.

There was no significant increase in pH during storage at 4°C.The pH value range of the burger was 6.29-6.8 during storage time. Soy protein has a relatively high pH value compared to the meet protein. Lean meat has approximately pH of 6.0. Therefore increasing the levels of soy protein have a tendency to increase the pHvalue (Hoogenkamp, 2005).

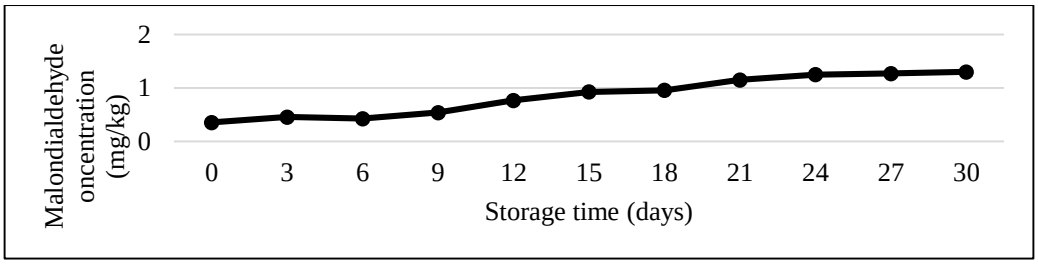


Figure 3: Changes in lipid oxidation value with the storage

There was a significant increase in lipid oxidation during the storage at 4°C for 30 days. Polyunsaturated fatty acids oxidized readily because their double bonds are unstable. Oxidation of unsaturated fats produces a variety of compounds that smell and taste rancid. Saturated fats are more resistant to oxidation (Whitney *et al*., 2011). Soya bean is rich in lipoxygenase and unsaturated fatty acids. Mechanical destruction and the presence of water or heat can accelerate the rate at which lipoxygenase catalyze unsaturated lipid oxidation (Riaz, 2006). Therefore increase of the oxidation due to the continuous oxidizing process of the poly unsaturated fatty acids of the soya bean. But according to the results, level of oxidation was within the acceptable level. Therefore, the product developed is suitable even after 30 days of storage even though the lipids oxidized during storage.

There was no growth of hazardous microorganism in the sample during the time of testing. According to SLSI specification for quick frozen whole fish, fish fillets, steaks and minced fish products microbiology test were done. There were only positive results in total plate count but levels did not exceed the SLSI recommended limits

## Conclusion

The best dilution series for fish flavor extraction is 1:1 ratio of fish and NaCl (1% w/v).Fish flavored vegetable burger was a nutrient rich low cost product.

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# Induced breeding of Silver Dollar (*Metynnis hypsauchen*) using ovaprim

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## Introduction

Production of ornamental fish is a rapidly growing sector of the aquaculture industry (Tlusty, 2001). Among the ornamental fish production in Sri Lanka, exotic ornamental fishes have a significant demand in the market.Silver Dollar (*Metynnishypsauchen)* which was originated from South America is such kind of exotic ornamental fish in Sri Lanka that a higher demand has been achieved. Silver Dollar is not breeding very often in Sri Lankasince it takes a longer spawning period. To avoid that problem, the fish can be bred artificially. Among all the artificial breeding methods, induced breeding by hormone administration is the most reliable method (Yanong, *et al*., 2013). In this study attempts were made to develop induced breeding of Silver Dollar (*Metynnis hypsauchen)* in Sri Lankan environmentusing inducing hormone "Ovaprim".

## Materials and method

Sexually matured and healthy Silver Dollar brooders were selected based on the external features. Eighteen pairs in same age were randomly collected and conditioned. Then Ovaprim as a single dose by intramuscular injection at a dosage of 0.2 $mlkg^{-1}$, 0.3 $mlkg^{-1}$, 0.4 $mlkg^{-1}$, 0.5 $mlkg^{-1}$ and 0.6 $mlkg^{-1}$ of body weight was administered to the brooders. Natural spawningwas also allowed without inducing by Ovaprim as a control. After the hormonal injection, the best range of Ovaprim dose to have least response time and better breeding performance of Silver Dollar was determined based on response time (hours). Relative fecundity, post mortality rate of brooders and water quality parameters in experimental tanks were also monitored.Data analysis was done by one way ANOVA and Tukey test.

## Results and Discussion

The effects of different doses on the breeding performance of Silver Dollar are shown in Table 1.Salmon gonadotropin releasing hormone analogue sGnRHa (Ovaprim) successfully induced spawning in Silver Dollar (*Metynnis hypsauchen*). Five different Ovaprim doses supported the spawning activity and the breeding performance was favored by lower and middle inclusion level of Ovaprim dose in the experiment.

Ovaprim is a well-known commercial spawning aid which is mostly used in induced breeding of fish (Anonymous, 2012). It has been used in successful manner for several fish families (Hill *et al*., 2005). In the present study,all the brooders spawned, except the brooders which were injected with 0.6 ml $kg^{-1}$ of body weight Ovaprim. Among those 6 treatments, the least response time was recorded with 0.3 ml $kg^{-1}$ of body weight Ovaprim as 5.66 hours. The maximum response time was observed in naturally spawned pairs as 632 hours (27 days). According to the literature, 0.5 ml $kg^{-1}$ of body weight is the standard Ovaprim dose for fish (Hill *et al*., 2005). However, in the case of Silver dollar, 0.3 ml $kg^{-1}$ of body weight is the best dose to have the minimum response time (Table 1).

Table 1: Breeding performance of Silver dollar induced with Ovaprim

| Parameter | Dose 1 (0 ml kg$^{-1}$ OP) | Dose 2 (0.2 ml kg$^{-1}$ OP) | Dose 3 (0.3 ml kg$^{-1}$ OP) | Dose 4 (0.4 ml kg$^{-1}$ OP) | Dose 5 (0.5 ml kg$^{-1}$ OP) | Dose 6 (0.6 ml kg$^{-1}$ OP) | P value |
|---|---|---|---|---|---|---|---|
| **RT (hrs)** | 632± 146.60$^{a}$ | 6.33± 0.57$^{b}$ | 5.66± 0.28$^{b}$ | 9.50± 0.50$^{b}$ | 7.00± 0.50$^{b}$ | 0.00± 0.00$^{b}$ | 0.000 |
| **RF** | 4.63± 1.86$^{ab}$ | 3.61± 1.32$^{ab}$ | 2.19± 1.20$^{bc}$ | 5.22± 0.30$^{a}$ | 6.43± 0.50$^{a}$ | 0.00± 0.00$^{c}$ | 0.000 |

[Values are presented as means ± S.D., means in each raw with different superscripts are significantly different from each other. (OP: Ovaprim; RT: Response time; RF: Relative fecundity)]

The maximum relative fecundity was observed with 0.5 ml kg$^{-1}$ of body weight Ovaprim (Table 1). Dose range between 0.4ml kg-1 - 0.5 ml kg$^{-1}$ of body weight could be identified as the better range to have a higher fecundity. Because of that, further studies should be followed to identify the best dosage which is occurred between 0.4 ml kg$^{-1}$ - 0.5 ml kg$^{-1}$ of body weight Ovaprim. Spawning has not occurred with 0.6 ml kg$^{-1}$ of body weight Ovaprim (Table 1). It indicates that, dosage beyond 0.5 ml kg$^{-1}$ of body weight Ovaprim might not be effective in breeding of Silver Dollar. The use of Ovaprim as a spawning aid in ornamental fish was surveyed in the United States, and they have found that some species may not be responsive to the GnRHa in Ovaprim or may require application under a different protocol (Hill *et al*., 2005). Based on the literature and the obtained results of the present study, a comparatively medium level of Ovaprim dose (0.4ml kg$^{-1}$– 0.5 ml kg$^{-1}$) can be recommended for a higher relative fecundity.

The survival rate of brooders was 100 % after Ovaprim was injected. According to the observation, the hormone dosage range which was used for the present study might not be harmful and there was no negative effect to Silver Dollar. Achionye and Obaroh, (2012) have found that procedure of injection, quality of the hormone and degradation of water quality during holding and handling of fish affect to the post mortality of brooders. At the present study, conditioning and domesticating brooders before hormone injecting, maintaining water quality, supplying nutritious feeds, using quality hormone and reduced handlings of fish due to the single dose administration to both sexes might have affected for this decreasing of post mortality of brood fish (More *et al*., 2010). There was no any significant difference ($P > 0.05$) in water temperature, Dissolved oxygen and pH in six different treatment tanks.

Since a successful result could be obtained through the study, following further studies and providing the facilities for practicing induced breeding of Silver Dollar using Ovaprim can be done to make Silver Dollar available to breeders and producers for mass scale production. Because, considering the relatively simple technique involved, this activity has the potential to create adequate job opportunities, increase export earnings as well as develop the ornamental fish industry in Sri Lanka.

## Conclusions

Minimum spawning time in Silver Dollar can be achieved by 0.3 ml kg$^{-1}$ of body weight and maximum relative fecundity can be obtained with 0.5 ml kg$^{-1}$body weight Ovaprim. From the

available references along with the present study on the induced breeding of the Silver Dollar, it was observed that better breeding performances were achieved from a comparatively lower dosage of Ovaprim.

**Acknowledgement**

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# A comparative study on the effectiveness of gillnet and longline fishing methods used by multi-day fishermen in Matara fisheries district

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## Introduction

The fisheries sector of Sri Lanka is a primary source of animal protein production. According to the high rate of population growth in Sri Lanka, fish food demand is increasing. To fulfill this increasing demand, there should be an effective fishing method for high rate of exploitation and exploited resources should be high quality and high value for the better utilization. In the late 1980s, Sri Lankan state introduced multiday offshore fishing vessels for the development of Sri Lankan offshore fisheries (Kariyawasam, 2010). The gillnet fishery and the longline fishery is the common fishing methods used in the deep sea fishing in Sri Lanka. According to the DFAR statistics in 2013, Matara fisheries district is one of the districts which provide high fish production to the nation. The gillnet fishery is most commonly used fishing method in multiday boats fishermen in Matara fisheries district and they do not engage in longline fishery very much. The identification of the suitable fishing methods is important to increase production level, quality of the production and income of the multiday fishermen. Therefore the present study is focused on comparison of the effectiveness of gillnet fishing and longline fishing methods as a deep sea fishing method used by multiday fishermen in Matara district.

## Materials and Methodology

The data were collected from multiday fishing boats in "Dondra" fisheries harbor from 1$^{st}$ of May to 14$^{th}$ of June 2014. The sample size was determined by "Moving average method" and the total landings and fishing methods of 66 multiday boats were collected accordingly. Catch and effort data, income of the fishermen and quality of the landing were collected using prepared data sheets. The catch and effort data collection sheet was consisted of data regarding the duration of the fishing, the fishing techniques (gear) used in the trip, total catch per day, the species composition of the catch in number and/ or weight, gear information (length of net, mesh size, number of hooks per long line, soaking time,) vessel information (storage facilities, hauling technique, length of boats). The income data collection sheet was consisted of species composition, total weight of each fish species and price of the fish in particular day. Organoleptic survey has been done in order to determine the quality of the fish yield of each boat. According to the organoleptic evaluation, nature of the fish skin, nature of the gill, eye appearance and consistency of flesh were evaluated. The quality of the fish has been evaluated by scoring them according to the level of quality. Then mean of the score of the quality parameter was calculated to determine quality of the harvest in each multi-day boat. The collected data have been analyzed by using "Microsoft excel-2010" and compared with "One-way ANOVA table" by using "Minitab 16" software.

**Results and Discussion**

According to the study, there were 3 types of main fishing methods which were used by multi-day fishermen in Matara fisheries district. They are, gillnet, longline and combination of gillnet and longline fishing methods. There were 39.4% multiday fishing boats which used only gill net, 22.7% multiday fishing boats which used only long line and 37.8% fishing boats which used a combination of gillnet and long line. Mainly tuna and tuna like species were targeted in the study. The total catches of the different fishing gears were taken as weight of harvest per boat day. According to the results, the mean catch per boat day of the gill net, long line and combination of the longline and gill net were 133.7 kg, 94.2 kg, and 165.1 kg respectively. Therefore the multiday boats which used combination of gillnet and longline fishing method gained significantly higher yield than that of gillnet and longline fishing methods. The lower mean catch per boat day was gained by the longline fishing method.

When considering main fish species which were caught by each fishing gear, the mean catches per boat day of Skipjack tuna (*Katsuwonus pelamis*) were 62.11 kg, and 64.76 kg respectively for gill net, and combination of the gill net and longline. In Matara fisheries district there were no multiday fishermen who used longline fishing method to catch skipjack tuna. The mean catches per boat day for yellow fin tuna (*Thunnus albacares*) were 7.05 kg, 79.39 kg and 70.56 kg respectively for gillnet, longline and combination of gillnet and long line. Similarly the mean catches per boat day of frigate tuna (*Auxis thazard)* were 12.29 kg, and 70.56 kg in gillnet, and combination of gillnet and longline respectively. There was no frigate tuna catch in long line fishery. According to this result, mainly long line fishing gear was used to harvest yellow fin tuna. The skipjack tuna and frigate tuna were harvested by using gillnet fishing method.

When considering income of the multiday fishermen, the mean of the total income of multi-day fishermen who harvested fish using gill net, longline and combination of gillnet and longline is Rs 300,577.00, Rs 1,251,567.00 and Rs 1,068,474.00, respectively. The highest income was gained by the multi-day fishermen who used longline fishing method and the lowest income was gained by fishermen who used gillnet fishing method, among the three fishing methods.

According to the organoleptic survey data, the quality of the fish in gill net, long line and combination of gill net and long line fishing methods were $1.99 \pm 0.41$,$2.32 \pm 0.31$ and $2.04 \pm 0.39$,respectively. The quality of the fish was high in fish which were harvested by longline and quality was low in fish which were harvested by gillnet.

In the ANOVA test, there was not significant different between gear categories and the total catch per boat day ($P>0.05$). But, there was a significant different between gear categories and catch per boat day of tuna and tuna like species ($P<0.05$). Similarly, there were significant differences between gear categories and income of the fishermen and also gear categories and quality of fish ($P<0.05$). According to these result, it shows gear categories are not significantly affect on the total catches per boat day but it significantly affect for the catches of tuna and tuna like species, income of the fishermen and quality of fish.

According to the above results, the gillnet fishing method has recorded, high catch, low income and low quality fish and long line fishing method has recorded low catch, high income and high quality fish while combination of gillnet and long line fishing method has recorded high catch, medium income and medium quality fish.

But the ANOVA result showed total catch per boat day was not significantly affected by fishing gear categories. Therefore, though they have similar amount of fish harvest, multi-day boat fishermen who used longline fishing method has had high income and high quality fish than other two types of fishing methods. The analysis of catch composition of tuna and tuna like species showed that long

line fishing method is much more species selective fishing gear than other two types of fishing methods. It is used to catch only target fish species which having high commercial value. And also, the amount of fish discarded by the longline is less than that of gillnet due to harvest of high quality fish in longline fishing method. The reason is that the fish remain alive for much longer period when hooked than when gilled (Santos*et al.*, 2002). Because of that reason, the quality of the fish that harvested by longline is higher than gillnet fishing method. Because of their high quality, the value of the fish increases and fishermen obtained higher income with the longline fishing method.

## Conclusion

When considering all these aspects, it can be suggested that the longline fishing method is an effective fishing method for multi-day fishermen in deep sea fishing at Matara fisheries district comparatively. And the longline fishing method can be used to harvest other targeted fish species by changing bait types and hook size.

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# A review of export trade of indigenous aquatic plants species in Sri Lanka and their conservation issues

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## Introduction

Aquatic plants are adapted to aquatic environments and are required special adaptations for living submerged in water or at the water's surface. In addition to various ecological and industrial values, most of aquatic plants are having ornamental value. Due to the ornamental value of the aquatic plants, they have a huge demand and are exported from Sri Lanka. Along with ornamental fish industry, aquatic plants are introduced and exported as a simultaneous industry. Present study was intended to analyze and evaluate the trade of ornamental aquatic plants in Sri Lanka with a particular focus on indigenous species. The objectives of the study are determine the exported species and their quantities, the actual foreign exchange earnings, identify the conservation issues related to indigenous species, identify the trends to occur irregularities in exportation procedure and propose suitable.

## Materials and Methods

Exported aquatic plants species data and their quantities were extracted from the Customs Goods Declaration Forms (CusDec) submitted by the ornamental aquatic plants exporters to the Air Cargo Terminal in Katunayake under the Department of Sri Lanka Customs. The Customs Goods Declaration Forms submitted during the period of one year from 1st March 2013 to 28th February 2014 were analyzed. A questionnaire was also used to gather information regarding the conservation issues through ornamental aquatic plants exporters, Custom officers at frontier and local villagers.

## Results and Discussion

During the one year period from 1st March 2013 to 28th February in 2014, a total of 218 species of aquatic plants has been exported to 43 countries from Sri Lanka. Among the total, 176 species were indigenous, 1 species was endemic. When considering the total quantities of exported indigenous aquatic plants during the one year period, the most common species exported was the *Dracaena sanderiana white* (168185 individuals) and *Lobelia cardinalis "small leaf"*(4 individuals) was the species exported in least quantities. During the one year study period, 1504531 individuals of aquatic plants and 2047620 all types of live plants have been exported from Sri Lanka. When considering the proportions of species exported during one year period, the endemics consist of 0.04% (685individuals) and other indigenous species consisted of 80.91%(1217353individuals) among all other aquatic plants. The proportion of indigenous aquatic plants species consisted of 59.45% and endemics consisted of 0.03% among exported all types of live plants from Sri Lanka. And the proportion of exported aquatic plants to all live plants is 73.47% from Sri Lanka during my study period.

The foreign exchange earned from ornamental aquatic plant industry has shown a considerable level of earnings. The all individual export prices of species ranged from US $ 0.14 to US $ 12.99. Among all exported indigenous aquatic plant species, *Echinodorus grisebachiibleheri* has earned highest amount (SL Rs. 84,051,603.55) while *Dracaena sanderiana* baskets have brought in the least earning (SL Rs. 199.06) during the concerned time period.

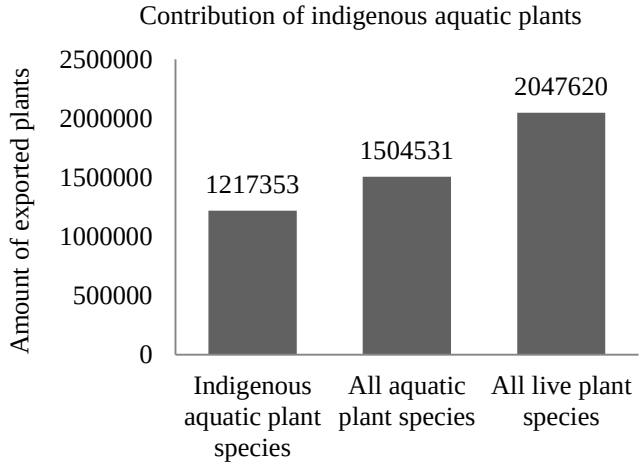


Figure5: Indigenous aquatic plants contribution to the all live plants exported

Total income generated from the ornamental aquatic plant trade during one year period was SL Rs.546,950,172.67 (US $ 813,735.45).When considering the earnings, contribution of indigenous aquatic plant species was SL Rs. 447,667,856.28 (US $ 3,373,279.00) and it was 80.16% from total export of ornamental plants. The earnings obtained from the endemic aquatic plant species was SL Rs. 499,075.86 and contribution is 0.091% for the aquatic plant industry. The contribution of the endemic plants to the all live plants exported is negligible (0.089%). Finally, the contribution of the ornamental aquatic plants for all exported live plants is 97.94%.

There were only 13 exporters who actually engaged in exportation of live ornamental aquatic plants during my study period. From that, all exporters were identified as indigenous aquatic plant exporters who are occationally export endemic species based on the foreign demand. The exporters are not extracting plants from the wild and contribution of nurseries production of plants for export is 100%.

Since, in spite of all precautionary measures are taken by Biodiversity, Cultural and National Heritage Protection division of Sri Lanka Customs, maximum advantage of loopholes in regulations is taken by smugglers through false declarations and misleading terms. According to the approximate calculations of previous offences committed by exporters who were found guilty in the Customs detections (As per the information found in Casefiles), SriLanka Customs had detained ("Kekatiya") *Aponogeton crispus* (US $ 730,325) and *Cryptocoryne species* (US $ 1800) on the suspicion of violation of regulations under the Forest Ordinance and Custom Ordinance which were attempted to export through BIA, Katunayake without having permission. Those smuggled aquatic plants have collected from several tanks in Puttalum and Kurunegala districts.

The sustainability of the ornamental aquatic plants industry and the conservation of endemic and indigenous aquatic plants can be mandated and committed by enforcement of existing laws and legislations. The greatest thing is long run economical gains obtained through the protection of ecosystems than any short term economic return earned from smuggling, over exploitation like undesirable activities. If the involvement of the government authorities is in a sufficient condition,

the due revenues from the trade can be increased. But the legal status behind the export of endemic plants species hampers their development and therefore, investments are worthless until legal status are cleared and positively regulated. Adequate culture techniques are not practiced by the exporters to boost the industry with new technology and conservation of the endangered species. The major factors which are responsible for the depletion of water plants from the natural environment are deforestation, constructions, sand and gem mining, bad practices of fish harvesting methods, agricultural and industrial wastes, over exploitation and invasive species. Therefore the government should involve for collaborate all those parties for a sustainable trade of aquatic plants in Sri Lanka and awareness should be created among all stake holders of ornamental aquatic plants industry including officers at frontiers, exporters, farmers, students, conservationists and all related agencies.

## Conclusion

During the period of one year from 1st March 2013 to 28th February 2014, 176 aquatic plants species were indigenous out of all 218 species identified. The quantity of exported indigenous aquatic plants species has shown a considerable proportion to exported aquatic plants species, 80.91%. It is noteworthy to highlight that 73.47% of the entire export quantity of annual live plants trade consist of aquatic plants species. The calculated actual foreign exchange earnings from exported indigenous aquatic plants species was 80.16%. The main causative factors should be minimized to address conservation issues such as constructions, deforestation, sand and gem mining, industrial and agricultural wastes and invasive species. Based on the gathered information from the exporters, there are no exporters who practice wild collection of endemic species. The irregularities at the exportation procedure are taken place basically due to false declarations and misleading terms. Therefore, the laws and regulations should be enforced and monitored to avoid misconducts and corruptions.

## Acknowledgement

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# Development of garment leather from Yellowfin tuna (*Thunnus albacares*) skin

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## Introduction

Leather is defined as hide or skin with its original fibrous structure more or less intact, tanned to prevent putrefaction (Covington, 2009). Due to tanning, skins that have been processed to prevent putrefaction retain its characteristics such as flexibility and toughness. Hides and skins from cattle, buffalo, sheep, pig, goat, horse, crocodile, snake and fish are used for leather production. When considering the fish leather, fish skins are used for production of leather after tanning and re-tanning processes. Texture of fish leather depends on pocket size of the scales. Presently, carp, pacific salmon, bass, sturgeon, shark, tuna, catfish, salmon, tilapia and several other fish species are taken for leather production. Garment leather is tanned with chrome and treated with softeners. The quality of the garment leather should be thin enough to use on garments and it should feels softer and smoother than any other types of leather. These types of leathers are made from the top-grain of a hide. Good stitch tensile strength and light weight are some other characters of garment leathers. Cow hide and skins from deer, pig and lamb are commonly used for garment leather manufacturing. But there is a potential to develop garment leather from fish skin similar to other garment leathers. The present study was carried out to add value to waste generated during the Yellowfin tuna (*Thunnus albacares*) fish processing and promote a fish leather production in Sri Lanka through developing garment type leather using discarded skins. At present, hides and skins from cattle, buffalo, sheep and goat are used for leather production. In addition, fish species including carp, pacific salmon, shark, tuna, catfish and tilapia are taken for leather production in the world. The objectives of this study were to find out the best fat liquor percentage to obtain maximum softness of chrome-tanned Yellowfin tuna fish leather and to find out the best tanning method for garment leather production from Yellowfin tuna skin.

## Methodology

The current study was carried out at the tannery of Ceylon Leather Product PLC (CLP), Mattakkuliya. Tuna skins were collected from the processing factory of Jay Sea Food (Pvt) Ltd in Ja-Ela. Two experiments were carried out to find out best fat liquor concentration and best tanning method. In experiment 1, yellowfin tuna skins were treated with 33% basic chromium sulphate and five different concentrations (12%, 14%, 16%, 18% and 20%) of fat liquors (on weight of pelt). In experiment 2, yellowfin tuna skins were treated with four different tanning methods (Full chrome tanning, full vegetable tanning and two types of semi chrome tanning methods - vegetable tanned skins directly tanned with chrome and vegetable tanned skins tanned with chrome after stripping with $NaHCO_3$). Before initiating the experiments pre-trial was conducted to find out the optimum conditions for liming. Six pieces of raw skins were immersed in solutions of 0.25%, 0.5% and 1% $Na_2S$, 6% $Ca(OH)_2$ and 200% water (on weight of skins). One day after, skins were taken out and scales and flesh were removed. Then, skins were kept for another 5 days in a new 6% $Ca(OH)_2$ solution. Weight

and the physical conditions (scale pockets, colour and plumpness) of the skin were observed daily. After identifying the optimum conditions for liming 40 skins were subjected to 8 production process steps (liming, de-liming, pickling, tanning, basifying, fat-liquoring, fixing, drying and dying). Experiment 1 was done in fat-liquoring step and experiment 2 was done in tanning step. Then, the dried leathers were dyed and waxed. Finally softness, feel, tensile strength, tear strength and stitch tear strength were measured in developed leathers. Physical evaluation was done to check softness and feel by ten expertise. Tensile strength, tear strength and stitch tear strength were done using universal testing machine. This experiment was designed according to Complete Randomized Design (CRD). The collected data were analyzed using Friedman test and one-way ANOVA in MINITAB 16 and SPSS 22 statistical analyzing software to find out the significant difference between treatments. Mean separation was done using pairwise comparison.

Chemicals percentages were weighted according to the weight of skins, used in experiment 1 and 2.

**Results and Discussion**

According to pre-trial, 0.5% $Na_2S$ solution was identified for descaling with 6% $Ca(OH)_2$ and 200% $H_2O$. For liming it was identified that immersing for 4 days is the best method in 6% $Ca(OH)_2$ and 200% $H_2O$ solution.

In experiment 1 (from the five different concentrations of fat liquors), there was a significant effect on treatment method on tensile strength, tear strength and stitch tear strength ($P<0.05$). Maximum tensile strength and tear strength values were observed in 16% fat-liquored leather with average values of $23.46 \pm 6.06$ N/mm$^2$ and $401.59 \pm 77.75$ N/mm, respectively meanwhile 18% fat-liquored leather showed the highest stitch tear strength ($187.91 \pm 5.39$ N/mm). There was a significant treatment effect on softness of leather ($P<0.05$) and on feel of leather ($P<0.05$). According to the ranking values, treatment 4 (18% fat liquor) showed the best response for softness (Ranking value= 46.5) and feel (Ranking value = 47.0) compared with the other treatments.

While adding fat-liquors, it improves the tensile strength of leathers (Tex Biosciences, 2008). But increasing the fat liquor concentration further leads to decreasing of the ability to make fine emulsion as well as reduction of the ability of fat liquor penetration in to collagen fiber. Hence, softness is reduced when increasing the fat liquor concentration therefore, the hardness of leather is increased (Gutterres and Melo dos Santos, 2009). It may be the reason for reduction of tensile strength.

Increasing and again decreasing of the values of tear strength and stitch tear strength may be due to the decreasing of the ability to make fine emulsion. Hence, ability of fat liquor penetration in to collagen fibers was decreased. The reason for increasing softness might be fat liquor which acts as a lubricant in between collagen fibers (Gutterres and Melo dos Santos, 2009). Reason for increasing and again decreasing the softness maybe due to the decreasing of the ability to make fine emulsion. Therefore, the ability of fat liquor penetration in to collagen fibers is decreased. Hence, it can be suggested to use 18% fat liquor concentration to produce garment type leather from yellowfin tuna skin.

From the four tanning methods studied in experiment 2, there was no significant effect of treatment on tensile strength ($P>0.05$). But full chrome tanned leather showed the highest value for tensile strength ($22.56 \pm 0.86$ N/mm$^2$). When considering the tear strength there was no significant effect of treatment ($P>0.05$). Highest value of tear strength showed the full chrome tanned leather ($373.75 \pm 23.20$ N/mm). But there was a significant effect of treatment on stitch tear strength ($P<0.05$). Highest value of stitch tear strength showed the full chrome tanned leather ($187.91 \pm 5.39$ N/mm). There was a significant treatment effect on softness of leather and on feel of leather ($P<0.05$). In addition, the highest ranking value for softness (30.0) was observed in full-chrome tanned leather. Hence, it can

be suggested to use full chrome tanning with 18% fat-liquor concentration to produce garment type leather from yellowfin tuna skin.

There was no effect from fat liquor concentration and surface treatment on tensile strength, tear strength, stitch tear strength, softness and feel due to equal fat liquor concentration (18%) and surface treatment (wax). Reason for no significant effect of treatment on tensile strength and tear strength might be due to the reason that tensile strength and tear strength are only dependent on the fiber structure of the skin. Fish skin has a cross fiber structure (Hebrank and Hebrank, 1986). Reason for high value for stitch tear strength might be due to the high amount of covalent bonds between chromium sulphate and collagen fibers in full chrome tanned leather. Vegetable tanned leather hardness was higher than the chrome tanned leather. Hence, softness is higher in full chromed tanned leather than the vegetable tanned leather. When considering the tanning agents chromium sulphate makes covalent bonds with collagen fibers and mimosa acts as a filling agent between collagen fibers.

**Conclusion**

According to the results obtained in this study, the best fat-liquor concentration was 18% to prepare soft garment leather from yellowfin tuna skin. The most effective tanning method was the full chrome tanning compared to full vegetable tanning and semi tanning methods. Using this combination a marketable garment leather from yellowfin tuna skin can be produced. This could be used to produce commercially valuable products such as ready-made garments.

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# Balancing the benefits of protein content and the risks of trace metal toxicity exposure from Skipjack tuna (*Katsuwonus pelamis*) consumption in Sri Lanka

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## Introduction

Fish is considered as an excellent source of protein that can provide immense health benefits to human being. Protein is the major nutrient in fish consumption and it is highly digestible and consist all the essential amino acids. However, recent claims that marine fish are contaminated with trace metals exceeding the recommended maximum allowable limits have raised concerns among consumers regarding fish consumption. This may lead to rejection of marine fish both by local and export markets (Liyanage, 2009) as fish contaminated with toxic trace metal can lead to acute and chronic effects in human being. In the present study, protein content and major toxic trace metal concentrations in skipjack tuna (*Katsuwonus pelamis*) which is a major commercial marine fish species were studied with the aim of assessing benefits and risks in consumption of skipjack tuna in Sri Lanka.

## Materials and Methods

Samples of skipjack tuna fish (n = 44) were collected to represent all fish landing site areas around Sri Lanka during April-July, 2014. Concentrations of toxic trace metals Hg, Cd, Pb and As were analysed individually for all the samples while the protein content analysis was carried out for composite samples that were prepared based on gender and standard length of each fish. Crude protein content was analysed according to 928.08, AOAC 2000 standard method. Crude protein content was determined using UDK 132 (VELP Scientifica, Usmate, Italy) semi-automated Kjeltec system. All composite samples were analysed in triplicates. Hg, Cd, Pb and As trace metal concentrations were analysed by Atomic Absorption Spectrophotometer (AAS; Varian240 FS, Varian Inc., Australia) following the standard method in AOAC 1998. All analyses were strictly adhered with quality control procedures. Protein content of skipjack tuna was assessed in terms of benefits with reference to its Recommended Dietary Allowance (RDA) value whereas the toxicity of each trace metal was assessed based on the stipulated Provisional Tolerable Weekly Intake (PTWI) with the Probable Weekly Intake (PWI) values. Average consumption of skipjack tuna flesh in Sri Lanka was considered as 2.8 g/person/day (MFARD, 2013) and the average body weight of a Sri Lankan adult person was assumed as 55 kg. In addition, resulted mean toxic trace metal concentrations were compared with the established maximum allowable limits for toxic trace metals in Sri Lanka and European Union standards for skipjack tuna.

**Results and Discussion**

In order to determine the recovery percentage in crude protein analysis, spiked samples with $(NH4)_2SO_4$ were used and the recovery values were maintained within the acceptable range of 90-110%. The method of trace metal analysis was evaluated for its suitability in terms of their respective Limit Of Detection (LOD) and recovery levels using spiked samples and certified quality control materials. Calculated recovery values for all the trace metals were within the expected recovery range of 80%-120%.

The mean standard length of the analysed skipjack tuna fish was 47.4±3.9 cm and the range was 36-56 cm whereas the mean total weight was 2.2±0.5 kg and it had a variation of 1.1 - 4.2 kg. Among the analysed specimens 24 were males and 20 were females.

Table 1: Protein content (%) of the flesh of skipjack tuna and other major tuna species*

| | Skipjack tuna [a] | Yellowfin tuna[b] | Bigeye tuna[b] |
|---|---|---|---|
| Crude protein | 24.13±2.01 | 23.52±0.61 | 23.72±0.16 |

* Data are expressed as mean±SD on a fresh weight basis

[a] The present study

[b] Peng *et al*., 2013

As per the results obtained, skipjack tuna is a good source of protein (Table 1). The resulted percentage value for protein content of skipjack tuna was compared with the values recorded by Peng *et al*., 2013 for other major commercially important tuna species; yellowfin and bigeye tuna (Table 1). This shows that skipjack tuna is similar in terms of protein content; the major targeted nutrient in fish, with yellowfin and bigeye tuna. The resulted percentage value in this study for crude protein content in skipjack tuna slightly differs with the results of certain previous studies. This could be due to the variation of protein content in fish according to the seasonal changes as described by Clucas and Ward, 1996. Although skipjack tuna is a rich source of protein, the obtained value for the contribution for RDA value was lower (1.2%). The major reason to gain this lower value is the average skipjack tuna consumption in Sri Lanka is still a lower value (2.8 g/person/day).

Table 2: Provisional Tolerable Weekly Intake (PTWI) and Probable Weekly Intake (PWI) values of Hg, Cd, Pb and As

| Toxic trace metal | PTWI* (mg/kg of body weight ) | Provisional Tolerable Weekly Intake (mg) | Probable Weekly Intake (mg) |
|---|---|---|---|
| Hg | 0.005 | 0.275 | 0.0025 |
| Cd | 0.007 | 0.385 | 0.0003 |
| Pb | 0.025 | 1.375 | 0.0001 |
| As | 0.015 | 0.825 | 0.0180 |

* WHO/FAO Joint Expert Committee on Food Additives and Contaminants

According to the results of the present study, all the recorded mean values for toxic trace metal concentrations were lower (0.13±0.06 Hg, 0.02±0.01 Cd, 0.01±0.01 Pb and 0.92±1.12 As in mg/kg). All the recorded mean values were well below the established maximum allowable limits for toxic trace metals in Sri Lanka and European Union standards in terms of seafood safety. The resulting of lower concentrations for all the toxic trace metals could be due to the reason that skipjack tuna is a

short lived animal which has a less potential for bioaccumulation. All the calculated PWI values were well below the estimated PTWI values (Table 2). This indicates that skipjack tuna does not contain a health risk on human due to trace metal toxicity.

In recent past several researchers have claimed that most of the major and popular marine food fish such as yellowfin tuna, bigeye tuna, sward and certain marlin fish have an increased risk of trace metal toxicity (Kojadinovic *et al*., 2007; Jinadasa *et al*., 2014). In addition, the market values of these major marine food fish are very high with compare to skipjack tuna (MFARD, 2014). As per the results of this study, skipjack tuna is a good source of protein which does not contain any health risk due to trace metal toxicity and can be accessed by consumers for a cheaper price.

## Conclusion

Skipjack tuna is a good protein source as same as the majorly attracted other tuna species such as yellowfin and bigeye tuna by the fish consumers. Skipjack tuna does not pose any health risk due to trace metal toxicity by Hg, Cd, Pb and As.

## Acknowledgement

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# Seashell processing: An emerging industry in Kinniya divisional secretariat division of Trincomalee district

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## Introduction

The seashell processing industry functions by grinding the seashells for production of lime for building construction purposes and for making poultry feed (Fisheries Year Book, 2007).The low income people in the Kinniya Divisional Secretariat (DS) division collect seashells to earn money for their daily living. The people who are engaged in this industry earn sufficient income (Sunday Observer, 2012). Seashell deposits are available in Kakkamunai village of Kinniya DS division, which is located closer to the mouth of Thampalagamam Bay, which is enriched with bivalves. Shell mining has taken place for last three decades in a sustainable manner. There is a high demand for shells from the poultry feed industry, thus generating a good income from this activity (Minerals Year Book, 2007). In this context a survey was carried out to study this emerging industry in Kinniya DS division of Trincomalee district.

## Methodology

This study was carried out during the months of April and May, 2014 in ten villages in Kinniya DS division. Using random sampling procedure, a total of 90 seashell processors were selected, which includes collectors, grinders, transporters, loaders and mill owners and a structured interview schedule was used to collect the information through personal interview at their home and seashell processing mills. Collected data were analyzed using the SPSS package.

## Result and Discussion

Personal and socio-economic characteristics of seashell processors in Kinniya DS division of Trincomalee district revealed that all the seashell processors (100%) were males. Young age and middle age categories were same (40%). 80% were under primary level of education. Majority (68.9%) of the respondents depended mainly on seashell industry. More than half (54.5%) of seashell processors belonged to medium income group of Rs.20, 000 to Rs. 40,000 per month. Majority of respondents (87.8%) were part time workers. Majority (85.6%) of respondents had 5 to 10 years experience in seashell processing. Only 11.1% respondents had organizational membership; because the mill owners only had the membership with social organizations. The seashell processors have not participated in any extension activity related to seashell processing.

All the respondents (100%) indicated that seashell collection was the most difficult work in seashell processing. Among the people who involved in seashell collection, most of them obtained medium income of Rs.1000 - Rs.1500 per day. Most of people who involved in seashell grinding obtained high income (Rs. 420 per bag) from seashell grinding per day. Majority (91.1%) of the respondents involved in seashell industry were rural people. All the respondents (100%) were in the view that the overall business condition of the industry is good. All (100%) of respondents reported that the ground seashell bags were marketed directly to the consumers. The demand for ground seashells is high in Kurunagale district. Kandy, Matala, Puttalam, Kalutara, Colombo, Avissawella and Galle are the other places getting ground seashells from Kinniya mills.

**Economic status of the respondent before and after joining with seashell industry**

Table 01: Distribution of respondents according to their economic status before and after working in seashell industry

| Category | Before working in the seashell industry (% ) | After working in the seashell industry (%) |
|---|---|---|
| Upper class | 0.00 | 14.5 |
| Upper middle class | 02.2 | 61.1 |
| Lower middle class | 31.1 | 23.3 |
| Poor | 54.5 | 01.1 |
| Very poor | 12.2 | 00.0 |

Source: Field survey, 2014

Table 01 provides the comparison of the distribution of respondents according to their economic status before and after working in the seashell processing industry. The results indicates that majority (54.5%) of the respondents were under poor category of economic status before working in the seashell industry followed by lower middle class (31.1%), very poor (12.2%) and upper middle class (2.2%) respectively. There was no one under upper class category among the respondents before working in this seashell industry.

Table 01also indicates that majority (61.1%) of the respondents were under upper middle class category after working in this seashell industry followed by lower middle class (23.3%), upper class (14.5%) and poor (1.1%) respectively. It is good to note that there was no one under very poor category after joining with the seashell industry.

**Socio-economic conditions of the respondents before and after working in seashell industry**

Before the establishment of this industry, employment, income and the living standard of the respondents were in low level. But, after the establishment of this seashell industry the employment, income, living standard and the overall socio-economic status were improved for all categories of respondents (Owners, Collectors, Grinding persons, Loading persons and Transporters). This leads to reduction in poverty level of the people who were involved with seashell industry.

The shell mining activities should be maintained at a sustainable level to prevent the environmental effects and future negative impacts. For that Natural Aquatic Resources and Development Agency (NARA) has given a maximum limit to the seashell processors. They cannot exceed the limit of 20,000 packs of shells per month. The Government has made this restriction to protect the natural resources. Exceeding this limit will cause severe environmental problems by the lapse of time. And these resources should be protected for the next generation. Or else this industry will have a natural death.

**Conclusions**

From to the study conducted it can be concluded that all the seashell processors involved in this industry were males and majority of respondents were under primary level of education. More than half of seashell processors belonged to medium income group. Majority of respondents had 5 to 10 years experience in seashell processing. The seashell processors were not participated in any

extension activity related to seashell processing. Majority of respondents involved in seashell industry were rural people and majority of them were poor before working in this seashell industry and presently majority were under upper middle class. The living standard and the overall socio-economic status of people were low before the establishment of this seashell industry, but after the establishment of this seashell industry those conditions were improved. And the poverty level was decreased after the establishment of this seashell industry. Over seashell mining leads to environmental adverse effects. Therefore, to prevent those effects shell mining should be maintained at a sustainable level.

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# Effect of growth regulators on in-vitro multiplication of *Lagenandra ovata* and *Lagenandra lancifolia*

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## Introduction

Sri Lanka is a country which consists with number of endemic aquatic plants. These endemic aquatic plants are having high demand in aquatic plant industry (Galapitagedra, n.d.). Due to the lack of effective propagation methods plant collectors collect plant from wild to fulfill the market demand. It leads to the depletion of natural plant stock and bio diversity. *Lagenandra* species only can observe in Sri Lanka, Southern India and Bangladesh (Dassanayake *et. al*., 2001). In Sri Lanka there are seven species and six species are considered as endemic. Red List of International Union for the Conservation of Nature in 2013, categorized five of those endemic species under the highly threatened category. Main purpose of this study is to develop a proper method for micro propagation of *Lagenandra ovata* and *Lagenandra lancifolia* to overcome inadequate supply and depletion of natural plant stock. Present study was carried out to evaluate effect of different hormone concentrations in basal media for shoot initiation and multiplication of rhizome explants,to identify the best explant of *L. lancifolia* for micro propagation and to identify the best medium for *L. ovata* seed culture.

## Methodology

Present study was carried out at Royal Botanic Gardens, Peradeniya. Seven experiments were conducted in order to achieve the objectives of the study. Explants of *L. ovata* (rhizome and seeds) and *L. lancifolia* (rhizome and smaller plantlets) were sterilized using standard procedures. *L. ovata* rhizomes were placed in Ms Semi-solid media with different cytokinins such as BAP, Kinetin and TDZ with the presence of IAA. Different concentrations of BAP and Kinetin such as 0.4, 0.8, 2, 5 and 8 $mgl^{-1}$ and 0.4, 0.8, 1.6 and 2 $mgl^{-1}$ of TDZ were used. Grown plants of *L. ovata* were transferred in to multiplication media with 1, 2 and 3 $mgl^{-1}$ BAP hormone concentrations. Smaller plantlets of *L. lancifolia* were placed in MS semi solid media with and without growth regulators. Different concentrations of cytokinins such as 0.4 and 0.8 $mgl^{-1}$ of BAP and Kinetin concentrations and IAA were added to the medium. Grown Plantlets of *L. lancifolia* were transferred in to multiplication medium with 1, 2 and 3 $mgl^{-1}$ BAP hormone levels. Survival rate of *L. lancifolia* plantlets and rhizomes were measured weekly in order to identify the best explant. The best medium for *L. ovata* seed germination was identified by placing seeds in different media such as; solid medium, semi-solid medium, liquid medium and sterilized distilled water medium. After the germination seeds were transferred in to solid or semi-solid medium for further growth.

## Results and Discussion

This study shows the importance of growth regulators for the shoot initiation of *L. ovata* rhizome culture. According to the one way ANOVA, there was a significant effect ($p<0.05$) of growth

regulators such as BAP, Kinetin and TDZ on shoot initiation. The highest mean number of shoot initiation of *L. ovata* rhizomes was observed at 0.4 $mgl^{-1}$ Kinetin with the presence of 0.1 $mgl^{-1}$ IAA. The second highest mean number of shoot initiation was observed at 0.8 $mgl^{-1}$ TDZ with the presence of 0.1 $mgl^{-1}$ IAA. According to the data lower concentrations of growth regulators stimulate shoot initiation highly. Highest shoot multiplication was observed at 2 $mgl^{-1}$ BAP level. According to the one way ANOVA there was a significant effect of hormone treatments for the shoot multiplication ($p < 0.05$).

Table 1: Effect of different BAP hormone concentrations for the mean number of new shoot regeneration after three weeks of culture establishment

| **Treatment** | BAP hormone concentration ($mgl^{-1}$) | Mean number of new shoot regeneration |
|---|---|---|
| **Control** | 0 | $0.000^{b}$ |
| **$T_1$** | 1 | $1.000^{b}$ |
| **$T_2$** | 2 | $2.667^{a}$ |
| **$T_3$** | 3 | $0.667^{b}$ |

Means that do not share a letter are significantly different

As indicate by the table there was a significant difference between treatment 2 and all other treatments. Hormone free MS media did not show any shoot initiation or multiplication. The highest seed germination of *L. ovata* was observed in sterilized distilled water medium at the second week of culturing. Low contamination possibility and low cost are main advantages of sterilized distilled water medium. There was a significant difference of seed germination between sterilized distilled water and all other treatments.

Table 2: Mean number of seed germination in different media after two weeks of culture establishment

| **Treatment** | Media type | Mean number of seed germination |
|---|---|---|
| **T1** | Solid media | $2.400^{c}$ |
| **T2** | Semi- Solid media | $2.600^{bc}$ |
| **T3** | Liquid media | $4.800^{b}$ |
| **T4** | Sterilized distilled water | $8.200^{a}$ |

Means that do not share a letter are significantly different

The best shoot initiation of *L. lancifolia* smaller plantlet culture was observed at 0.4 $mgl^{-1}$ Kinetin with the presence of 0.1 $mgl^{-1}$ IAA hormones.

Table 3: Effect of different BAP hormone concentrations for mean number of new shoot regeneration of *L. lancifolia* after three weeks of culture establishment

| **Treatment** | BAP hormone concentration (mgl-1) | Mean number of new shoot regeneration |
|---|---|---|
| **Control** | 0 | 0.000[c] |
| **T1** | 1 | 1.333[b] |
| **T2** | 2 | 2.667[a] |
| **T3** | 3 | 1.000b[c] |

Means that do not share a letter are significantly different

As indicated by the above table there was a significant difference in new shoot regeneration of both treatment 1 and 2 when compare to the other treatments. The highest shoot multiplication of *L. lancifolia* was observed at 2 $mgl^{-1}$ BAP level. Therefore treatment 2 was considered as the best treatment for new shoot regeneration of *L. lancifolia*. The survival rate of *L. lancifolia* rhizome was below 30% and survival rate of plantlets was above 80% at the fifth week of culture establishment. Therefore, smaller plantlets of *L. lancifolia* were recommended as the best explants source.

## Conclusion

Hormone treatments should be used for the shoot initiation of *L. Ovata* rhizome cultures. According to which obtained 0.4 $mgl^{-1}$ Kinetin with presence of 0.1 $mgl^{-1}$ IAA suitable or both *L. ovata* rhizomes and *L. lancifolia* smaller plantlets culture. The maximum shoot multiplication was observed at 2 $mgl^{-1}$ BAP level. Smaller plantlet of *L. lancifolia* is recommended as the best explants source for micropropagation based on the survival rate. Best medium for *L. ovata* seed germination is sterilized distilled water.

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# A preliminary study on the effectiveness of organic fertilizers for the survival rate of *Catla catla*

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## Introduction

Fish can be considered as one of the main sources of animal protein (26.2%) in human diet (Khan *et al.,* 2004). Fish also become a popular source of food in Asia and developing countries. Both aquaculture and fisheries activities conducting in marine and inland waters, cater the protein requirement of people in Sri Lanka. Indian and Chinese Carp species are commonly used today in inland aquaculture. *Catla catla* (Catla) is a zooplankton feeding Indian major carp species which was introduced to reservoirs in Sri Lanka to uplift the inland fishery production. This species has become a very popular fish species among the fish farmers due to higher growth rate, ability to co-exist with other major carps and consumer preference. Aquaculture Development Center (AQDC), Udawalawa belongs to National Aquaculture Development Authority (NAQDA) is producing fish seeds of carp species including Catla, for the development of inland aquaculture and fisheries. The problem identified in fish seed production in the AQDCs was the low survival rate of *Catla* at rearing of post larvae (PL) to fry stage. Moreover, it was observed that survival rate in mud ponds is lower than the survival rates in cement tanks. In the AQDC Udawalawa, cow dung is commonly used for fertilization of rearing tanks and ponds. This study was carried out to find out what the best effective organic fertilizer for the higher survival rate and growth of *Catla catla*. Cow dung, *Leucaena leucocephala* (Ipilipil) and *Oriza sativa* (rice) straw were selected as organic fertilizers as they are of low cost and readily available in the area of the study.

## Materials and Methods

The experiment was conducted in nursery ponds (mud ponds) and nursery cement tanks in AQDC, Udawalawa. A mud pond and a cement tank which were already fertilized during five days (as normal practice in the AQDC) using cow dung (250g/$m^2$) were selected and plankton densities (individuals per liter) were recorded by assuming ponds were reached optimum plankton density. Mean value of those densities was calculated and used as baseline value. Dried cow dung (250g/$m^2$) was selected as control for the study as it was the normal practice in the AQDC. Rice straw (30g/$m^2$) and dried Ipilipil (30g/$m^2$) were the selected treatments for the study. These are the commonly used fertilizer concentrations in the field. Initially, the time taken to reach the plankton density to the baseline value was recorded for Rice straw and Ipilipil fertilizer types.

The surrounding of three mud ponds was cleaned and four hapa net cages were fixed to the bottom of the three mud ponds to prepare four replicates. All the four replicates were fixed in same way to maintain the same volume of water. Firstly the ponds were filled up to 50 cm with water. Complete Randomized Design (CRD) was conducted as the experimental design.

Four days old PL in a single cohort, who spent seven days in hatchery were stocked in the morning in cement tanks and hapa net cages in mud ponds. The recommended stocking density in tanks and ponds was 250-300 PLs per square meter (FAO, 2014). Three hundred PL were stocked in cement tanks per square meter and 250 PL per square meter were stocked in hapa net cages in mud ponds. Altogether 54 000 PL were stocked in nine cement tanks including 6 000 PL in each tank (20 $m^2$) and 6 000 PL were stocked in 12 hapa net cages fixed in three mud ponds including 500 PL in each cage (2 $m^2$). Harvesting of fry (2.5 cm) was done after three weeks rearing time period. Total length (TL) and weight were measured weekly using randomly taken samples (10% of population) of PLs from each tank and happa, until harvesting. Analytical balance (±0.001 g) was used in measuring the weights of PL. Venire caliper (±0.01 cm) was used for measuring the total length of PL. Average weight and average TL was calculated using the data obtained.

Temperature and pH were measured daily using electronic pH meter and thermometer. Dissolved oxygen (DO) level was observed using Winkler method to keep the treatment units at the optimum DO level during the study period. Secchi disk values were taken weekly by using secchi disk. Percentage survival rate, percentage weight gain (PWG) and percentage length gain (PLG) were calculated (Okunsebor and Ayuma, 2011). Obtained data were analyzed using analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of MINITAB 16 and Excel 2010 office package.

**Results**

The highest value of survival rate could be observed in the treatment of rice straw as 80.02 % ($< P = 0.05$) in cement tanks. The highest value of survival rate in mud ponds could be observed in the treatment of rice straw as 36.45 % ($< P = 0.05$). The highest percentage length gain (PLG) (309.29±2.50 cm) and the highest percentage weight (PWG) gain (4667±252 g) were observed in the treatment of rice straw in cement tanks ($P < 0.05$). Further the highest PWG (14950±173) and the highest PLG (305.73±2.60) were observed in the mud ponds fertilized by rice straw ($P < 0.05$). In considering the values of plankton count, the highest mean value of phytoplankton number in cement tanks could be observed in the ponds fertilized by cow dung (control). The lowest mean value was observed in the ponds fertilized by rice straw. In mud ponds also the same results were obtained at the date of stocking PL for rearing up to fry. The highest zooplankton count in cement tanks could be observed in the ponds fertilized by rice straw while the lowest value was observed in the ponds fertilized by rice straw. In mud ponds also the highest zooplankton count was observed in the treatment of rice straw at the date of stocking PL. As *Catla catla* was a zooplankton feeder the highest survival rate, the mean values of highest PWG and highest PLG were observed in the treatment unit of rice straw that included highest zooplankton amount in the water. The highest zooplankton amount in the water could provide more live feed and it might be the reason for the highest survival and growth of fry at harvesting. The highest secchi disk value was observed in the treatment of rice straw throughout the study period in both cement tanks and mud ponds.

**Discussion**

European Inland Fisheries Advisory Commission indicates that turbidity can have a harmful impact on freshwater fish by reducing food supplies and affecting gill function, killing them or reducing their growth rate, preventing successful development of fish egg and larvae and affecting the efficiency of methods for catching fish (MPCA, 2008). Very high phytoplankton blooms create high turbidity and it causes negative effects on survival of larvae. In this study also shows that both cement tanks and mud ponds fertilized by rice straw shows lower phytoplankton and higher zooplankton community. Fluten *et al.* 2002 found that feeding and growth rates reduced due to more turbid water. The lower turbidity could be observed in the treatment of rice straw than two other treatments. Catla PL can easily find out their live feed in low turbid water. It was commonly found copepods, daphnia and rotifers as zooplankton in water sampled in the mud ponds and cement tanks fertilized by rice straw.

That might be the reason for highest survival rate and growth (PWG and PLG) of *Catla catla* as a zooplankton feeder in the units fertilized by rice straw.

Shahabuddin et al., 2012 mentioned that rice straw extract showed allelopathic activity to Microcystis to improve the water quality. Few researches have been explored the potential of using rice straw to improve water quality, algal control and enhance Tilapia fish production. It was found that covering pond dikes with rice straw reduced the clay turbidity and enhanced growth of Tilapia. Therefore, use of rice straw should be one of the best alternatives for water quality management and microbial production. Above mentioned details will cause low turbidity, improve water quality, maintain phytoplankton density and leads to high survival and better growth of Catla fry. PL could find their feed of zooplankton easily in clear water.

As mentioned by Kasper, 2012 most fish survive 2-5 ppm DO level, but the growth may be retarded if the above level continues for some period. Throughout the study period the DO level was higher than 5 ppm. It emphasizes that rice straw might not cause for the reduction of DO and rice straw could provide favorable condition for higher growth and survival of *Catla catla.* Therefore in fertilizing ponds or cement tanks using rice straw in rearing *Catla catla* (PL to fry), provides live feed through better zooplankton growth and maintain better water quality with lower turbidity. Ultimately it leads to the better growth and higher survival of *Catla catla* fry comparing with other two fertilizers

**Conclusion**

The highest survival rate could be observed in PL to fry rearing in the mud ponds as well as in cement tanks that were fertilized with Rice straw and the highest growth rate could be observed in the mud ponds and in cement tanks that were fertilized with Rice straw

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# Bio assay on effectiveness of the chemical hydrolyzation for denaturing agrochemical contaminated wastewater

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## Introduction

Pesticides provide the primary means for controlling organisms that compete with man for food and fiber, livestock and crops. Global insecticide use in 2007 has been estimated 404 000 metric tons of active ingredient (Grube *et al.* 2011). The agricultural sector is the primary user of pesticides, consuming over four million tons of pesticides annually (Chen *et al.* 2009 and Chevillard *et al.* 2012). Most agrochemicals imperviousness to microbial degradation and has tendency to bio-accumulate in the soil fauna and flora. Water contamination has turned into a significant danger to the presence of living life forms in aquatic environment and aquatic organisms are highly susceptible for the agrochemical lethality. Many studies have shown the toxicity effect of agrochemical, but few studies have done to investigate the effectiveness of those treatment methods. Since the usage of agrochemical cannot be banded, best thing is finding a suitable method to detoxify them and understand the effectiveness of the particular method. Hydrolysis is a chemical reaction in which natural constituents respond with water and break into more diminutive (and less toxic) compounds. Fundamentally, hydrolysis is a destructive technology in which the original molecule forms two or more new molecules (EPA, 1993). Hydrolysis could be a viable treatment technology for agrochemical wastewater. In this study the effectiveness of the alkaline hydrolysis was estimated by using field data which were taken from the effluent treated plant (ETF) of agrochemical formulation and repacking industry, and also a bio assay was used to analyze the effect to the aquatic species from the treatment method.

## Methodology

To check the effectiveness of " Alkaline Hydrolysis" method, samples were collected from a wastewater effluent treated plant in pesticide repacking and formulation industry. Samples were collected from raw water and treated tanks and measured Chemical Oxygen Demand (COD), Total Suspended Solid (TSS) and pesticide active ingredients (Glyposate, MCPA, Profenofos). The samples were analyzed according to the American Public Health Association (APHA 2540 D, 2014) standard methods. All analysis were carried out at Environment Technology Section (ETS) and Chemical and Microbiological Laboratory (CML) section in Industrial Technology Institute (ITI).Those parameters were compared and checked the reduction efficiency. To check the effect to the aquatic ecosystems after applying the treatment "Guppy" (*Poicelia reticulatae)* were used for a bio assay. Behaviors and mortality rates were evaluated after introducing them to the treated effluent. One hundred fifty specimens of *P. reticulatae* with mean length of 2.5 ±0.5 cm and mean weight 0.2 ±0.5 were collected from the drainage canals with scoop nets and carried to the laboratory in a doubled polythene bags half filled with water from the source. They were kept in fifteen holding tanks (30X30X30 cm). One quarter 1/4 were filled with de chlorinated tap water and allowed to acclimatize to experimental environment condition: $30^0$ C, pH 7.8 for 1 week before applying treated effluent. Ten fish per tank were stocked (With active animals in each) Physico-chemical parameters such as DO, Temperature. pH of the test media were

measured before and during the experiment period using Horiba Water Quality Checker. Mortality assessment was carried out for 24 h to 96 h of intervals. Fishes were assumed to be dead when there was no body or opercula movement .Statistical data analysis was done in the MINITAB (version 16.0) statistical software package. All the data were analyzed statistically using one way ANOVA (analysis of variance) table to detect difference among locations ($p < 0.05$).

**Results and Discussion**

Results which were obtained by the field data, it shows "Alkaline Hydrolysis" is effective in treating agrochemical contaminated water. When considering the statistics of COD comparison, it indicates a clear difference of mean values, coefficient of variance is nearly the same indicating the span of data is almost the same over the mean values. Therefore it can be concluded that raw effluent has a higher COD than the treated water samples. Further when considering pesticide analysis, it has shown raw wastewater which contained high amount of pesticide active ingredients has decreased and became non detectable after treating. This clearly showed "Alkaline Hydrolysis'' has the ability to lower the toxicity. When considering the bio assay all the physico chemical conditions of the test media during the toxicity tests were fairly constant. The $p^H$ ranged between 7.5-7.8, Dissolved Oxygen (DO) was between 6.5 and 7 mg $L^{-1}$ while temperature ranged between 28.0 and 31 $^0$C over 96 hours toxicity evaluation. The results of the toxicity test of treated effluent on *P.reticulata* in 24, 48, 72 and 96 h of exposure showed mortality shown in Figure 1.

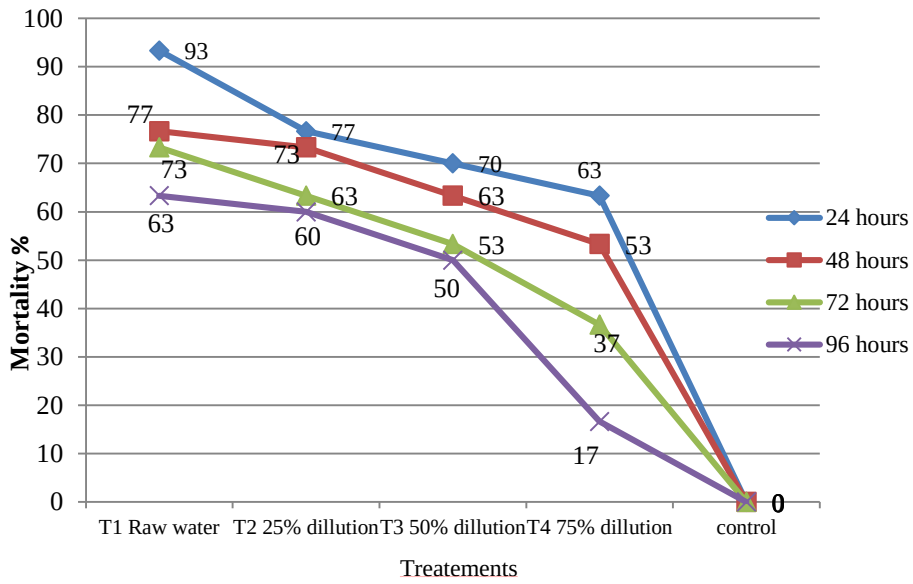


Figure 01: Treatments Vs Mortality

No adverse behavioral changes or any mortality was recorded in the control fish tanks throughout the period of bio assay. Symptoms of toxicosis observed in the behavioral of fish exposed to test media. Before the eventual death species showed lack of balance erratic swimming and restlessness. In the study highest mortality was recorded, in less
diluted effluent and lowest exposure time (24 h) , lowest mortality was recorded in highest dilution (75%) and longest exposure time (96 h). The findings in this study has revealed that when discharging the agrochemical contaminated waste water after hydrolyzation, it should be mixed with rain or storm water and keep the contaminated water in the maturation tank for further degradation. Because in the study it has shown highest dilution and highest exposure duration caused minimum

mortality. According to the results which were obtained from bio-assay to avoid the effect to the ecosystem, dilution should be done. Therefore before discharging treated water to the outer ecosystems, it should be subjected to proper dilution. Then the negative effect to the ecosystems can be minimized. This study showed that at 96 h exposure in high dilution (75%) caused minimum mortality. Toxicity has shown to increase with lowering the dilution. The exposure of *P.reticulata* to treated wastewater which was contaminated by agrochemical (Profenofos) exhibited aggressive behavior, rapid gulping water, increased opercular movements. *P.reticulata* was stressed progressively with the time before death. Analysis of Variance (ANOVA) showed that there was significant
difference ($p<0.005$) in the quantal response at 24, 48, 72 and 96 hours of exposure in each dilution level. The findings in this study have revealed that agrochemical is toxic to fish and suitable treatment method can detoxify the toxicity of them. Establishing proper treatment methods are highly recommended for contaminated areas.

## Conclusion

Study is suggested toxicity depends on dilution and exposure time. Alkaline hydrolyzation is one of the best treatment methods that can be applied to the agrochemical contaminated areas. Most suitable option that can be taken to alter the problem is keeping the treated effluent in a maturation tank for one month like period and mixed that with rain or storm water with a suitable dilution factor before discharge to the natural environment. Therefore the toxicity and remaining active ingredients can be degraded naturally with the time. And by the time it will be subjected to natural hydrolysis also. This will reduce further bioaccumulation in ecosystems.

## Acknowledgement

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# Preliminary study on mangrove diversity in Irakkandy lagoon, Trincomalee

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## Introduction

The term 'mangrove' describes both the ecosystem and the plant families that have developed specialized adaptations to live in the tidal environment (Tomlinson, 1986). Preliminary study on diversity of the mangrove stands at Irakkandy lagoon (Trincomalee) was investigated to document the status of the mangrove forest and the mangrove distribution in relation to the soil salinity variation. Due to the past two decades war dilemma and present developmental activities increase the pressure on mangrove ecosystem at an alarming rate Eastern region of Sri Lanka. In addition, Tsunami has collectively contributed to the destruction of mangroves at large in the Eastern province. In this backdrop, this research aims to analyse the diversity of mangrove in the Irakkandy lagoon which further attempts to provide some suggestions to protect mangrove and its ecosystem.

## Methodology

Fifteen transect lines were laid perpendicular to the shore in different sites of the lagoon and sampling was conducted from May 2014 to July 2014 at selected locations. The precise locations were determined by portable GPS unit (ETREX 10) and hydro physico-chemical parameters of each site were recorded over high tide and low tide. Whilemeasuring the mangrove diversity, Temperature and pH were checked using Multiple Test Kit (Thermo scientific) and turbidity was measured using Turbidity meter (Hach model (2100q)) in Nephelometric Turbidity Units (NTU). Salinity was measured using a Refrectrometer (Erma Hand Refractometer, Salinity: 0-100) in units parts per thousand (ppt). Data on floristic composition was identified using standard identification keys. Moreover height of the species was measured by Suunto Clinometer. Three soil samples were collected along the transect line of each site from the edge of the lagoon to end of the mangrove existence. Soil salinity was calculated according to Gibbs, 2000. Shannon-Wiener diversity index and Pielou's eveness index incorporated in the Primer software version 6.1.2 and Minitab ver.16 used for data analysis and statistical analysis.

## Results and Discussion

Five different true mangrove species and nine mangrove associate plants were identified from the study site. *Avicennia marina* was the dominant species with Height (H) of 1.39± 2.54m followed by *Lumnitzera racemosa* (3.13±1.92m), *Excoecaria agallocha* (3.28±2.662 m), *Rhizophora apiculata* (3.28 ±4.79m) and *Heritiera littoralis* was found as rare species with Height of (5.27 ±2.21m) respectively.

Figure 1 describes the calculation of Shannon –Wiener index obtained for each transect which express the number of different species in a particular area.

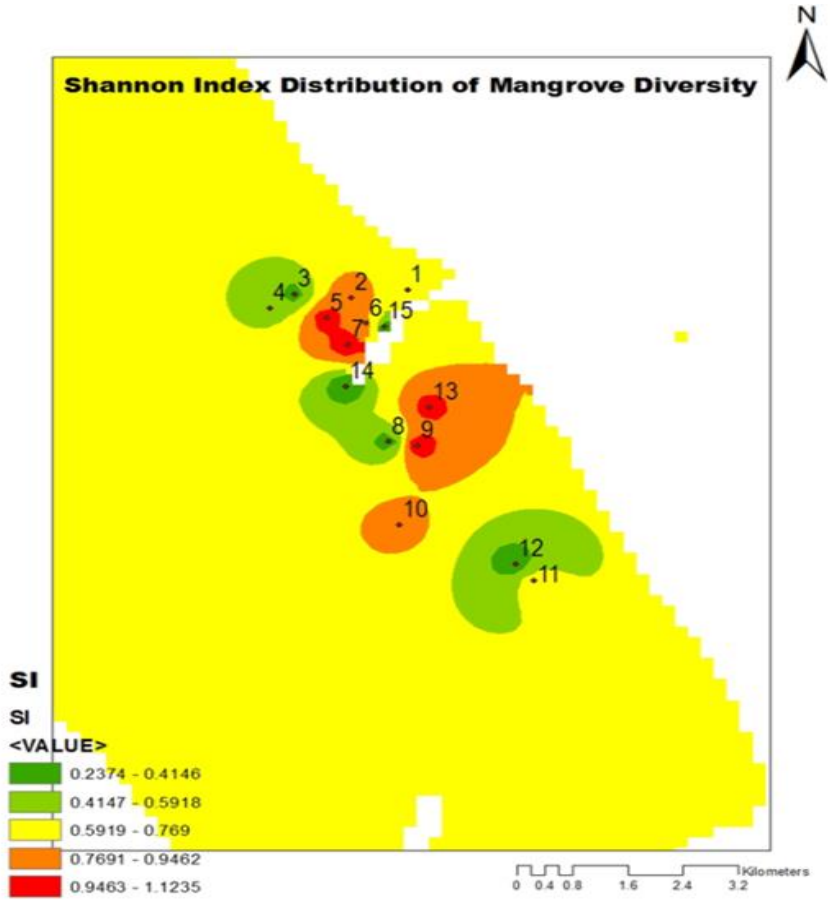


Figure 1: Shannon-Wiener Index of different Transects

The highest values (1.16) of Shannon - Wiener index shows high diversity representing diverse and equally distributed community in transect 7 while lowest value (0.22) of Shannon - Wiener index in transect 14 represents less diverse mangrove community. Transect 11 could be described as being-richer-insofar as most species present are more evenly represented by numbers of individuals since the species evenness (e) value is larger (1). Transect 14 where some species are represented by many individuals, and other species are represented by very few individuals has a low species evenness (0.16).

The wide salinity tolerance range (1-16 ppt) was observed in *Avicennia marina*. Pinto (1982) has indicated that the presence of a *Rhizophora* border on the shore may be due to its morphological adaptations in resisting water currents with the help of prop roots. Presence of a *Rhizophora* border instead of an *Avicennia* border in transect 2 may be due to the depth and slope as well as due to the lack of sandy soil and poor aeration.

The water salinity increases in high tide due to the sea water inclusion towards the lagoon and low in low tide as sea water extrude towards the sea. There is a positive moderate linear relationship between mangrove species and distance from the shore (ANOVA, $P<0.05$). In Irakkandy Lagoon, mangrove forest experiencing total diurnal inundation is dominated by *Avicennia marina* while *Excoecaria*

*agallocha* dominated sites that are not completely inundated. Amarasinghe *et al.* (2013) has found that *Avicennia marina* do not grow in fresh water and may be obligate halophytes. Also *Excoecaria agallocha,* survives well in fresh water and may not have obligatory requirement for salt beyond trace amount.

There is a significant difference between soil salinity and distance from the shore (ANOVA, $P<0.05$). Low frequency and duration of tidal inundation can be cited as the probable reason for low soil salinity at the landward sites (Joshi and Ghose, 2003). As indicated by the results, decreasing salinity with increasing distance is not observed in some places. The reason can be the evaporation occurred when the temperature is raised. In contrast, frequent inundation permanently saturates the soil with seawater salt content.

There is a negative weak linear relationship between soil salinity and height of the mangrove tree (ANOVA, $P<0.05$) since low-saline mangrove forests usually show a more luxuriant growth than the high-saline ones (De Silva and de Silva, 1998). There is a negative moderate linear relationship between soil salinity and mangrove species (correlations, $P<0.05$).

**Conclusion**

The results of the study indicate Irakkandy lagoon consists of low biological diversity of mangroves compared to Negombo, Chilaw and Puttalam lagoons but is extremely valuable as a living mangrove forest due to its extent.

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# Analyze the Histamine level in various positions of the Histamine developed Tuna fish

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## Introduction

Sea food processing industry is a high income generating field in Sri Lanka and it brings high foreign exchange to the country. Big eye tuna (*Thunnus obesus*) and yellow fin tuna (*Thunnus albacares*) are the major tuna types which are exported by Sri Lanka to the international market. (FAO, 2014).However the presence of Histamine is the problematic factor inTuna fish processing industry which leads the industry to many health issues and income losses.

Histamine is a chemical compound created from histidine and enteric bacteria are capable of transforming histidine to histamine by the enzyme decarboxylase. Once histamine is formed, it cannot be not destroyed by freezing, cooking, smoking, curing or canning. Histamine level of more than 5mg/100g is classified as unsafe by U.S. Food and Drug Administration. (Ebrahim*et al.,* 2012).Histamine level varies position of the tuna fish body. Hence this research was carried out to identify and analyze the Histamine level in various positions of the Histamine developed tuna fish.

## Methodology

Survey was done to select the positions of taking samples from tuna fish. 15 fresh fish processing companies were selected and questionnaire was given. Three positions were selected based on the questionnaire filled by the fish processing companies. Three positions of the tuna fish were selected, beneath the pectoral fin of the fish, near the belly area and the tail end respectively and thirty tuna fish were subjected to Histamine test individually. ELISA method and histaminevertox test kit were used to analyze the histamine levels in the tuna fish.Sample preparation, sample extraction, sample dilution and Histamine testing are the major steps done in ELISA method. Collected data were analyzed by using Minitab 17 software.Highest mean values and variance values were taken from those positions. Non parametric Mann-Whitney test was done to find out the significant different among positions.

## Results and Discussion

Highest mean values and variance values were taken from those positions.

High Histamine was recorded in the belly area due to the most of the bacteria which responsible for converting Histidine to Histamine, lived in the gut of tuna fish. Through poor post-harvest techniques, low hygiene practices, bad catching method, bad killing methods and bad handling methods could expose the gut material to the fish muscles and so enteric bacteria easily release the Histidine decarboxylase enzyme to Histidine free specific amino acid and then forming Histamine (Koohdar*et al.,* 2010).This reaction cannot be stopped and can only be controlled. Usually low histamine levels could be observed from gilled and gutted fish because gilled and gutted fish had

low probability to contaminate by histamine forming enteric bacteria (Ebrahim*et al.,* 2012).Very low Histamine level was recorded in the tail area because effect of enteric bacteria which lived in the tail was very low because of that ability to bacterial contamination also very low and histamine also very low.

Table1. Comparison of mean, median, variance and standard deviation of histamine levels of tuna fish body

| Position of the fish body | Mean | Median | Standard deviation |
|---|---|---|---|
| Beneath the pectoral fin | 22.97 ppm | 19.70 ppm | 19.15 |
| Near the belly area | 25.74 ppm | 18.30 ppm | 26.44 |
| Tail end | 9.20 ppm | 05.80 ppm | 10.82 |

High Histamine was recorded in the belly area due to the most of the bacteria which responsible for converting Histidine to Histamine, lived in the gut of tuna fish. Through poor post-harvest techniques, low hygiene practices, bad catching method, bad killing methods and bad handling methods could expose the gut material to the fish muscles and so enteric bacteria easily release the Histidine decarboxylase enzyme to Histidine free specific amino acid and then forming Histamine (Koohdar*et al.,* 2010).This reaction cannot be stopped and can only be controlled. Usually low histamine levels could be observed from gilled and gutted fish because gilled and gutted fish had low probability to contaminate by histamine forming enteric bacteria (Ebrahim*et al.,* 2012).Very low Histamine level was recorded in the tail area because effect of enteric bacteria which lived in the tail was very low because of that ability to bacterial contamination also very low and histamine also very low.

Though belly area of the fish had high probability for forming Histamine in Tuna fish, most of the sea food companies preferred to take sample from beneath the pectoral fin. After taking sample from belly area small hole could be seen. It could reduce the good appearance of the products and more meat had to be removed to take the good quality of the products. Therefore sea food companies rather preferred beneath the pectoral fin of Tuna. Samples had to be taken out from deepest areas of those positions. It could increase the effectiveness of the test.

## Conclusion

Highest Histamine value was recorded near the belly area of the tuna fish therefore best position for taking sample for Histamine test was near the belly area. Next Highest Histamine value was recorded beneath the pectoral fin and next best position for taking sample for Histamine test was beneath the pectoral fin.

## Acknowledgement

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# A Geographic Information System (GIS) approach in identification of the potential reservoirs for Giant Freshwater prawn (*Macrobrachium rosenbergii*) culture: A case study in Moneragala district, Sri Lanka

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## Introduction

Culture Based Fishery (CBF) is a better approach to overcome poverty and malnutrition in Moneragala District since the district is enriched with large number of village reservoirs and minor perennial reservoirs. Introducing a valuable, high demanding and protein rich species such as Giant Fresh Water Prawn (*Macrobrachium rosenbergii*) through CBF is the best way to get the maximum utilization of these natural resources. Current practice of stock enhancement of *Macrobrachium rosenbergii* in reservoirs has resulted a heavy loss of stock and low returns. Therefore it needs a careful selection of potential reservoirs prior to stocking of post larvae.

As a tool in decision making, Geographic Information System (GIS) is still a new concept for CBF in Sri Lanka for aquaculture planning. The main intent of this study was to highlight the role of GIS in identifying potential reservoirs for stock enhancement of *Macrobrachium rosenbergii* under inland CBF in Moneragala District, Sri Lanka by developing a map.

## Methodology

Nineteen minor perennial reservoirs distributed over nine divisional secretariat divisions in Moneragala District were visited during the dry season as the sample. Climate (Rainfall, Temperature), Bio-physical (Elevation) and Water quality (pH, Temperature, Hardness, Alkalinity, Dissolved Oxygen, transparency) and Socio-economic factors (proximity to roads and village, land use, poverty and population) were identified as influential factors for *Macrobrachium rosenbergii* culture based fishery. Data were collected from field surveys and responsible government institutes. Water quality parameters were tested on site and the university laboratory. In order to generate thematic layers for above each factors Interpolation techniques were applied for climate, elevation and water quality data; Population and poverty were considered in respective to DS divisions; multiple ring buffers were created for the proximity factors. Each factor was classified according to four suitability scales; very suitable, suitable, moderately suitable and unsuitable. Land use types in the district land use map were classified according to their suitability. Factors were ranked according to their relative influence on *Macrobrachium rosenbergii* fishery and weights were assigned according to their relative influence using the method of "Rank Sum". Finally, all thematic layers were integrated in ArcGIS 10.1 (Esri, 2012) environment to generate the potential map.

**Results**

According to the resulted map (Figure 1) unsuitable areas occupy about half of the extent of the district. If potential reservoirs for *Macrobrachium rosenbergii* culture were indicated in respective to DS divisions, Badalkumbura, Moneragala, Wellawaya, Medagama and Sevanagala divisions were resulted as highest potential areas. Thanamalwila, Bibile, Madulla, Buttalaand Siyambalanduwa divisions were resulted as Suitable areas and Latter part of Madulla was indicated as Moderately suitable area.The district can gain more benefits by stocking *M. rosenbergii* in reservoirs that fall in most suitable areas.Since the water quality parameters were given the highest weight final result has high influence by water quality factor. Results are basically applicable to the dry season which is the period that water quality data were collected.

According to the field observations dry season is not favorable for CBF. Application of CBF at present is not in a satisfactory level with compared to the existing number of reservoirs.Potential areas resulting from multi-criteria evaluation (MCE) are mostly associated around the reservoirs where the optimum water quality for *M. rosenbergii* culture exists. Results could be advanced by tallying the obtained results with catch data of Giant Prawn as some reservoirs are already practicing prawn culture, but lacking of accurate catch data was a limitation for the research. Suitability of the reservoirs included in the sample could be concluded as follows (Table 1).

Table 3: Suitability of Selected Reservoirs

| DS Division | Reservoir | Surface Area (ha) | Potential |
|---|---|---|---|
| **Sevanagala** | HabaraluWewa | 80 | Most Suitable |
| **Thanamalwila** | MahaWewa | 80 | Suitable |
| | DemodaraWewa | 100 | Suitable |
| | HambegamuwaWewa | 210 | Suitable |
| **Kataragama** | GestupanaWewa | 80 | Suitable |
| | MilegamaWewa | 80 | Suitable |
| **Siyambalanduwa** | SugalaDewi | 50 | Unsuitable |
| | DoserWewa | 50 | Suitable |
| | HeekaduAra | 50 | Suitable |
| | New HeekaduAra | 30 | Suitable |
| | Kotiyagalawewa | 120 | Suitable |
| **Moneragala** | MeepanaAra | 10 | Most Suitable |
| | Thambalawinna | 15 | Most Suitable |
| **Bibile** | MeegahaAra | 120 | Suitable |
| | NagalaWewa | 15 | Most Suitable |
| **Badalkumbura** | Katugahagalge | 10 | Most Suitable |
| **Buttala** | AmbakolaWewa | 66 | Suitable |
| | Yudaganawa | 60 | Suitable |
| **Wellawaya** | Handapanagala | 226 | Most Suitable |

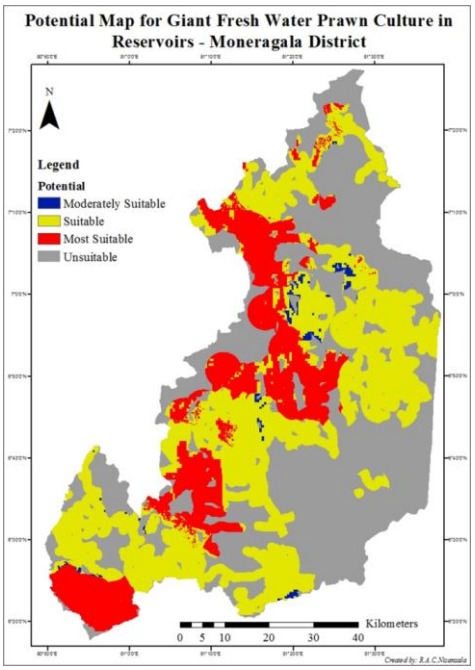


Figure 1: Potential Map for Giant Fresh Water Prawn (M. rosenbergii) culture in reservoirs – Moneragala district

## Conclusion

Application of CBF at present is not in a satisfactory level with compared to the existing number of reservoirs.The district can gain more benefits by stocking *M. rosenbergii* under CBF in reservoirs falls in most suitable areas.

The result of study is very dependent on weighting, classifying suitability scores and ranking. Different weighting, rating, and classification methods could generate a variety of results.

Overall, the results of this study demonstrates that the GIS based approach is a useful tool for assessing potential reservoirs for culturing *M. rosenbergii* under culture based fishery especially in data-scarce conditions.

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# Study of water quality changes and growth of cultured edible oysters (*Crassostrea madrasensis*), culture sites at Gagewadiya and Kandakuliya in Puttlam district

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## Introduction

Global bivalve production from aquaculture has consistently increased over the years. Sri Lanka is a country which has vast natural resources and suitable environmental conditions for aquaculture. Therefore it has a great potential for develop and contribute to national fish and shellfish production. Although the bivalve industry is highly developed industry in East Asian region finfish and shellfish, specially mollusk and sea cucumbers cultures are at very initial stage in Sri Lanka (Samarasundera, 2010).Sustainable utilization of unexploited high demand finfish and shellfish species are a good alternative to develop the industry. Oysters are nutritious, still unexploited fishery resources in Sri Lanka. Which has good export demand worldwide. Although Sri Lanka have required resources naturally to uplift the industry in large scale, lack of information, limited supply of seeds and lack of trained personals are act as major constraints (FAO, 2006). The success of bivalve culture greatly depends on suitable environmental factors that ensure both optimal growth and quality as well as ensure food safety (FAO, 2006). Kandakuliya and Gagewadiya areas are blessed with natural oyster resources but which are not used commercial scale at present. Therefore the two locations have significant possibility to conduct oyster culture in large scale which providing self-employment opportunities for fisher communities. The study of water quality changes and growth of edible oysters (*Crassostrea madrasensis*) culture, sites at Gagewadiya and Kandakuliya in Puttlam district was carried out to investigate the possibility of establish these culture in commercial scale.

## Methodology

The research project was conducted in two experimental sites (Gagewadiya and Kandakuliya), locates in Puttlam district, Sri Lanka. Field data were collected during October 2013 to July 2014from pre-establish two experimental culture sites. There were four sampling points in each site separately K1, K2,K3, K4in Kandakuliya and G1, G2, G3, G4in Gagewadiya. Water quality data, growth data and phytoplankton data were collected each site separately. Water quality and phytoplankton data were collected twice a month, and growth data were collected once a month during the studied period. Temperature, pH, salinity, transparency were recorded as onsite measurements. Further analysis were conducted for nitrite, nitrate, phosphate and ammonia using DR-4000U spectrophotometer according to standard procedures of Parsons *et al*., 1984. Unionized ammonia levels were calculated using total

ammonia levels. Phytoplankton samples were collected using phytoplankton net (50 µm mesh size).The samples were examined under light microscope and identified to genus level using identification keys (Newell and Newell, 1963; Rebert, 2003; Swadling, 2008; Verlencar and Somshekar, 2004).Length (distance between the end of umbo and the ventral shell margin) and width (length at the widest axis of the body) were taken as growth parameters. Twenty five C. *madrasensis* organisms were used to take measurements from each site separately, for the growth study.

Both primary and secondary data were used to analysis. Secondary data were taken from IDRC oyster research and culture programme. Minitab 16 statistical package was used to data analysis. All data were analyzed statistically using one way ANOVA (Turkey test) for all selected locations. Person product movement correlation coefficient analysis was done between water quality parameters and growth of oysters to find whether there were significant relationship between those variables.

**Results and Discussion**

According to the water quality study there were no significant difference ($P \geq 0.05$) in nitrite, nitrate, phosphate, unionized ammonia, temperature, pH, depth and transparency at Kandakuliya and Gagewadiya except salinity during the studied period. All water quality parameters were in acceptable range for oyster culture. Gagewadiya (2-29 ppt) showed lower salinity and wide salinity variation than Kandakuliya (25 -43 ppt), as this site receives fresh water from "*kalaoya"*. Rapid decline of salinity which make unfavorable for cultured oysters were observed in November 2013 and April 2014 at Gagewadiya. It was 2 ppt and 4 ppt respectively. This lower salinity was resulted from increased fresh water discharge from "*kalaoya"*catchment area. According to Sasikumar *et al.* (2007) *Crassostrea madarasensis* species can tolerate salinity changes from 0-40 ppt. However if these unfavorable salinities were exist longer period oyster spats can be transferred to other sites with optimum salinity. Finally it will help to increase the growth rate of *C. madrasensis* in that site.

According to growth study, there was no significant difference ($P \leq 0.05$) in growth rates (length and width) of *Crassostrea madarasensis* at Kandakuliya and Gagewadiya. Since the water quality parameters in both sites were nearly equal to each other, growth in both sites were similar. Even though there were no significant difference ($P \leq 0.05$) in growth, organisms in Gagewadiya site shown slightly higher growth than Kandakuliya. This is because of favorable aquatic environment for oysters in Gagewadiya than Kandakuliya. That creates by nutrition rich fresh water comes from "*kalaoya"*.Finally it cause to higher growth rate of the oysters in Gagewadiya than Kandakuliya.

Correlation analysis revealed that, there was no significant relationship ($P \geq 0.05$) between growth of *C. madrasensis* with nitrite, phosphate, unionized ammonia, pH and salinity levels. Nitrate, temperature and transparency have significant relationship ($P \leq 0.05$) with growth (length and width) of *C. madrasensis*. Nitrate cause to growth of phytoplankton in the surrounding water, which is primary food source for oysters. Therefore it directly affect to the growth of oysters. No harmful algal species were recorded during the studied period.

**Conclusion**

Salinity levels in both Gagewadiya and Kandakuliya were in tolerable levelfor *C. madrasensis* during the studied period. The absence of toxic algae (dianofllagelates) at both sites and suitable ranges of temperature, pH, transparency, nitrite, nitrate, phosphate, and unionized ammonia levels suggest that Kandakuliya and Gagewadiya areas are suitable for commercial oyster culture practices. According to growth study, C. *madrasensis* growth in Gagewadiya site shows slightly higher growth rate than Kandakuliya site. Therefore Gagewadiya site can be recommended as best site among those two sites.

**Acknowledgment**

We would like to express our heartfelt gratitude to all the people in IARAD and ESD divisions in National Aquatic Resources Research and Development Agency, who gave their tremendous help to successfully completion of this research work. Further we like to extend our sincere gratitude to International Development Research Center (IDRC) for providing grants to conduct the research work.

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# Technical Session - Export Agriculture

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## Oral Session

## Poster Session

# *In vitro* antifungal activity of selected medicinal plant extracts against selected postharvest pathogens in fruits and vegetables

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## Introduction

Fungal diseases are a major problem occurred in fruit and vegetable cultivations and during post-harvest life of fruits and vegetables. Application of systemic fungicides is the most common practice for commercial control of most of the post-harvest pathogens. Although synthetic fungicides have provided effective control of major postharvest diseases, their application may be harmful to human health and the environment and they become ineffective after prolonged use (Awoit*et al*, 2013).There are some natural plant products with antifungal activity against various fungal groups. Those natural compounds can be used to control the post-harvest fruit and vegetable pathogens in environmental friendly manner(Paster*et al*., 1995).

## Methodology

The current study was conducted to determine the antifungal activity of the leaves of *Azadirachtaindica*(Neem) and *Calendula officinalis*Linn(Marigold) and the peel of the fruit of *Myristicafragrans*(Nutmeg) against post-harvest disease causing fungal species such as*Colletrotrichumgloeosporioides*, *Fusariumoxysporum*,*Rhizoctonia solani* and *Trichoderma*spp. This experiment was conducted at the laboratories of Natural Products Chemistry division of the Institute of Fundamental Studies (IFS), Kandy.

The selected plant materialswere collected from the home gardens in Kandy. Plant materials were cleaned well under running tap water and air dried. The dried plant materials were crushed. Each plant powder (50 g) was extracted with hexane,ethyl acetate, methanol and distilled water respectively in a sequential process and the evaporation of solvent using rotary evaporator finished 12 extracts.The fungal cultures were obtained from Pathology Division of Horticultural Crops Research and Development Institute (HORDI), Gannoruwa, which were isolated from fruits and vegetables. The antifungal assay was conducted in 9cm diameter petri dishes. The extracts were dissolved in 10% Dimethyl sulfoxide (DMSO) to prepare 5000 ppm concentration of each extractand the 10% DMSO without plant extracts was used as the negative control.

The poisoned food technique (Chutia*et al*., 2009) was used to test for the antifungal activity. Plant extracts were mixed with the Potato Dextrose Agar (PDA) medium and poured to the petri dishes. The test fungal groups were inoculated with 8 mm diameter mycelial disc from 7- 10 daysold cultures. The plates were incubated at room temperature and colony diameter was measured after three days. This experiment was conducted by using Two Factor Factorial in Complete Randomized Design and data analysis was done by using Analysis of Variance (ANOVA) in General Linear Model. The mean comparison was done by using Tucky pairwise

comparison method at significance level of 5% ($\alpha = 0.05$) in Minitab 17 software.

**Results and Discussion**

Average colony diameter of each fungal species relevant to each plant extract is given in the table 1.

Table 1: Effect of the plant extracts on the growth of each fungal species

(H- Hexane,EA- Ethyl acetate,M- Methanol, DW- Distilled water, NC- Negative control)

| Plant | Solvent | Colony diameter (mm) | | | |
|---|---|---|---|---|---|
| | | *R. solani* | *C. gloeosporioides* | *F. oxysporum* | *Trichoderma*spp |
| *A. indica* | H | 42.00$^{bc}$ | 15.67$^{bc}$ | 17.33$^{ab}$ | 47.67$^{bc}$ |
| | EA | 35.00$^{bcd}$ | 18.00$^{bc}$ | 17.33$^{ab}$ | 46.33$^{bcde}$ |
| | M | 40.33$^{bc}$ | 16.67$^{bc}$ | 11.67$^{b}$ | 40.00$^{de}$ |
| | DW | 40.00$^{bc}$ | 16.33$^{bc}$ | 15.33$^{ab}$ | 39.67$^{ef}$ |
| *C. officinalis* | H | 39.33$^{bc}$ | 23.67$^{abc}$ | 19.67$^{ab}$ | 46.33$^{bcde}$ |
| | EA | 41.33$^{bc}$ | 21.33$^{abc}$ | 17.33$^{ab}$ | 48.00$^{bc}$ |
| | M | 42.00$^{bc}$ | 23.33$^{abc}$ | 19.67$^{ab}$ | 49.33$^{abc}$ |
| | DW | 36.67$^{bcd}$ | 22.67$^{abc}$ | 22.33$^{ab}$ | 51.67$^{ab}$ |
| *M. fragrans* | H | 29.33$^{cd}$ | 13.33$^{bc}$ | 14.00$^{b}$ | 43.00$^{cde}$ |
| | EA | 31.00$^{bcd}$ | 12.33$^{c}$ | 14.33$^{ab}$ | 32.33$^{f}$ |
| | M | 26.00$^{d}$ | 13.00$^{bc}$ | 14.67$^{ab}$ | 39.00$^{ef}$ |
| | DW | 43.00$^{b}$ | 26.33$^{ab}$ | 23.67$^{ab}$ | 47.33$^{bcd}$ |
| | NC | 57.33$^{a}$ | 31.67$^{a}$ | 26.33$^{a}$ | 56.67$^{a}$ |

* Values followed by the same letter are not significantly difference at $p \leq 0.05$ when subjected to Tukey pairwise comparison.

According to the results of this experiment, the lowest growth diameter against *R. solani* was given by the methanol extract of the fruit peel of *M. fragrans* (26 mm). The growth of the *C. gloesporioides* was highly controlled from ethyl acetate extract of the fruit peel of *M. fragrans*(12.33 mm). The lowest growth diameter against *F. oxysporum*was given by the methanol extract of the *A. indica* leaves(14 mm) and the growth of the *Trichoderma*spp was highly controlled from ethyl acetate extract of the fruit peel of *M. fragrans* (32.33 mm). With these results the *M. fragrans* shows higher antifungal activity for *C. gloesporioides*, *R.solani* and *Trichoderma*spp than other extracts while*A. indica* shows higher antifungal activity against *F. oxysporum*.

## Conclusions

The best antifungal extract against *R. solani* is methanol extract of fruit peel of*M. fragrans* and the best antifungal extract against *C. gloeosporioides* and *Trichoderma*spp is ethyl acetate extract of fruit peel of *M. fragrans* plant. The best antifungal extract against *F. oxysporum* is methanol extract of *A. indica* plant.

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Paster, N., Menasherov, M., Ravid, U. &Juven B. (1995). Antifungal activity of oregano and thyme essential oils applied as fumigants against fungi attacking stored grain. Journal of Food Protection, 58, 81−85.

# Technical efficiency of Mirahawatte organic tea smallholders: a stochastic frontier approach

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## Introduction

Organic agriculture is now becoming very famous among Sri Lankan farmers as it is able to catch more foreign exchange to the country. World public is more concerning on sustainable agro-product consumption to secure the economic, environmental and social benefits. Tea is one of the most prominent organic export crops in Sri Lanka. The relevant actions need to take to develop the organic tea production in the country. Before moving to that, most effective solution to upgrade the production is increasing the technical efficiency; ability to produce maximum output using existence inputs and technology. Measuring the technical efficiency will prove the actual sustainability of tea industry in economics terms.

Sri Lanka tea industry consists with estate sector and tea smallholdings. Contribution from the tea smallholders to the national tea production was 72% in 2013 (Ministry of Plantation Industries, 2013).As tea smallholders play a major role in Sri Lankan economy, analyzing technical efficiency is imperative. Main objectives targeted to measure the value of technical efficiency of tea smallholders in Mirahawatte and to find out the determinants of technical efficiency of organic tea smallholders in Mirahawatte.

## Methodology

Technical efficiency of Mirahawatte organic tea smallholders were measuredin this study with 71 organic tea small holders registered under Marginalized Organic Producer's Association. Stochastic frontier model was used to estimate the technical efficiency. Primary and secondary panel data were collected during the period of 2011/2012 to 2013/2014. Technical efficiency was estimated by a stochastic frontier function using a Cobb-Douglas model, incorporating technical inefficiency effect model. In Cobb-Douglas model effect of eight inputs against output was measured. In technical inefficiency function, sixteen variables were identified as efficiency components oftechnical inefficiency. Data ware analyzed using STATA version 11 and frontier 4.1c computer programme.

$Y_{it} = exp(x_{it}\beta + V_{it} - U_{it})$; (Battese andCoelli, 1995)

Cobb-Douglas model specification is,

$$ln(Y_{it}) = \beta_0 + \beta_1 ln(x_1)_{it} + \beta_2 ln(x_2)_{it} + \beta_3 ln(x_3)_{it} + \beta_4 ln(x_4)_{it} + \beta_5 ln(x_5)_{it} + \beta_6 ln(x_6)_{it} + \beta_7 ln(x_7)_{it} + \beta_8 ln(x_8)_{it} + V_{it} - U_{it}$$

Specification of technical efficiency function is,

$$U_{it} = \delta_0 + \delta_1(Z_1)_{it} + \delta_2(Z_2)_{it} + \delta_3(Z_3)_{it} + \delta_4(Z_4)_{it} + \delta_5(Z_5)_{it} + \delta_6(Z_6)_{it} + \delta_7(Z_7)_{it} + \delta_8(Z_8)_{it} + \delta_9(Z_9)_{it} + \delta_{10}(Z_{10})_{it} + \delta_{11}(Z_{11})_{it} + \delta_{12}(Z_{12})_{it} + \delta_{13}(Z_{13})_{it} + \delta_{14}(Z_{14})_{it} + \delta_{15}(Z_{15})_{it} + \delta_{16}(Z_{16})_{it} + W_{it}$$

Table 1: Description of variables of Cobb-Douglas model

| Notation | Variable | Description |
|---|---|---|
| $Y$ | Output | Kilograms |
| $\beta_0$ | Parameter for intercept of regression line | |
| $x_1$ | Land extent | Acre |
| $x_2$ | Family labour | Mandays |
| $x_3$ | Hired labour | Rupees |
| $x_4$ | Compost utilization | Kilograms |
| $x_5$ | Liquid fertilizer utilization | Litres |
| $x_6$ | Plant protection utilization | Grams |
| $x_7$ | Dolomite utilization | Kilograms |
| $x_8$ | Poultry manure utilization | Kilograms |
| $V$ | Random error | |
| $U$ | Efficiency component of technical inefficiency | |

Table 2 : Description of the variables of the technical inefficiency model

| Notation | Variable | Description |
|---|---|---|
| $Z_1$ | Age of farmer | Years |
| $Z_2$ | Gender | Dummy (1=male,0=female) |
| $Z_3$ | Occupation dummy 1 | Dummy (1=none, 0=otherwise) |
| $Z_4$ | Occupation dummy 2 | Dummy (1=informal, 0=otherwise) |
| $Z_5$ | Occupation dummy 3 | Dummy (1=formal, 0=otherwise) |
| $Z_6$ | Experience in tea cultivation | Years |
| $Z_7$ | Experience in organic farming | Years |
| $Z_8$ | Education | Scored (1=below O/L, 2=O/L, 3=A/L,4=Degree) |
| $Z_9$ | Other income | Rupees per month |
| $Z_{10}$ | Age of plantation | Years |
| $Z_{11}$ | Pruning frequency | Years |
| $Z_{12}$ | Pruning practice | Dummy (1=yes, 0=no) |
| $Z_{13}$ | Training | Times |
| $Z_{14}$ | Post | Dummy (1=yes, 0=no) |
| $Z_{15}$ | Crop dummy 1 | Dummy (1=VP, 0=otherwise) |
| $Z_{16}$ | Crop dummy 2 | Dummy (1=seedling, 0=otherwise) |
| $W$ | Unobservable random variable | |

**Results and Discussion**

According to the maximum likelihood estimates for the prameters of stochastic frontier, land extent became significant at 1% significant level and family labour and hired labour became significant at 10% significant level. All the variables had a positive relationship with the output. Gamma (γ) value is 0.626. Accordingly, 62.6% of random variation on organic tea production is explained by inefficiency.

Maximum likelihood estimates of parameters for the inefficiency model are mentioned in Table 4. Age, gender, occupation dummy 1, occupation dummy 3, experience in tea cultivation, experience in organic farming, education and crop dummy 2 become significant. According to those results, technical efficiency would be increased by increasing younger, male, experienced and VP tea cultivated smallholders. Unemployed and the smallholders engaged in formal occupations obtained more efficiency.The mean technical efficiency was found to be 71.39%. Technical efficiency ranged between 10.12% and 94.45%.

Table 3: OLS and Maximum Likelihood Estimates for the parameters of stochastic frontier

| Variable | Parameter | Coefficient | | SE | | t ratio | |
|---|---|---|---|---|---|---|---|
| | | OLS | MLE | OLS | MLE | OLS | MLE |
| Constant | $\beta_0$ | 5.758*** | 7.219*** | 0.309 | 0.432 | 18.587 | 16.68 |
| Land extent | $\beta_1$ | 0.862*** | 1.168*** | 0.111 | 0.102 | 7.712 | 11.348 |
| Family labour | $\beta_2$ | 0.093** | 0.069* | 0.041 | 0.038 | 2.281 | 1.809 |
| Hired labour | $\beta_3$ | 0.077*** | 0.04* | 0.019 | 0.02 | 3.87 | 1.917 |
| Compost | $\beta_4$ | 0.024 | 0.006 | 0.019 | 0.018 | 1.209 | 0.367 |
| Liquid fertilizer | $\beta_5$ | 0.065** | -0.008 | 0.03 | 0.035 | 2.12 | -0.246 |
| Plant protection | $\beta_6$ | 0.048 | 0.045 | 0.041 | 0.042 | 1.093 | 1.111 |
| Dolomite | $\beta_7$ | -0.022 | -0.0001 | 0.029 | 0.03 | -0.765 | -0.004 |
| Poultry manure | $\beta_8$ | -0.0009 | 0.0008 | 0.022 | 0.021 | -0.043 | 0.042 |
| $\sigma^2$ | 0.387 | | | | | | |
| $\gamma$ | 0.626 | | | | | | |
| Log likelihood | | -0.00011 | -0.007 | | | | |
| LR test | | 0.663 | | | | | |

**: Significance at 10%, **: Significance at 5%, ***: Significance at 1%*

Table 4: Determinants of inefficiency of Cobb-Douglas model for organic tea small holders

| Variable | Parameter | Coefficient | Standard error | t ratio |
|---|---|---|---|---|
| Age | $\delta_1$ | 0.07*** | 0.015 | 4.451 |
| Gender | $\delta_2$ | -1.652*** | 0.49 | -3.31 |
| Occupation dummy 1 | $\delta_3$ | -1.328** | 0.65 | 2.042 |
| Occupation dummy 2 | $\delta_4$ | -0.57 | 0.578 | -0.986 |
| Occupation dummy 3 | $\delta_5$ | -1.705* | 0.978 | -1.743 |
| Experience in tea | $\delta_6$ | -0.042** | 0.02 | -2.099 |
| Experience in organic | $\delta_7$ | -0.39*** | 0.118 | -3.304 |
| Education | $\delta_8$ | 1.202*** | 0.257 | 4.667 |
| Other income | $\delta_9$ | -0.00001 | 0.00001 | -0.955 |
| Age of plantation | $\delta_{10}$ | -0.005 | 0.03 | 0.179 |
| Pruning frequency | $\delta_{11}$ | -0.007 | 0.063 | -0.12 |
| Pruning practice | $\delta_{12}$ | 0.081 | 0.351 | 0.231 |
| Training | $\delta_{13}$ | -0.176 | 0.162 | -1.086 |
| Post | $\delta_{14}$ | -0.594 | 0.546 | -1.088 |
| Crop dummy 1 | $\delta_{15}$ | -0.365 | 0.522 | -0.7 |
| Crop dummy 2 | $\delta_{16}$ | 1.746** | 0.738 | 2.365 |

**: Significance at 10%, **:Significance at 5%, ***:Significance at 1%*

## Conclusion

There is still 28.61% of remaining potential to develop the output levels without increasing input levels and technology. Several policy recommendations can be given. Empowering policies to attract especially young people and females, organizing special extension programmes for elder smallholders, arranging regular meetings among farmer groups to share knowledge from experienced farmers and government involvement to increase replanting subsidy are the identified recommendations.

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Ministry of Plantation Industries. (2013). Progress Report, Colombo.

# Assessment of oil yield and quality in cinnamon (*Cinnamomum zeylanicum* Blume) leaves under different severity levels of two types of leaf galls

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## Introduction

Leaf gall infestation in cinnamon, is one of the prominent pest damage found in cinnamon cultivations. In cinnamon, two conspicuous leaf gall types are available. They are upper leaf galls caused by jumping plant louse (Trioza cinnamomi), a homopteran and lower leaf galls caused by Eriophyes boisi, a mite belongs to family Eriophyidae. Two pests are plant sappers and form galls on leaf blade as their habitats. The feeding by Eriophyes boisi or Trioza cinnamomi causes abnormal cell development and formation of galls. Each gall type is identical and their dimensions are variable. The galls are solitary and widespread on the leaf blade but are not on the veins. These Gall forming pests generally do little damage to plants and its bark yield because the affected parts are able to carry out photosynthesis with near normal efficiency. But cinnamon leaf oil yield and its quality may be changed significantly due to gall forming (Perera et. al., 1985; Prematilaka and Dharmadasa, 1995). Therefore this study was conducted to determine the effect of two different leaf galls in cinnamon leaves under different severity levels on the leaf oil content and quality of oil.

## Methodology

Cinnamon leaf samples infested with two types of galls, were collected from a field in Palolpitiya, Matara. Leaves only suffered from upper and lower gall infestations were harvested separately and categorized each of them into five pre-determined severity levels for oil extraction. Four severity levels of upper leaf gall infestation 1-50, 51 – 100, 101 – 150 and more than 151 galls per leaf and four severity levels of lower leaf gall infestation 1-15, 16 – 30, 31 – 45 and more than 46 galls per leaf were compared with cinnamon leaves without galls separately. Five treatments were assigned in randomized complete block design with five replicates. 50 g of air dried cinnamon leaf sample taken from each severity level was weighed and all the galls in the sample were isolated and weighed. Weight of galls in each severity level was expressed as a percentage to the whole sample weight. Each sample was subjected to extract leaf oil by hydro distillation. Amount of the major chemical components present in the extracted oil samples were measured by performing Gas Liquid Chromatography (GLC). Oil content and quality were subjected to analysis of variance and regression analysis by SAS programme.

## Results and Discussion

Thus it revealed that leaf oil contents were significantly different with the intensity of upper gall infestation (Table 1). It was observed that cinnamon leaf oil content had been lost from 10.48% at 25.62% severity to 74.26% at 97.26% severity. Same trend was observed in the case of lower

gall infestation (Table 2), but oil reduction due to this infestation had been occurred from 25.87% at 22.7% severity to 96.45% at 99.63% severity. Experimental results showed that mite galls (lower leaf galls) had reduced the oil yield in greater than the insect galls (upper leaf galls). Both upper and lower leaf gall infestations were caused to reduce the oil yield in cinnamon leaves and those infestations showed a strong negative significant relationship with the oil content in cinnamon leaves (Fig. 1 and 2). Prematilaka and Dharmadasa (1996) reported about 35% of oil reduction could be made due to upper leaf gall infestation, but the current study revealed that loss of oil content has been varied on severity of infestation.

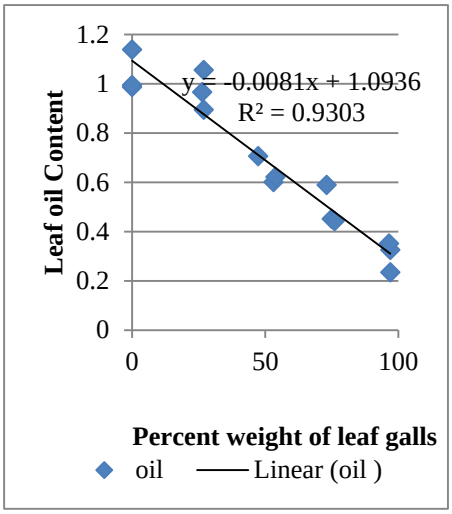


Figure 1: Correlation between leaf oil content under different infestation levels of upper leaf galls (proportion weight of leaf galls)

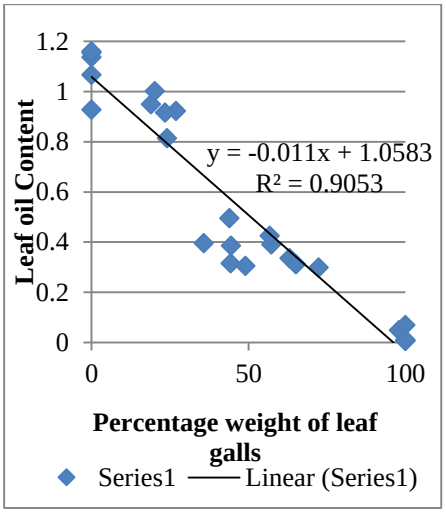


Figure 2: Correlation between leaf oil content under different infestation levels of lower leaf galls (proportion weight of leaf galls)

Table 1: Changes of cinnamon oil contents and its major components under different severity levels of upper leaf galls infestation made by *Trioza cinnamomi*

| Severity level (No. of galls) | Percent Weight of galls | Oil content (%) | Eugenol | Acetyl Eugenol | Cinnamaldehyde |
|---|---|---|---|---|---|
| 1(no) | 00.00 $^{e}$ | 1.05 $^{a}$ | 85.44 $^{cb}$ | 5.47 $^{c}$ | 1.88 $^{c}$ |
| 2 (< 50) | 25.62 $^{d}$ | 0.94 $^{b}$ | 86.80 $^{ab}$ | 4.91 $^{c}$ | 2.09 $^{bc}$ |
| 3 (51 – 100) | 51.43 $^{c}$ | 0.68 $^{c}$ | 84.29 $^{c}$ | 7.61 $^{a}$ | 2.04 $^{bc}$ |
| 4 (101 – 150) | 74.41 $^{b}$ | 0.49 $^{d}$ | 87.23 $^{a}$ | 7.75 $^{a}$ | 2.72 $^{ab}$ |
| 5 (> 151) | 97.26 $^{a}$ | 0.27 $^{e}$ | 82.34 $^{d}$ | 6.31 $^{b}$ | 3.48 $^{a}$ |
| P value | 0.0001 | 0.0001 | 0.0007 | 0.0001 | 0.006 |
| CV | 3.038 | 10.103 | 1.14 | 7.11 | 17.69 |
| LSD (α=0.05) | 1.99 | 0.09 | 1.77 | 0.83 | 0.79 |

Mean values in each column followed by the same letters are not significantly different (p>0.05)

While there was a significant reduction of eugenol content in cinnamon leaf oil, upper leaf gall infestation significantly increased an acetyl eugenol and cinnamaldehyde contents which are minor components in cinnamon leaf oil (Table 1). Significant reduction of eugenol content and

increment of cinnamadehyde content were observed when intensity of lower leaf gall infestation was increased (Table 2).

Table 2: Changes of cinnamon oil contents and its major components under different severity levels of upper leaf galls infestation made by *Eriophyes boisi*

| Severity level (No of galls) | Percent weight of galls | Oil content (%) | Eugenol | Acetyl eugenol | Cinnamaldehyde |
|---|---|---|---|---|---|
| 1(no) | 00.00$^{e}$ | 1.09$^{a}$ | 87.4867$^{a}$ | 3.627 $^{c}$ | 1.068$^{b}$ |
| 2(<15) | 22.70$^{d}$ | 0.92$^{b}$ | 83.2140$^{b}$ | 9.482 $^{ab}$ | 1.950$^{ab}$ |
| 3(16-30) | 43.49$^{c}$ | 0.38$^{c}$ | 78.7500$^{c}$ | 12.230 $^{a}$ | 2.495$^{ab}$ |
| 4(31-45) | 62.93$^{b}$ | 0.25$^{d}$ | 76.3150$^{d}$ | 8.436 $^{b}$ | 4.717$^{a}$ |
| 5(46<) | 99.60$^{a}$ | 0.03$^{e}$ | 73.5320$^{e}$ | 6.770$^{bc}$ | 4.640$^{a}$ |
| P value | 0.0001 | 0.0001 | 0.0001 | 0.0087 | 0.0775 |
| CV | 9.114 | 13.160 | 0.94 | 22.492 | 53.59093 |
| LSD($\alpha$=0.05) | 5.59 | 0.09 | 1.411 | 3.434 | 2.3244 |

Mean values in each column followed by the same letters are not significantly different (p>0.05)

This is clear evidence that leaf gall infestation may change the chemical physiology of leaf oil in addition to leaf oil content. It may be happened due to disturbance or blocking shikimic acid pathway in some extent at a point before producing eugenol in the leaf, so it is yet to be investigated detail in future.

## Conclusions

Both leaf gall infestations have an ability to change the leaf oil content and quality significantly in cinnamon and there was a strong negative significant relationship with intensity of infestation and cinnamon leaf oil content. In term of oil quality, there was a negative correlation between intensity of gall infestation and eugenol content, but positive correlation with cinnamaldehyde contents and acetyl eugenol as well.

## Acknowledgement

Laboratory facilities provided by the National Cinnamon Research and Training Center, Matara are acknowledged.

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# Development of low Glycemic Index bread using a composite flour mixture

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## Introduction

Composite flour technology is initially referred to process of mixing wheat flour with cereal and legume flour for making bread and biscuits. However, the term can also be used with regard to mixing of non-wheat flours, roots and tubers or other raw materials (Singh and Raguvanshi, 2011).Bread is a product obtained by baking yeast leavened dough prepared from wheat flour and with or without the addition of ingredients and permitted additives (SLS 141: 1992). The Glycemic Index (GI) of a food refers to the effect the food has on the body's blood sugar levels. Modern day people seek to avoid wheat flour bread, due to health risk. There is growing interest about nutrients content in bread using composite flour technology. Therefore, this research was carried out to develop low Glycemic Index bread as a solution for various health effects occurred due to the consumption of wheat bread.

## Methodology

The current study was carried out at Food Research Unit, Gannoruwa. Six experimental trials with different treatments were conducted during this study. Finally three treatments were prepared and evaluated on sensory and microbial analysis. 10%, 12% and 14% finger millet incorporated, treatments were used for sensory evaluation. The sensory evaluation was done using 15 semi trained panelists. In chemical analysis, proximate composition was determined for moisture content, fat, crude protein, ash, fiber, total carbohydrate and calcium. Specific volume was measured in selected three bread dough and bread samples using Modified Rapeseed Displacement Method. Texture was measured using a penetrometer for selected bread sample from sensory evaluation. Microbiological analysis was done for Escherichia coli, Total Plate Count (TPC), yeast and mould. Self-life determination was done by stored normal temperature with polythene wrap and without polythene wrap. Glycemic Index was measured using ten healthy volunteers in Food Research unit

## Result and Discussion

According to the sensory evaluation, the 12% finger millet incorporated bread was selected as best bread sample by giving good texture, taste, aroma and colour.

According to the figure 01, just after baked mean pressure become 0.83 kg. Then texture was soft. The pressure gradually increased with the time. With the time texture become harder than just after baked. After two hours mean pressure was 16.67 kg. Texture is mainly governed by gluten percentage. High gluten content gives soft texture due to gluten network. In this bread,

Finger millet flour was used. Due to it fibrous content it affects for the texture and it gives more hard texture with the time. High pressure show poor texture.

Figure 01: Mean Pressure Change with the Time

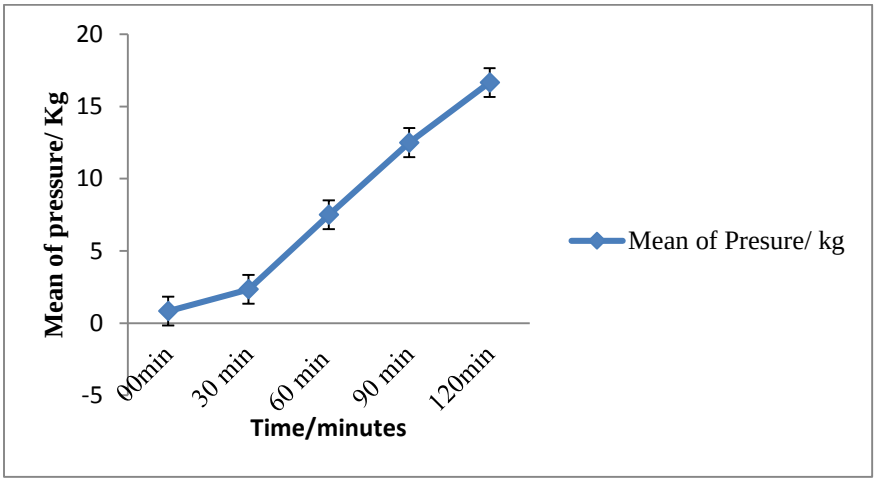


Table 01: Specific Volume of Bread Dough

| Finger millet % | Specific volume Time/ $kg^{-1}m^3$ | | |
|---|---|---|---|
| | 00 min | 30min | 60min |
| 14% | 670±104.4 | 790±61.10 | 1430±137.4 |
| 12% | 810±55.07 | 900±61.3 | 1600±290.91 |
| 10% | 820±41.6 | 1100±110.5 | 1950±60 |

Mean ± SD determination in triplicate

According to the Table 02 and table 03, specific volumes of bread dough and bread sample were decreasing when increasing finger millet flour percentage. Initially the highest specific volume obtained by 10 % finger millet flour incorporated bread dough and bread. Lowest specific volume obtained from 14% Finger Millet incorporated bread dough and bread.When increasing Finger Millet flour percentage, the percentage of wheat flour was decreased. Due to that ability of stretch of the dough was restricted. Reason is decrease of gluten and week gluten structure.

Table 03: Specific Volume of Bread

| Finger millet % | Specific volume Time/ $kg^{-1}m^3$ |
|---|---|
| 14% | 2150± 51.96 |
| 12% | 2280± 172.14 |
| 10% | 2530± 326.54 |

Mean ± SD determination in triplicate

According to the table 04, Due to soy flour selected bread was containing high protein than wheat bread. Therefore this bread is suitable for vegetarian as a protein supplement. When considering fat content and total carbohydrate content lower than wheat bread. High fiber

content good for the diabetic patients because it helps for low digestibility. This bread contain high amount of calcium. Thus this bread formula gives good supplement of calcium. Finger millet flour content is the main reason for this high calcium percentage.

Table 04: Proximate Analysis

| Proximate Composition | Selected bread sample | Wheat bread* |
|---|---|---|
| Moisture % | 31.2 | 40 |
| Ash% | 3.5 | 0.1 |
| Crude Protein% | 20.3 | 10.49 |
| Ether Extract ( Fat)% | 8.6 | 11.8 |
| Crude Fiber % | 2.9 | 0.25 |
| Calcium g/kg | 2.7 | 0.13 |
| Total Carbohydrate% | 33.5 | 73.5 |

*****Source: SLS 141: 1992 and Tiimub, 2013

TPC in the samples and presence of yeast and mould in samples complied with the requirement of Sri Lankan Standard (SLS). Zero *E.coli*shows the safe of consumer.There was no detectable moulds growth on breads, Wrapped using 150 gage polythene, during the first 48 hours from baking. There was detectable microbial growth under normal room temperature after 48 hours of baking.GI for the prepared bread sample was 57. Then this bread is included in Moderate Glycemic Index food. Moderate Glycemic Index foods are good for the diabetic patients. Therefore, prepared bread is good for diabetic patients.

**Conclusions**

Prepared bread has best nutritional profile and it is safe and helps to protect healthiness of consumers with good sensory properties. This bread can be used as balance diet for children and adults.According to the Glycemic Index value prepared bread is good for healthy consumers as well as diabetic patients.

**Acknowledgement**

Laboratory facilities provided by the Food Research Unit, Gannoruwa,are acknowledged.

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Tiimub, B.M., 2013Proximate analyses of three brands of bread under different storage conditions available on the Ghanaian market.*Food Science and Quality Management***[**Online] Available at http://www.iiste.org.

# Development of a protocol for *in-vitro* propagation of black pepper (*Piper nigrum* L.) local selections

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## Introduction

Black pepper (Piper nigrum L.) belongs to family Piperaceae and it is one of the most economically important spice crops in the world (Srinivasan, 2007; Mathew et al., 2001). Unavailability of sufficient mother plant stock in the field, obtaining basal runners for propagation and less success and multiplication rate of the high yielding local pepper cultivars are the major problems faced by the farmers who cultivate. Being in vitro propagation a promising option, this study was focused to develop a suitable protocol for in vitro propagation of black pepper local selections.

## Methodology

This research was carried out at Central Research Station, Department of Export Agriculture, Matale. Four experiments were conducted during the research period. Experiment one was conducted to find out the suitable surface sterilization method for the sterilization of black pepper shoot tips. Selecting of appropriate media for the culture establishment of black pepper shoot tips were carried out in second experiment using 1/3Murashige and Skoog (MS) medium and 1/2 Woody Plant Medium (WPM).Experiment three was conducted to find out suitable combination of auxin and cytokinin for the shoot multiplication of black pepper local selections. In fourth experiment, priority was given for the selection of best media and hormonal combination for the callus initiation of TG7 black pepper local selection. Full and half strength MS media were used as the culture media and two different concentration levels of kinetin and NAA were used as the growth regulators. Complete Randomized Design (CRD) was used as the experimental design. ANOVA was used to analyze the statistical difference of parametric data and non-parametric data were subjected for logarithmic transformation. SAS statistical software was used to analyze the data and mean separation was performed using Least Significant Difference (LSD).

## Results and Discussion

As the results summarized in Table 1, sterilization using 10%- 20% Clorox for five to ten minutes (T1 to T5) showed higher percentages of bacterial contamination (40 to 80 %). Lower percentages of fungal contamination was observed in T4 to T8 within the period of three to five days (3% to 7%).The highest survival percentage (66.6 %) was reported in T8, 0.04 % HgCl2 for five minutes. Similarly, the lowest percentages of bacterial and fungal contamination were observed in T8. The highest percentage of phenolic browning (80%) was shown in T6 and lowest percentage of phenolic browning (10.0%) was observed in T2, i.e. 10% Clorox for 10 minutes within four to seven days.

Table 2 : Percentages of survival, bacterial and fungal contamination and phenolic browning at different surface sterilization methods

| Treatment | Survival % | Bacterial % | Fungal % | Browning % |
|---|---|---|---|---|
| T1- 10% Clorox for 5 minutes | 15.0 | 50.0 | 20.0 | 15.0 |
| T2- 10% Clorox for 10 minutes | 0 | 80.0 | 10.0 | 10.0 |
| T3- 15% Clorox for 5 minutes | 15.0 | 40.0 | 15.0 | 30.0 |
| T4- 15% Clorox for 10 minutes | 35.0 | 40.0 | 5.0 | 30.0 |
| T5- 20% Clorox for 5 minutes | 10.0 | 50.0 | 5.0 | 35.0 |
| T6- 20% Clorox for 10 minutes | 15.0 | 0 | 5.0 | 80.0 |
| T7- 0.1% $HgCl_2$ for 1 minute | 38.5 | 26.9 | 7.6 | 26.9 |
| T8- 0.04% $HgCl_2$ for 5 minutes | 66.6 | 18.18 | 3.01 | 12.12 |

In experiment two, there was a significant difference between two media (1/3 Murashige and Skoogmedium and 1/2 Woody Plant Medium) for the shoot development of black pepper local selections. As shown in table 2, 1/2 Woody Plant Medium showed the highest mean survival (0.4892) three weeks after culturing.

Table 3: Mean survival rate of Black Pepper shoot tips in 1/3Murashige and Skoog (MS) medium and 1/2 Woody Plant Medium (WPM)

| Medium | Mean of Survival |
|---|---|
| 1/3 MS | $0.16250^{b}$ |
| 1/2 WPM | $0.48920^{a}$ |
| LSD | 0.0782 |

Means with same letters along the columns are not significantly different at probability level of 0.05

Table 4: Mean number of shoots, number of leaves and shoot length of shoot tip cultures affected by various growth hormones

| Treatment | | | Mean shoot number | Mean leaves number | Mean shoot length |
|---|---|---|---|---|---|
| BA(mg/L) | NAA(mg/L) | Kinetin(mg/L) | | | |
| T1-3.0 | 0 | 0 | $2.0^{a}$ | $4.4^{a}$ | $0.1^{c}$ |
| T2-3.0 | 0.5 | 0.1 | $1.4^{c}$ | $4.5^{a}$ | $0.1^{c}$ |
| T3-3.0 | 0.5 | 0.2 | $1.5^{bc}$ | $3.9^{a}$ | $0.1^{c}$ |
| T4-3.0 | 1.0 | 0.1 | $2.3^{a}$ | $4.6^{a}$ | $0.3^{b}$ |
| T5-3.0 | 1.0 | 0.2 | $1.9^{ab}$ | $4.4^{a}$ | $0.4^{a}$ |
| | LSD | | 0.434 | 0.8446 | 0.125 |

Means with same letters are not significantly different at probability level of 0.05

According to the Table 3, higher number of shoots were observed in T4, followed by T1and T5.Higest number of leaves were observed in T4.There was a significant difference in shoot length between treatments. The highest shoot length was observed in T5. With considering number of shoots and shoot length, Woody Plant Medium with 3 mg/L BA, 1.0 mg/L NAA and 0.2 mg/L Kinetin was the best hormonal combination for shoot multiplication of black pepper local selections(T5).

As the table 4 shows, there was no significant difference between two media (Full strength MS and half strength MS) for the callus formation.

Table 5. The status of callus formation on full and half strength MS media

| Media | Mean Callus formation |
|---|---|
| Full strength MS medium | 0.54 [a] |
| Half strength MS medium | 0.49 [a] |
| LSD | 0.07 |
| CV% | 18.7 |

Means with same letters are not significantly different at probability level of 0.05

As Table 5 indicates, there was a significant difference between the T2, T4 and T5 for the callus formation. The highest callus development (0.74 score) was observed in T4.

Table 6.Callus development in different kinetin and NAA level fourweeks after culture

| Treatment No | Treatment | | Mean score | Color |
|---|---|---|---|---|
| | NAA (mg/L) | Kinetin (mg/L) | | |
| T1 | 0.5 | 1.0 | 0.69 [ab] | Whitish brown |
| T2 | 0.5 | 1.5 | 0.55 [c] | Whitish brown |
| T3 | 1.0 | 1.0 | 0.59[bc] | White |
| T4 | 1.0 | 1.5 | 0.74 [a] | White |
| T5 | 0 | 0 | 0.0 [d] | No |
| LSD | | | 0.11 | |
| CV% | | | 18.71 | |

Within the column means with same letters are not significant at probability level of 0.05

**Conclusions**

In development of a protocol for *in vitro* propagation of black pepper (*Piper nigrum* L.) local selections, following methods for surface sterilization, culture establishment, shoot multiplication and callus induction are established.The best surface sterilization method for the shoot tips of black pepper local selections is 0.04 % Mercuric Chloride for five minutes. Half of WPM supplemented with 3.0 mg/L of BA and 1.0 mg/L of kinetin is the best media for the culture establishment using shoot tips of black pepper local selections. The best hormonal combination for the shoot multiplication of black pepper local selections is WPM with 3.0 mg/L of BA, 1.0 mg/Lof NAA and 0.2 mg/L of Kinetin. Either full or half strength MS medium supplemented with 1mg/L of NAA and 1.5 mg/L of Kinetin is better to use for callus induction from leaves of black pepper local selections.

**Acknowledgement**

Laboratory facilities provided by the Central Research Station, Mataleare acknowledged.

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Srinivasan, K. (2007). Black pepper and its pungent principle-piperine: A review of diverse physiological effects Critical Rev. Food Nut. 47: 735-748.

# Analysis of technical efficiency of pepper growers in Kandy district

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## Introduction

Pepper is the second most important perennial spice crop, next to Cinnamon, in Sri Lankan economy, and the most important perennial spice for domestic consumption. The pepper growers have faced severe problems during the last decades. Some of these problems are prolonged fall in the production and productivity of pepper. Agricultural productivity refers to the output produced by a given level of input(s) in the agricultural sector of a given economy (Fulginiti and Perrin 1998). Technical efficiency reflects the ability of producers to maximize output for a given set of resource inputs (Chirwa 2003).The Department of Export Agriculture in Sri Lanka with the mandate of perennial spices launched several programmes to develop this sector, including subsidy schemes for new planting, replanting and infilling, fertilizer subsidy schemes and extension services. Despite such efforts, the performances of spice based agro-forestry systems are not **satisfactory**. The average yield of pepper is 350-500 kg per hectare, but target yield is 1000 kg per hectare (Department of Export Agriculture in Sri Lanka 2002). Farmers have less information on efficiency. In order to realize increased production and efficiency, farmers in Sri Lanka need to efficiently utilize the limited resources accessed for farm income generation. This research determined efficiency levels of pepper farmers and identified socio economic factors affecting efficiency levels.

## Methodology

The study was conducted in Kandy District in 2014. Kandy district comprises with 6,982.8 ha of cultivated land of pepper. The total sample size was hundred (100) respondents from six selected extension office ranges. Multi Stage sampling technique was used. Primary sample data was collected from farmers using a survey method involving a structured questionnaire which was administered to the selected pepper producing farmers in Kandy District. The analysis of Cobb-Douglas frontier production function was tested by ordinary least square (OLS) and maximum likelihood estimation (MLE). STATA version 11 was used for the summary statistics and estimate coefficient of stochastic frontier and measure technical efficiencies.

## General model and variables

In the model specification,

$$Y_{it} = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + v_i - u_i$$

Table 1: Production Function Variables

| Variable | Parameter | Remarks |
|---|---|---|
| Yield of pepper | $Y_{it}$ | Kilograms ( kg) |
| Land extent | $x_1$ | Acre |
| Family labour | $x_2$ | Man days |
| Hired labour cost | $x_3$ | Rupees (Rs:) |
| Fertilier utilization | $x_4$ | Kilo grams (kg) |
| Dolomite utilization | $x_5$ | Kilo grams (kg) |
| Number of pruning | $x_6$ | Number |
| Weedicide cost | $x_7$ | Rupees (Rs:) |
| Number of manual weeding | $x_8$ | Number |

Technical Inefficiency Function

In the model specification,

$$U_I = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 + \delta_{10} Z_{10} + \varepsilon_i$$

Table 2: Technical Inefficiency Function Variables

| Variable | Parameter | Remarks |
|---|---|---|
| Age of farmer | $Z_1$ | Years |
| Gender | $Z_2$ | If Male= 1,Otherwise = 0 |
| Field visits by Extension officer | $Z_3$ | Number |
| Subsidy received | $Z_4$ | If Received= 1, Otherwise=0 |
| Experience in pepper cultivation | $Z_5$ | Years |
| Plantation Age | $Z_6$ | Years |
| Education | $Z_7$ | Primary = 1 Below O/L =2 A/L= 3 Degree or Diploma= 4 |
| Number of trainings attended | $Z_8$ | Number |
| Occupation dummy 1( Informal) | $Z_9$ | If Informal occupation= 1 ,Otherwise =0 |
| Occupation dummy 2 (Formal) | $Z_{10}$ | If Formal occupation=1, Otherwise =0 |

**Results and Discussion**

Table 3: Ordinary Least Square and Maximum Likelihood Estimates for the parameters of stochastic frontier

| Variable | Co Efficient | | Standard Error | | P value | |
|---|---|---|---|---|---|---|
| | OLS | MLE | OLS | MLE | OLS | MLE |
| Land Extent | 0.8255534*** | 0.7491909*** | 0.1183377 | 0.104854 | 0.000 | 0.000 |
| Family Labour | -0.1266223** | -0.1302913** | 0.0546958 | 0.0528619 | 0.023 | 0.015 |
| Hired Labour Cost | 0.0671582* | 0.0904791*** | 0.0361036 | 0.0298858 | 0.066 | 0.002 |
| Dolomite application | 0.0819011*8 | 0.0429783 | 0.041237 | 0.0357624 | 0.050 | 0.229 |
| Fertilizer applicaation | 0.0370185 | 0.0313447 | 0.0407722 | 0.0348231 | 0.366 | 0.372 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Manual Weeding | -0.5796257** | | 0.2835348 | 0.2515604 | 0.044 | 0.026 |
| | -0.5664492** | | | | | |
| Pruning | -0.0071533 | 0.0667656 | 0.3607513 | 0.3085742 | 0.984 | 0.830 |
| Weedicide Cost | -0.1587041*** | | 0.0579177 | 0.0458077 | 0.007 | 0.000 |
| | -0.1759709*** | | | | | |
| Constant | 5.425643 | 5.741027 | 0.4920459 | | 0.000 | 0.000 |
| $\gamma$ | 0.740005 | | | | | |
| $\sigma^2$ | 1.493149 | | | | | |

** Significant at 10 % ** Significant at 5 % and *** Significant at 1 %*

Estimates were done by using both OLS and MLE. According to the frontier output, land extent, family labour and hired labour were significant. As extent of Pepper land was increased by one percent, yield of Pepper was also increased by 0.82 percent on average when other variables remained constant.

The coefficient of hired labour cost was significant and had a positive sign for pepper farmers, indicating that pepper production is labor intensive, especially at weeding and harvesting stages. This implies that optimal use of labor will lead to increased output. Adebayo (2006) and Ogundele and Okoruwa (2006) inferred that hired labor contributed positively to farm productivity.

Table 4: Technical Efficiency Ranges of the Farmers

| Technical Efficiency range | Farmer TE percentage of the sample |
|---|---|
| 0-10 | 1 |
| 10-20 | 2 |
| 20-30 | 2 |
| 30-40 | 5 |
| 40-50 | 7 |
| 50-60 | 10 |
| 60-70 | 7 |
| 70-80 | 15 |
| 80-90 | 21 |
| 90-100 | 30 |

Table 5: Statistics of Technical Efficiency

| Technical Efficiency | Mean | Std.Deviation | Minimum | Maximum |
|---|---|---|---|---|
| | 73.64 | 21.80 | 7.74 | 99.29 |

Table 6: Determinants of Technical Inefficiency

| Variable | Co efficient | Standard error | z | P>\|z\| |
|---|---|---|---|---|
| Age | 0.206257 ** | 0.0945559 | 2.18 | 0.029 |
| Gender | -0.8659193 | 0.9426061 | -0.92 | 0.358 |
| Field visit | -0.9265452 | 0.7164361 | -1.29 | 0.196 |
| Subsidy | 2.198565 | 1.905281 | 1.15 | 0.249 |
| Experience | -0.0546185 | 0.0448456 | -1.22 | 0.223 |
| Plantation age | -0.0269816 | 0.0508191 | -0.53 | 0.595 |
| Education | 0.1609216 | 0.6826663 | 0.24 | 0.814 |
| Training | -0.3276421 | 0.2541289 | -1.29 | 0.197 |
| dumy1 | 0.8216772 | 1.33086 | 0.62 | 0.537 |
| dumy2 | 0.7006096 | 1.68 | 0.42 | 0.677 |
| _cons | -11.54224 | 6.443964 | -1.79 | 0.073 |

** Significant at 10 % ** Significant at 5 % and *** Significant at 1 %*

Analysis of the inefficiency model contained in above Table 3 pepper production shows the signs and significance of the estimated parameter coefficients in the inefficiency model have important implications on the technical efficiency of pepper producers in the study area. Coefficients of age were positive for the pepper farmers. The coefficient of age was significant and gender was not significant for farmers. These coefficients imply that relatively older in age experience lower technical efficiency.

**Conclusion**

The research assessed technical efficiency of pepper production in Kandy District and determined the socio-economic factors affecting the pepper production. The research revealed mean value of the technical efficiency of the farmers in Kandy District was 73.64. The findings in this study showed that pepper farms were efficient where the mean of technical efficiency of pepper farms were high. The technical efficiency was ranged from 7.74 to 99.29 per cent. Majority of the farmers have technical efficiency between 90-100 per cent. There was a vast difference between technical efficiency levels of farmers even if they used the same level of inputs.

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# Feasibility study for direct planting of *in vitro* potato (*Solanum tuberosum* L.) varieties Granola and Golden Star in aeroponic system

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## Introduction

The major constraints in potato cultivation are high seed cost, poor seed quality, unavailability of quality seeds at correct time for planting, frequent application of fungicides to control late blight disease, misappropriation of agrochemicals and limitation of suitable land. The total seed potato requirement in Sri Lanka is about 22,500mt per annum. Total annual importation of seed potato is about 7000mt and the Department of Agriculture produces about 400mt of high generation seed potato per annum. The rest of the seed potato requirement of about 60% is fulfilled by farmers own seed production. Seed potatoes are the most costly input having 53% of the total cost of production.Main objective is to study the feasibility of direct planting of Granola and Golden star in vitro plants in aeroponic system. Other objective is to identify the suitable liquid media for hardening of in vitro potato plants.

## Materials and method

The planting materials which were used in research are In vitro potato plants, MS media, Albert solution and aeroponic system. First culture media was prepared for in vitro potato plants. Stock solution was measured to prepare MS medium. Then 0.1g of myo-inositol, 30g of sugar, 1g of charcoal and 9g of agar were measured and mixed well. Solution was diluted up to the 1l. pH was measured and adjusted up to 5.75. Culture bottles were filled by solution up to 30ml. Bottles were allowed for settle.*In vitro* plants were cut with node and cuttings were placed in culture bottles. Then bottles were labeled and placed in the culture room. Cultured bottles were kept for one month period.

Half MS, full MS and Albert solution were prepared. pH was measured in MS solutions and adjusted to 5.75. Electrical conductivity was adjusted up to 1.7 in Albert solution. Six treatments were taken. (Golden star in 1/2 MS medium as treatment 1, golden star in MS medium as treatment 2, golden star in Albert solution as treatment 3, granola in 1/2 MS medium as treatment 4, granola in MS medium as treatment 5, granola in Albert solution as treatment 6) Data were collected at one week intervals. Mean shoot length, mean root length and mean number of roots were taken as the parameters. (In this research increment of growth was measured for each parameters)

Albert solution was prepared for 250l of tank (EC-1.643 ms/cm). Electrical conductivity was adjusted up to the range of 1.5 to 2.0 ms/cm. Acclimatized plants were dipped in Thiram (2g/l). Then plants were placed in aeroponic system. Aeroponic system was adjusted to spray five second with once in five minutes at day time and once in fifteen minutes at night in first three

days. Next four days system was adjusted once in ten minutes at day time and once in twenty minutes at night. After that system was adjusted once in twenty minute at day time and once in thirty minutes at night. EC was checked every day. Data were collected at weekly for seven weeks. Mean shoot length, mean root length, mean stolen length, mean number of stolen and mean number of tubers were taken as the parameters. (In this research increment of growth was measured for each parameters)

**Results and Discussion**

In both experiments collected data were analyzed by using minitab 16 under general linear model. According to the Table 1, the highest shoot length growth (3.13cm) was observed in variety Golden star with Albert solution (T3). Others are statistically different, but T6, T1 and T3 are comparable. Though T2, T4 and T5 are comparable but significantly lower than T3. When comparing mean length of root growth, there is no significant different in each treatment. Number of root increment are statistically significant each other. Therefore using of any treatment is not largely effect on root number or root length.

Table 7 : Mean comparison of each responses in each treatment in 1st week in acclimatize period.

| Treatment | Mean Shoot length (cm) | Mean Root length (cm) | Mean Num. of Root |
|---|---|---|---|
| T1 | $2.50^{ab}$ | $0.23^{a}$ | $0.30^{a}$ |
| T2 | $1.45^{b}$ | $0.15^{a}$ | $0.00^{a}$ |
| T3 | $3.13^{a}$ | $0.18^{a}$ | $0.40^{a}$ |
| T4 | $1.26^{b}$ | $0.50^{a}$ | $0.00^{a}$ |
| T5 | $1.52^{b}$ | $0.17^{a}$ | $0.00^{a}$ |
| T6 | $2.05^{ab}$ | $0.32^{a}$ | $0.30^{a}$ |

* Means that do not share a letter are significantly different.

According to the Table 2, the highest shoot length growth (6.58 cm) was observed variety Golden star with Albert medium (T3). Second higher value observed in T1, T2 and T6. When comparing mean of the root growth, the highest root growth increment (0.49cm) having variety Golden star with Albert medium (T3) and T6 (Granola*Albert) also having the second highest root length. According to the analyze root number increment are not statistically significant. Therefore use of any treatment has not largely effected on root number.

Table 8 : Mean comparison of each responses in each treatment in 2nd week in acclimatize period

| Treatment | Mean Shoot length (cm) | Mean Root length (cm) | Mean Num. of Root |
|---|---|---|---|
| T1 | $3.09^{b}$ | $0.23^{bc}$ | $0.60^{a}$ |
| T2 | $2.22^{b}$ | $0.26^{abc}$ | $0.00^{a}$ |
| T3 | $6.58^{a}$ | $0.49^{a}$ | $0.80^{a}$ |
| T4 | $0.67^{c}$ | $0.13^{c}$ | $0.00^{a}$ |
| T5 | $0.87^{c}$ | $0.08^{c}$ | $0.10^{a}$ |
| T6 | $3.17^{b}$ | $0.37^{ab}$ | $0.70^{a}$ |

* Means that do not share a letter are significantly different.

According to the Table 3 the highest values of mean length of shoot growth were recorded in T1, T2 and T3. When considering mean length of root growth T1 and T2 recorded the highest values and T3 was recorded the second highest value. According to the mean length of stolen growth, there is no significant difference between T1, T2 and T3. When considering mean number of stolen growth, there is no significant difference between T1 and T2. According to the treatment combination T1, T2 and T3 were having highest number of stolen growth. Therefore Golden star performed well as a variety in terms of mean length of shoot growth, mean length of root growth, mean length of stolen growth and mean number of stolen growth. When considering the mean number of tubers growth T4, T5 and T6 were performed well.

Table 9: Mean of stolen number, stolen length and number of tuber according to initial treatments in aeroponic system

| Treatment | Mean shoot length (cm) | Mean root length (cm) | Mean stolen length (cm) | Mean number of stolen | Mean number of tubers |
|---|---|---|---|---|---|
| T1 | $40.11^{a}$ | $67.21^{a}$ | $33.23^{a}$ | $10.80^{a}$ | $0.00^{b}$ |
| T2 | $35.40^{a}$ | $65.91^{a}$ | $33.43^{a}$ | $11.00^{a}$ | $0.00^{b}$ |
| T3 | $35.91^{a}$ | $51.25^{b}$ | $36.06^{a}$ | $8.90^{ab}$ | $0.00^{b}$ |
| T4 | $8.13^{b}$ | $34.11^{c}$ | $23.09^{b}$ | $3.40^{c}$ | $15.50^{a}$ |
| T5 | $6.95^{b}$ | $36.67^{c}$ | $23.36^{b}$ | $3.00^{c}$ | $15.50^{a}$ |
| T6 | $8.25^{b}$ | $26.97^{c}$ | $24.18^{b}$ | $6.00^{bc}$ | $14.10^{a}$ |

* Means that do not share a letter are significantly different.

**Conclusion**

Albert solution is the best medium which gives the best result with each varieties. Though there is a similarity with the medium one (1/2 MS medium) and the Albert solution it can be avoided with the comparison to the cost. When considering the experiment two though there is a higher vegetative growth with the variety Golden star, variety Granola is performed well with in lower time period. In this research, Tuber initiation of the plants should be in low time period to fulfill the research problem (Increase the production of seed potato production).

Another thing is to reduce the cost for the production of seed potato. Normally seed potato production method get more than six month of period. In this research it is reduced up to below one month of period. Because of that cost for the crop management can be reduced.Moreover that using in vitro plant give the identical seed potato to have next generation with the best yield via quality and quantity.

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# Labour migration and paddy production; a comparative analysis

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## Introduction

Migration can be identified as the flow or movement of people from the place of origin to the other surrounding, whether inside or outside the country with various reasons. Migration plays a major role in the economic development of Sri Lanka. In recent years, the outflow of Sri Lankan workers has shown an increasing trend. Sri Lanka is predominantly an agricultural country and paddy sector receives the highest priority in development agenda in Sri Lanka, as rice is the staple food in the country. At present Sri Lankan paddy sector suffers from many constraints such as scarcity of arable land, high cost of inputs and scarcity of labour (Ranathunga, 2011). Scarcity of labour for paddy production occurs mainly due to labour migration (Paris.et.al, 2009). In many studies, researchers find out the various impacts of migration. But it is very fewer Sri Lankan studies on examine the impact of labour migration on paddy production. In this context the objectives of the study were (i) to find out the impact of labour migration on paddy production and (ii) to estimate the production function of paddy in relation to the labour migration.

## Methodology

Research was carried out Galaha, Thalathuoya and MarassanaGovijanaseva divisions under the Pathahewahata Divisional Secretariat division in Kandy District. Multi stage sampling technique was used to select 150 paddy farm families from selected area. Multi stage sample was surveyed based on a semi structured pre-tested questionnaire to gather necessary information. Both descriptive and inferential statistics were used to analysis the data. Descriptive statistical methods were used to describe the characteristics of the sample such as demographic information about paddy farmers and migrants, production details in paddy and labour usage in paddy cultivation. Cobb-Douglas Production function was used for econometrics analysis.(Nonthakot and Villano, 2008).

Empirical model : $\ln Y = \beta 0 + \beta i \ln (X i) + \varepsilon i$

The Y is the yearly output from paddy production in kilograms. Xi denotes the vector of independent variables such as family labour input, land extend, yearly fixed capital, fertilizer inputs, seed quantity, land quality and household type. In paddy production labour is used under three categories, family labour, hired labour and exchange labour. Among those categories family labour was used for the empirical model. Labour input was measured in man days. Variable of land extend was measured by acre. Yearly fixed capital gives the real value of all machinery, equipment, and value of land in rupees. Variable of fertilizer input shows the amount of fertilizer usage per year in kilograms. Variable of the seed quantity shows the quantity of seed paddy used for cultivation in kilograms. Land quality is a dummy variable distinguishing whether it is irrigated land or not. Household type is a dummy variable indicating the household with at least one out migrant. The references group is the household without any out migrant.$\varepsilon i$ is the stochastic disturbance term.

## Results and Discussion

According to descriptive statistics, nearly 78% in the sample was male and the rest 22% were female. Most of farmers in the sample were older than 40 years. 58% farmers of the sample were

educated up to ordinary level. Most of farmers in this area had a higher level of experience. 39% of farmers had more than 30 year experience. 40% of farmers had10 to 30 years experience. Farmers in this area had a diversified income sourcing, income from paddy cultivation, vegetable and other crops cultivation, animal husbandry, from private sector and government sector occupation and specially from the remittances. Most of farmers get 100000 to 600000 rupees income per year. In that income category 58.06% were migrant household and 41.94% were non-migrant household.

Most of farmers in the area engage in small scale paddy cultivation. Most of them (48%) cultivate less than an acre. Only 1.32% farmers cultivate more than 3 acre. The area gets 1500kg/acre average productivity. To cultivate 1 acre of land area need 70 man days, on average. 55% from the total sample were migrant household and 45% were non-migrant household. Among the migrants 74% were male and 26% were female. Most of migrants were very young people (<30 years). There were 121 migrants in the sample. Among them 81% were send in remittances to their household.In econometric analysis, first present the findings on the determinants of paddy production of the total sample.Labour input played a positive role in paddy production with elasticity being around 6.77 for households.Fertilizer was significant with a positive relationship. 1% increase of fertilizer caused to increase yield by 0.37%.Quantity of seed paddy was significant with-1.62 elasticity. Land quality is significant with -0.02elasticity.

Table 1: Results of the OLS Estimation in Household of the Total Sample

| Variable | OLS |
|---|---|
| Intercept | -5.34*** |
| Labour | 6.77*** |
| Land | 0.03 |
| Capital | -0.002 |
| Fertilizer | 0.37*** |
| Seed Quantity | -1.62*** |
| Land quality | -0.02* |
| Household Type | -0.005 |
| $R^2$ (%) | 99.81 |
| N | 150 |

*, **, *** Significant at 10, 5 and 1 percent probability level, respectively
Source - Sample survey, 2014

In second, present the major findings on the determinants of paddy production of the two type of households: Non migrant household (column 1) and migrant household (column 2) in Table 2. The impact of labour input on paddy yield varied across two type of households, with 1% of labour input yielding 6.72 % increase in paddy output in non-migrant household and 6.9 % yield increase in migrant household. Fertilizers also had positive relationship with both households. The elasticity of fertilizer was 0.29 in non-migrant household and 0.42 in migrant household.

Seed quantity was significant in both household but with a negative relationship. 1% increment of seed quantity caused to 1.31% of yield reduction in non-migrant household and 1.84% of yield reduction in migrant household. There were three seed sowing methods in this area, broadcasting, transplanting and parachute method. Among those methods, for broadcasting need higher amount of seed paddy (approximately 41.74kg/acre) but yield is comparatively lower. For seed sowing in parachute method, need comparatively very low amount of seed paddy (approximately 2.6 kg/acre) but gives higher yield than other two method. Transplanting is in between these two methods. This is the reason behind negative relationship with seed quantity and paddy yield.

Land was significant only for non-migrant household with elasticity of0.04 and non significant towards the migrant household. Most of farmers in this area were not the owners of the paddy lands and they rent lands from the owners and pay for the lands with yield. Farmers in migrant family, not going to rent land from others. They only cultivate if they had their own lands. Because of that land is not significant towards the migrant house hold. Capital was negatively significant with the migrant household and no any effect towards the non-migrant household. In migrant household though it had many more capital like machinery and equipment no one to operate it (if the earlier operator migrate from paddy cultivation), availability of the capital was a cost. Because of that reason 1% increase of capital in migrant household caused to 0.05% reduction of yield.

Land quality does not significantly affect to the paddy production of migrant or non-migrant household. Because, in this area, non-irrigated lands are rich with spring water and other lands are fulfilled their water requirement by using irrigated water. So there is no significant issue towards the paddy yield.

Table 2: Results of the OLS estimation in two type of household

| Variable | Non-migrant Household | Migrant Household |
|---|---|---|
| Intercept | -5.40*** | -5.36 *** |
| Labour | 6.72*** | 6.84 *** |
| Land | 0.04* | 0.007 |
| Capital | 0.002 | -0.005 ** |
| Fertilizer | 0.29*** | 0.42 *** |
| Seed quantity | -1.31*** | -1.84*** |
| Land quality | -0.02 | -0.01 |
| $R^2$ (%) | 99.83 | 99.81 |
| N | 68 | 82 |

*, **, *** Significant at 10, 5 and 1 percent probability level , Source - Sample survey, 2014

**Conclusions**

According to the study, There is a significant different between labour input in migrant household and non-migrant household. Corresponding yield of a unit of labour input in migrant household is higher than the non-migrant household or household in a total sample. Corresponding yield of a unit input of fertilizer also higher in migrant household than non-migrant household. Seed quantity is significant in both household and in total sample with negative relationship. Land variable shows the positive relationship only with the non-migrant household. Capital is significant only towards the migrant household with negative relationship.The land quality was not significant in both type of households.

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# Effect of nitrogen fertilization on nitrate accumulation in radish (*Raphunus sativus*) and beetroot (*Beta vulgaris*)

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## Introduction

Nitrate is one of the most frequent utilized forms of N from soil and it is the major form of nitrogen taken up by plants. Through root they reach stem and leaf where in photosynthetic processes they convert into proteins. Due to exposure to stress situations and excessive nitrogen fertilization, nitrate accumulation in plant tissues and organs occurs (Krnjaja, 2008). Excess amount of nitrate caused health hazards. Vegetables are the major source of daily intake of nitrate by human beings, supplying about 72 to 94% of the total intake. The Acceptable Daily Intake (ADI) of nitrate ion has been given 3.65 mg $kg^{-1}$ body weight (Santamaria, 2006). Higher concentration of nitrate is badly affected to environment, animals, and humans. Main objectives of this research are to investigate the effect of nitrogen fertilization on nitrate accumulation in radish and beetroot and to determine plant part where the maximum nitrate accumulations take place.

## Methodology

The current study was carried out at Horticultural Crop Research and Development Institute, Gannoruwa. Five different N levels of DOA (Department of Agriculture) recommended dosages together full recommended TSP and MOP levels were applied as treatments. No fertilizer treatment used as a control. Field trail was arranged according to Randomized Complete Block Design with three replicates. Recommended spacing used for each crop.

Table 01. Treatments

| Treatment | Fertilizer Levels |
|---|---|
| T 1 | No fertilizer |
| T 2 | 0% of urea (N) + Full recommend MOP and TSP |
| T 3 | 50% of urea (N) + Full recommend MOP and TSP |
| T 4 | 100% of urea (N) + Full recommend MOP and TSP |
| T 5 | 150% of urea (N) + Full recommend MOP and TSP |
| T 6 | 200% of urea (N) + Full recommend MOP and TSP |

Radish samples were taken two times. Beetroot samples were taken at the time of harvesting stage. Samples were thoroughly washed and there after samples were oven dried at 60 $^0$C until constant weight is reached. Dried samples were ground. By using dried samples plant nitrate accumulation levels were measured dry weight basis and fresh weight basis.Used distillation method. Data was analyzed using analysis of variance (ANOVA) using the General Linear

Model (GLM) procedure of MINITAB 17. Significant means of treatments were separated using Tukey test ($P< 0.05$).

**Result and Discussion**

Four weeks after planting nitrate accumulation level in radish fresh weight (FW) basis is given in Table 02.

Table 02. Nitrate Accumulation Level in Radish in Root Parts and Leaf Parts

| | Mean $NO_3^-$ mg/kg FW basis | |
|---|---|---|
| Treatment | Root | Leaf |
| $T_1$ ( No Fertilizer ) | $25.69^{d}$ | $233.7^{d}$ |
| $T_2$ ( 0% Urea) | $79.85^{c\,d}$ | $113.2^{e}$ |
| $T_3$ ( 50% Urea) | $135.97^{c\,d}$ | $211.1^{de}$ |
| $T_4$ (100% Urea) | $175.40^{c}$ | $419.6^{c}$ |
| $T_5$ (150% Urea) | $435.30^{b}$ | $1173.5^{a}$ |
| $T_6$ ( 200% Urea) | $589.80^{a}$ | $1005.2^{b}$ |

Values followed by the same letters are not significantly different at $p\leq0.05$

Harvesting stage nitrate accumulation level in radish fresh weight (FW) basis is given in Table 03.

Table 03. Nitrate Accumulation Level in Radish in Root parts and Leaf Parts.

| | Mean $NO_3^-$ mg/kg FW basis | |
|---|---|---|
| Treatment | Root | Leaf |
| $T_1$ ( No Fertilizer ) | $170.2^{bc}$ | $260.1^{bc}$ |
| $T_2$ ( 0% Urea) | $106.0^{c}$ | $150.8^{c}$ |
| $T_3$ ( 50% Urea) | $187.5^{bc}$ | $205.1^{bc}$ |
| $T_4$ (100% Urea) | $277.47^{b}$ | $485.4^{b}$ |
| $T_5$ (150% Urea) | $463.3^{a}$ | $1410.4^{a}$ |
| $T_6$ ( 200% Urea) | $454.1^{a}$ | $1236.0^{a}$ |

Values followed by the same letters are not significantly different at $p\leq0.05$

When increasing nitrogen fertilization significantly ($p<0.05$) increased nitrate accumulation in root part and leaf part. Higher amount of nitrate accumulation was recorded in leaf part than root part in radish and beetroot. This finding is also supported by PietroSantamaria (2006) who stated that nitrate content differs in the various parts of a plant. Indeed, the vegetable organs can be listed by decreasing nitrate content as follows, petiole > leaf > stem > root > inflorescence > tuber > bulb > fruit > seed.

Harvesting stage nitrate accumulation level in beetroot fresh weight basis is given in Table 04

Table 04. Nitrate Accumulation Level in Beetroot in Root Parts and Leaf Parts

| | Mean $NO_3^-$ mg/kg FW basis | |
|---|---|---|
| Treatment | Root | Leaf |
| $T_1$ ( No Fertilizer ) | 160.3 [a] | 387.0 [a] |
| $T_2$ ( 0% Urea) | 311.7 [a] | 389.0 [a] |
| $T_3$ ( 50% Urea) | 315.3 [a] | 490.0 [a] |
| $T_4$ (100% Urea) | 261.1 [a] | 496.0 [a] |
| $T_5$ (150% Urea) | 341.0 [a] | 462.6 [a] |
| $T_6$ ( 200% Urea) | 266.0 [a] | 439.0 [a] |

Values followed by the same letters are not significantly different at $p \leq 0.05$

There was no significant difference in nitrate accumulation in root part among the treatments ($p > 0.05$). Leaf nitrate accumulation was no significant difference with other treatments but it was comparatively higher than the root part nitrate accumulation in beetroot. Similar results reported by Maynard & Barker (1972).Which showed that petioles and stems were generally the sites of maximum nitrate accumulation in beetroot (Vityakon, 2012).

**Conclusions**

Higher rate of nitrate accumulation was occurred in leaf parts than the root parts in radish and beetroot. Higher rates of nitrogen fertilizer levels were caused to higher level of nitrate accumulation in radish and beetroot. But through the application of recommended level of fertilizer doses can obtain optimum yield with minimum nitrate accumulation.

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# Development of stirred type fruit yoghurt using wood apple (*Limonia acidissima*)

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## Introduction

Consumption of fruits and milk is important for human health as they are good sources of protein, vitamins and minerals (Alakali *et al*., 2008). Fruit yoghurts have been popular among milk products in the world. But, it is not very common in Sri Lankan market. In manufacturing fruit yoghurts, fruit is usually added to milk product in the form of fruit preparations or as fruit flavors. But, manufacturing fruit yoghurts, with natural fruit pulp or juice is very important to provide nutritional and natural balance diet. Yoghurt has nutritional benefits beyond those of milk. Lactose-intolerant individuals can sometimes tolerate yoghurt better than other dairy products, because the lactose in the milk is converted to glucose and galactose, and partially fermented to lactic acid, by the bacterial culture. When, underutilize fruits are concerned, wood apple is one of fruit which is cheap, highly nutritious, perishable and seasonally available fruit in Sri Lanka (Vidhyaasree, 2012). Therefore, this research was carried out to develop a stirred type wood apple yoghurt as a nutritional dessert as well as a balance diet.

## Materials and Methods

Current study was carried out at Food Research Unit, Department of Agriculture, in Gannoruwa, Peradeniya. Laboratory analysis was conducted at Uva Wellassa University, Food Research Unit, Veterinary Research Institute and chemical laboratory in SGS Lanka (Pvt.) Ltd. A series of preliminary trials conducted to find out the best product for further evaluations and development. First preliminary trial was carried out to preparation of main ingredients. Under that, plain yoghurt preparation, wood apple pulp preparation and sugar and fresh milk addition were undertaken. Second preliminary trial was carried out to adjust the pH value, brix value of the product and texture, mouth feel and taste of the product. The third preliminary trial was carried out to create four different recipes. Mainly four different wood apple pulp amounts (5, 7.5, 10 and 12.5%) were added to prepare four different recipes. Sensory evaluation was conducted for colour, taste, odour, mouth feel and overall acceptability using 50 semi-trained panelists. In physicochemical analysis, pH, titratable acidity, total soluble solids, total fat, solid non fat, proximate analysis, calcium and phosphorus contents and microbial analysis yeast, mould and *Escherichia coli* were evaluated for selected product samples with SLSI recommended levels. Shelf life analysis was conducted by analyzing some physicochemical, microbiological and sensory properties of selected product sample during the 1$^{st}$, 4$^{th}$, 7$^{th}$, 11$^{th}$, 15$^{th}$ and 20$^{th}$ days of storage. Finally, cost of final product was analyzed. Sensory data were analyzed using computer aided MINITAB 14 statistical analysis package Friedman non-parametric test and physicochemical and microbial tests were analyzed using one way ANOVA at 95% level of significant.

## Results and Discussion

Ten percent of wood apple pulp incorporated fruit yoghurt gave the highest estimated medians (taste – 4.25, colour – 3.875, aroma – 4.5, mouth feel – 4.25, overall acceptability – 4.625) and the highest sum of ranks for all sensory attributes. Therefore, 10% of wood apple pulp incorporated recipe ($R_1$) has given a desirable product. Web diagram for sensory evaluation data is shown in figure 1.

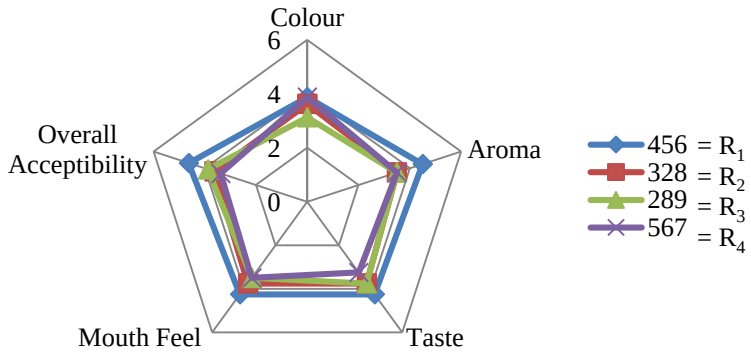


Figure 1. Web diagram for sensory evaluation data

According to physicochemical analysis (table 1), developed stirred type wood apple yoghurt product contained high protein (3.8%), calcium (166 ppm) and law fat (1%) content. Also, this newly developed product belonged to recommended level of SLSI, 1989 standard.

Table 1. Results of physicochemical analysis

| Food constituent | Plain yoghurt (SLSI) (per 100 g) | Fruit yoghurt (SLSI) (per 100 g) | Wood Apple yoghurt (per 100 g) |
|---|---|---|---|
| pH value | 4.2 – 6.5 | 4.2 -6.5 | 5.3 |
| Brix value | 20% | 20% - 35% | 28.4% |
| Titratable Acidity | 0.8 – 1.25 | 0.6 – 1.25 | 0.65% |
| Total Solids | > 20% | > 20% | 41.56% |
| Solid non fat | 8% | > 8% | 10.21% |
| Protein | 3.5% | 3.5% | 3.8% |
| Crude fat | 3% - 3.5% | 0.5% - 3% | 1% |
| Calcium | > 120 mg | > 120 mg | 166 mg |
| Phosphorus | - | - | 88.9 mg |

According to the shelf life study the product can be recommend as good quality food product for 15 days shelf life period. However, during this period product must be stored in 4$^{o}$C temperature in refrigerator condition. Web diagram for change of sensory data with storage time is shown in figure 2 and physicochemical data and microbial count for shelf life study is shown in table 2 and table 3.

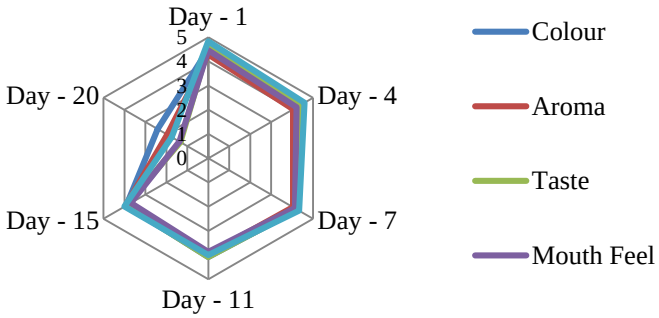


Figure 2. Web diagram for change of sensory data with storage time

Table 2. Physicochemical Data for Shelf Life Studies

| Storage (days) | Mean pH | Mean Brix % | Mean Titratable Acidity % |
|---|---|---|---|
| 01 | 5.32 ± | 28.4 ± | 0.65 ± |
| 04 | 5.32 ± | 28.4 ± | 0.65 ± |
| 07 | 5.29 ± | 28.4 ± | 0.65 ± |
| 11 | 5.28 ± | 28.0 ± | 0.66 ± |
| 15 | 5.26 ± | 28.0 ± | 0.66 ± |
| 20 | 4.76 ± | 28.0 ± | 0.69 ± |

According to the SLSI standards yeast count was not more than 1000 per 1 g, mould count was not more than one per 1 g and *E. coli* count must be negative in quality product.

Table 3. The Results of the Microbial Analysis for Shelf Life Studies

| Test Microorganisms | Day 1 | Day 4 | Day 7 | Day 11 | Day 15 | Day 20 |
|---|---|---|---|---|---|---|
| Mean Yeast (cfu) | 35 | 45 | 70 | 130 | 295 | 790 |
| Mean Mould (cfu) | 0 | 0 | 0 | 0 | 0 | 30 |
| Mean *E. coli* (cfu) | 0 | 0 | 0 | 0 | 0 | 0 |

Average commercial price for stirred flavoured yoghurt was Rs.45.00 in the August 2014. Allowing to the cost analysis, raw material cost for one wood apple yoghurt was Rs.19.77 is shown in table 4.

Table 4. Cost Analysis for Stirred Wood Apple Yoghurt Production

| Main Ingredients | Amount per 100 ml cup | Price per 100 ml cup |
|---|---|---|
| Plain Yoghurt | 84 g | Rs. 7.56 |
| Wood Apple Pulp | 13 g | Rs. 1.50 |
| Sugar | 11 g | Rs. 1.25 |
| Fresh Cow Milk | 16 ml | Rs. 0.96 |
| Other | Labour Cost, Electricity Cost, etc. | Rs. 8.50 |
| Total | | Rs. 19.77 |

## Conclusions

Ripe wood apple pulp can be introduced to yoghurt given the health benefits, higher sensory, physicochemical and microbiological properties. The selected best sample, 10% of ripe wood apple pulp gave acceptable results as SLSI standards. The product can be recommended as a quality food product for 15 days period under 4$^{o}$C temperature in refrigerator condition.

## Acknowledgment

The great assistance provided by the staff of Food Research Unit, Mr. P.D.S. Kulathilaka, Research and Development Executive, SGS Lanka Pvt. Ltd., Veterinary Research Institute, Underutilized Fruit Crop Research Institute, Biology Laboratory of Uva Wellassa University are highly acknowledged for their commitment to make this research study a success.

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# Investigating the factors that influenced the excess use of pesticides by the vegetable farmers in Badulla and Nuwara-Eliya districts

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## Introduction

Pesticides are the results of modern technology and synthetic organic poisons used to exterminate specific organisms by inhibiting certain vital functions. They are applied predominately to kill or control weeds, insect pests and animals. Pesticides are widely used because of ease of application, high efficiency, temporary economic return and etc. (Nagenthirarajah and Thiruchelvam, 2008). When pesticides are help to farmers to get high production, massive usage of pesticides have been reported in many of commercial cultivations in whole around the world (Wilson and Tiddsell, 2001). Similar to many developing countries, pesticide related issues in Sri Lanka have become a major concern in the present day context. Majority of cases have been occurred due to the excessive usage of pesticides. Excess uses of pesticides have severe effects on environment and human health that may lead to an immediate and long term effects.

Therefore it is important to identify the factors effect on excess use of pesticides which can help to overcome the intensive use of pesticides over the years in vegetable cultivation. In this context, the objectives of the study were (i) To investigate the farmers' level of awareness in use of pesticides and (ii) To investigate the factors that cause to excess use of pesticides.

## Methodology

The research was carried out in up country vegetable growing areas of Badulla and Nuwara Eliya district. Bandarawela, Welimada and Nuwara-Eliya Divisional Secretariat divisions were selected as the study area. Stratified random sampling technique was used to select 600 vegetable farmers from Nuwara-Eliya, Walimada and Bandarawela Divisional Secretariat divisions. Information were collected from farmers based on a semi structured pre-tested questionnaire. Both descriptive statistical method and binary logistic regression technique were used to analyze the data. Minitab 15 Statistical Software was used to get the output of binary logistic analysis. The variables defined for the empirical model are shown in Table 1.

## Empirical model

$$Y = \beta_0 + \beta_1 LEX + \beta_2 CT + \beta_3 UHL + \beta_4 UFM + \beta_5 SI + \beta_6 THI + \beta_7 CP + \beta_8 AGE + \beta_9 EDUL + \beta_{10} EXP + \beta_{11} ND + \beta_{12} SF + \beta_{13} TF + \beta_{14} PLF + \beta_{15} MF + \beta_{16} FA + \varepsilon_i \ldots\ldots\ldots\ldots\ldots (1)$$

Where, $\beta_0$ to $\beta_{16}$ = coefficients; $\varepsilon_i$ = error terms

Table 1: Description of variables in the empirical model

| Notation | Variables | Remarks |
|---|---|---|
| Y | Farmers' probability of excess use of pesticides | If excess use = 1 Otherwise = 0 |
| LEX | Cultivated land extent | Acre |
| CT | Cropping type | If mono cropping = 1 Otherwise = 0 |
| UHL | Use of hired labour | If use hired labour =1Otherwise = 0 |
| UFM | Use of farm machinery | If use machineries = 1Otherwise = 0 |
| SI | Seasonal income | Rupees |
| THI | Total household income per season | Rupees |
| CP | Cost of pesticides | Rupees |
| AGE | Age of farmer | Years |
| EDUL | Farmers' education level | Years |
| EXP | Farmers' experience on vegetable cultivation | Years |
| ND | Number of dependents | Count |
| SF | Social factors | Five point likert scale |
| TF | Technical factors | Five point likert scale |
| PLF | Policy and legal factors | Five point likert scale |
| MF | Market factors | Five point likert scale |
| FA | Farmer awareness | Awareness scores |

Eight awareness statements were used to calculate attitude index in the above regression model. They are scaled according to the five point likert scale form "strongly agree" (5) to "strongly disagree" (1). The Attitude Index for each factory was then calculated using following equation, where the value 40 in the numerator shows the maximum value can be obtained if the respondent strongly agrees with 05 statements (i.e. 5 × 5).

$$Awareness\ index = \frac{Summation\ of\ 08\ statement\ of\ each\ farmer}{8} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

**Result and Discussion**

According to the descriptive statistics, it can be said that nearly 64% farmers over use pesticides and almost all the farmers depended on chemical pesticides for the management of pest and diseases. When consider the farmers level of awareness in use of pesticides, if farmers have less than good awareness then most of farmers tend to overuse of pesticides more than recommended rates. Similarly, when the farmers have very good awareness then most of farmers do not tend to over use of pesticides. Result shows that most of (38.4%) farmers have average knowledge on use of pesticides and 63.7% farmers tend to excess use of pesticides. Figure 1 shows the farmers level of awareness with pesticide usage.

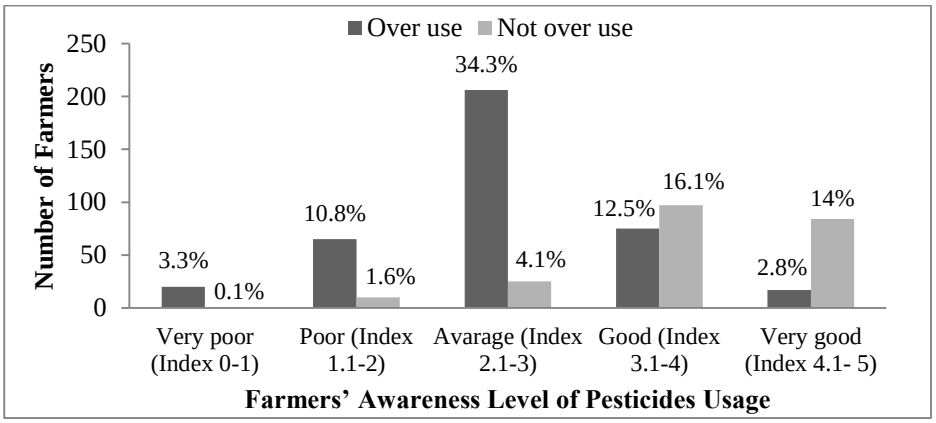


Figure 1: Farmers level of awareness with pesticide usage.

The Binary Logistic Regression model was used to determine the extent to which the identified factors affect farmers' probability of pesticide over usage and also quantify the relationship between dependent variable and independent variable. Binary Logistic Regression Model is yielded the following results.

Table 2: Results of the Binary Logistic Regression Analysis

| Variable | Coefficient | Standard Error Coefficient | Significant Value |
|---|---|---|---|
| Constant | 1.11215 | 2.58080 | 0.047** |
| LEX | 1.41592 | 0.507591 | 0.005*** |
| CT | 0.376077 | 0.364109 | 0.302 |
| UHL | -0.326939 | 0.432318 | 0.450 |
| UFM | -0.260718 | 0.710540 | 0.714 |
| SI | -0.0000011 | 0.0000033 | 0.736 |
| THI | 0.0000063 | 0.0000030 | 0.034** |
| CP | 0.0000069 | 0.0000135 | 0.612 |
| AGE | 0.0118588 | 0.0308302 | 0.700 |
| EDUL | -0.827147 | 0.293911 | 0.005*** |
| EXP | -0.0613994 | 0.0323089 | 0.057* |
| ND | -0.139205 | 0.127996 | 0.277 |
| SF | -2.11027 | 0.366147 | 0.0000*** |
| TF | 2.76283 | 0.477987 | 0.0000*** |
| PLF | -0.782096 | 0.181910 | 0.0000*** |
| MF | 1.22547 | 0.271988 | 0.0000*** |
| FA | -0.427377 | 0.0841074 | 0.0000*** |

Y = 1.11215 + 1.41592 LEX** + 0.376077 CT – 0.326939 UHL – 0.260718 UFM –0.0000011 SI – 0.0000063 THI* + 0.0000069 CP + 0.0118588 AGE – 0.827147EDUL** – 0.0613994 EXP** – 0.139205 ND – 2.11027 SF* + 2.76283 TF* – 0.782096 PLF* + 1.22547 MF* – 0.427377 FA*

*** Denotes significant at 0.01 level **Denotes significant at 0.05 level *Denotes significant at 0.1 level

R-Sq = 81.2%, Probability> F = 0.000

The model can be used to explain 81.2% of the variation of factors. Therefore this model is suitable to investigating the factors that influenced the excess use of pesticides.

## Conclusion

According to the study most of farmers have "average level" (awareness index= 2.1-3) of awareness in pesticide usage. As well results revealed that when the farmers' awareness was higher than "average level", there was less probability on excess use of pesticides and when farmers have "average level" or less than "average level" (awareness index < 3.1) awareness on pesticide usage, there was high probability on excess use of pesticides. Alsothe study indicate that Land extent, Total household income, Educational level, Farmers experience, Social factors, Technical factors, Policy and legal factors, market factors and farmers awareness are the factors which significantly affect to the excess use of pesticides.

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Wilson C., and Tisdell C. (2001). Why farmers continue to use pesticides despite environmental, health and sustainability costs,School of Economics, The University of Queensland, 36(1), 449-462.

# Mapping soil chemical properties and leaf quality parameters relation to tobacco production in Sri Lanka: a GIS approach

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## Introduction

Tobacco (*Nicotianatabacum L*) holds an unparalleled position among crop plants and in overall terms, the status achieved by this single species is truly remarkable (Akehurst, 1981). This crop significantly influences on world trade as a leaf basis product and is also a commercially widely grown crop as a non–food field crop (Akehurst, 1981).The chemistry and fertility of soils greatly influence the tobacco plant growth, leaf size, yield and physical, chemical and manufacturing properties of tobacco leaf.Among factors that influence on tobacco productivity, soil fertility and fertilizer use contribute nearly 50% of the yield and quality improvement of tobacco crop (Krishnamurthy and Deosingh, 2002).

Thus, by changing the soil properties and water quality, the yield and the quality of the final product can be greatly changed. Identifying lands with suitable soil propertiesfor the cultivation will help to understand the correct fertilizer application. Fertilizer recommendation based on soil test is important for improving the fertilizer use efficiency and thereby to increase the yield and quality of tobacco.

An understanding of spatial distribution of soil properties in the field is important for refining agricultural management practices. Soil variability is the outcome of many processes acting and interacting across a continuum of spatial and temporal scales and inherently scale-dependent (Cambardella et al., 1994).

Therefore, the study of relationship between the soil chemical properties and leaf quality can provide a scientific basis to find potential lands for quality tobacco production.This research presents the future potential tobacco growing areas based on the tobacco leaf quality distribution.

## Materials and methodology

In this study,Galewala and Mahiyanganaya tobacco growing areas were chosen as sample area.Data were collected from primary and secondary sources. Soil property data which wererecorded Ceylon tobacco company's (CTC) lab reports were collected as secondary data. Global Positioning System (GPS) coordinates were taken fromthe field as primary data. Soil analysis was undertaken by collecting soil samples in studyareas from 15 cm deep from the soil surface. The soil samples were collected from ten different places of one land with approximately 1kg of weight. Soil samples were analyzed for pH, organic matter, electrical conductivity, soil texture, calcium, magnesium, potassium, sodium, calcium/magnesium ratio, magnesium/potassium ratio, phosphorous, acid saturation, cupper, ferrus, manganese and zinc. Leaf quality data were taken from the CTC lab reports and identified the leaf nicotine percentage, chloride percentage and sugar percentages from the plants in selected locations.

Major soil chemical properties which affectontobacco leaf quality were identified by correlation analysis in MINITABstatistics. Soil chemical property and tobacco leaf quality distribution maps were processed using interpolation technique in ArcGIS. Interpolated leaf quality maps were reclassified in four suitability rankings i.e. most suitable, suitable, moderately suitable and fairly suitable as shown in Table 01. Finally all leaf quality layers were integrated in a GIS environment to generate the potential map.

Table 01: Suitability factors for identifying potential areas tobacco cultivation

| Factor | Most Suitable | Suitable | Moderately Suitable | Fairly Suitable |
|---|---|---|---|---|
| **Leaf Nicotine%** | >3.5 | 3.0 – 3.5 | 2.5 – 3.0 | < 2.5 |
| **Leaf Sugar %** | < 10 | 10 – 14 | 14 – 18 | > 18 |
| **Leaf Chloride %** | < 0.6 | 0.6 – 0.8 | 0.8 – 1.0 | >1.0 |

**Results and Discussion**

According to correlation analysissoil pH and magnesium affected on nicotine, chloride and sugar levels in tobacco leaves. Low soil pH and low soil magnesium levels result in lower chloride level and sugar level in tobacco leaves.Acid saturation of the soil basically affected on the nicotine level of tobacco leaves. High acid saturation in soil result in high nicotine level in tobacco leaves. Soil potassium level affected on the chloride level of tobacco leaves. When potassium level of soil was lower chloride level of tobacco leaves was also lower. Sugar level of the tobacco leaves is affected by soil nitrogen level. Lower the nitrogen level in soil; lower the sugar level in tobacco leaves.

With lower soil pH levels, acidic cations; $Mn^{+2}$, $Fe^{+3}$ and $Al^{+3}$ are more available, however $Cd^{+2}$ like heavy metals are also available at lower pH values. Availability of these cations can be a reason for the reduction of chloride level and sugar level of tobacco leaves.Magnesium is a part of the chlorophyll in all green plants and essential for photosynthesis. It also helps to activate plant enzymes needed for growth. This may results for the difference of nicotine, chloride and sugar levels in tobacco leaves.Acid saturation is the percentage of the cation exchange capacity occupied by $H^{+}$ ions. Increasing the acid saturation will reduce the pH.Having too much of potassium in soil, it can lead to salt damage and acid fixation of the root system. It may result in increasing the leaf chloride level.Nitrogen is a part of all living cells and is a necessary part of all proteins, enzymes and metabolic processes involved in the synthesis and transfer of energy. According to the results, leaf sugar levels can be affected directly by soil nitrogen.

Therefore soil with low pH, low nitrogen, low magnesium, low potassium and high acid saturation are favorable for quality tobacco production as shown in Table 02.

Table 02: Relationship between composition of soil chemical properties and tobacco leaf quality

| Factors | Mean value | | |
|---|---|---|---|
| Leaf Nicotine % | pH | Mg (Kg/ha) | Acid Saturation% |
| 2 - 2.5 | 4.7 | 428.1 | 7.05 |
| 2.5 – 3 | 4.96 | 392.3 | 8.72 |
| 3 - 3.5 | 5.57 | 296.1 | 12.6 |
| 3.5 – 4 | 5.61 | 226.0 | 16.33 |
| Leaf Chloride % | pH | Mg (Kg/ha) | K (Kg/ha) |
| 0 - 0.625 | 4.95 | 290.4 | 219.9 |
| 0.625 - 1.25 | 5.31 | 344.8 | 237.1 |
| 1.25 - 1.875 | 5.862 | 470.3 | 345.2 |
| 1.875 - 2.5 | 6.35 | 573.5 | 332.5 |
| Leaf Sugar % | pH | Mg (Kg/ha) | N (Kg/ha) |
| 0 – 10 | 4.925 | 299.5 | 15.5 |
| 10 – 15 | 5.321 | 359.4 | 16.53 |
| 15 – 20 | 5.638 | 408.7 | 20.54 |
| 20 – 25 | 5.533 | 435.7 | 28.67 |

Mahiyanganaya area is the most suitable area for quality tobacco production. Mahiyanganaya; Rideela, Dehiaththakandiya, Sandunpura, NawaMadagama and Diyawiddagama were identified as most suitable areas for tobacco cultivation. Polonnaruwa; Siripura, Pallegama and Selasumgama were identified as the most suitable areas. Galewela; Tholombagolla and Kalawewa are the most suitable areas for quality tobacco production as shown in Figure 01.

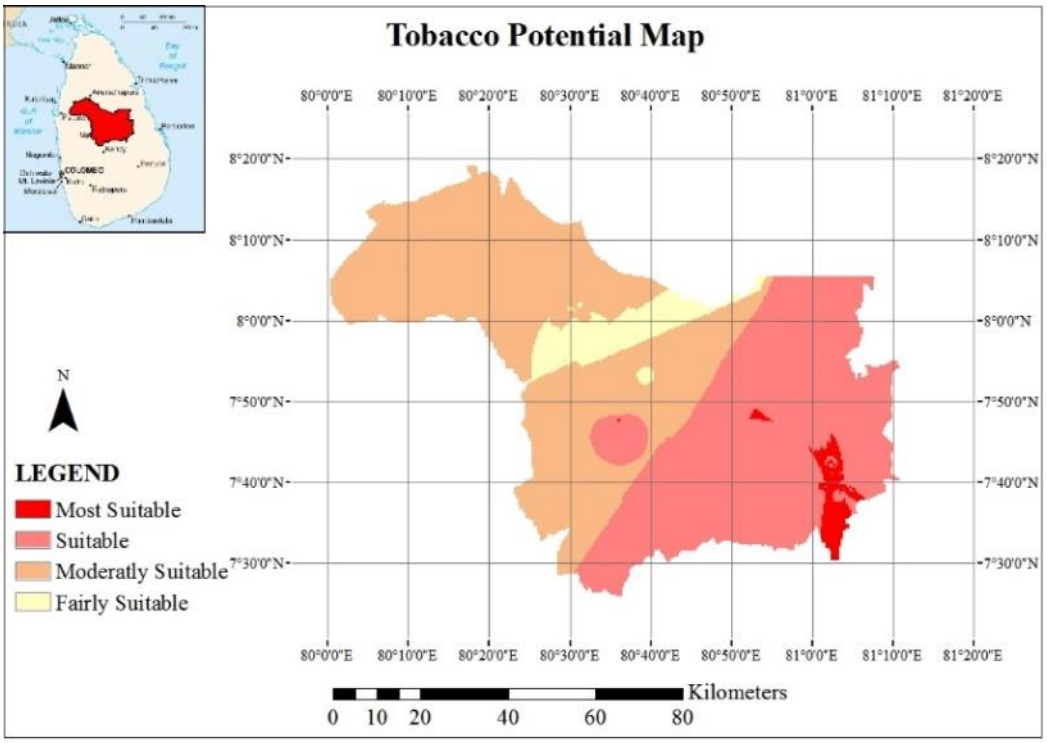


Figure 01: Tobacco Potential Map

## Conclusion

GIS based approach is a useful tool for assessing tobacco potential areas. Mahiyanganaya area is the most suitable area for quality tobacco production. Soil with low pH, low Nitrogen, low Magnesium, low Potassium and high Acid saturation are favorable for quality tobacco production.

Results of the study can be improved by adding evenly distributed sample locationsand analyzing with agro ecological conditions.

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# Willingness to adopt chemical leasing service by vegetable farming in Nuwara Eliya district, Sri Lanka

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## Introduction

Chemical leasing service is a new strategic business model which is service oriented to promote sustainable chemical management. This research paper aims to examine factors affecting on farmer willingness to adopt in chemical leasing service. Chemical Leasing definition developed by, United Nations Industrial Development Organization (UNIDO) "Chemical Leasing is a service-oriented business model that shifts the focus from increasing sales volume of chemicals towards a value-added approach. This represents an integrated preventive environmental strategy and a clear win-win situation for industry and the environment. The specific objectives of this study were to determine the vegetable farmers' willing to adopt on the chemical leasing model, to determine the vegetable farmers' willingness towards a chemical leasing service.

## Materials and methodology

Willingness to pay for agricultural services is influenced by a number of paradigms including the innovation-diffusion model (Francis M, el al 2010), economic constraints model (Makokha et. al, 1999).

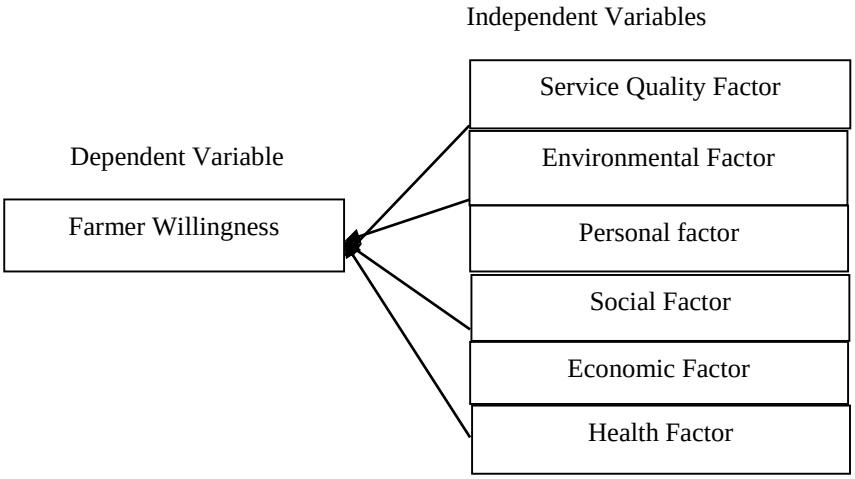


Figure 1: Conceptual Frame work

Figure 2.1 above shows the theoretical framework of the study. There are two variables discussed in this study as independent and dependent variable farmer willingness to adopt in chemical leasing showing dependency on Personal, social, economy, farmer health, environment, and Service quality.

The data applied in this study were collected in Nuwara Eliya by a questionnaire. The sample was determined by simple random sampling method. 150 farmers were selected as responders. Each head of household he/she was given a brief introduction about Chemical Leasing Service. The questionnaire used in the interviews was structured in one section contained straightforward questions. From second section to sixth section there are statement wise questions. Participants were asked to provide marks for the statements which are affected to their willingness to adopt Chemical Leasing service on decision.

Farmers were requested to record their responses on a five point likert scale as follows: Strongly disagree (1), disagree (2), not clear idea (3), agree (4) and strongly agree (5). The definitions of demographic/personal, social, environment, economic, health variables, and service quality variable and descriptive statistics of the sample are presented in descriptive statistics table. To achieve the objectives of this study; Chi-square test and Binary Logistic model were used. In the first analysis, chi-square contingency test was used to determine willingness to adopt chemical leasing service frequencies is independent of the respondents' demographic and other factors. The statistical program, Statistical package for Social Science (SPSS for Windows, version 22, SPSS) was used to transform where necessary, tabulate and analyse the data.

In binary logistic model the decision choice is a whether or not to have, adopt or not and this response is binary it takes on two values 0 and 1. $Y$= {0 *if* No, 1 *if* Yes}.

$$\text{logit}\,[p(x)] = \log\,[p(x)/1\text{-}p(x)] = a + b_1x_1 + b_2\,x_2 + b_3\,x_3 \ldots\ldots\ldots b_k\,x_k$$

$p$ = the probability that a case is in willingness to adopt,

a = the constant of the equation and,

b = the coefficient of the predictor variables.

$X_1$= Age

$X_2$= Area

$X_3$= outcome

$X_4$= Cost

$X_5$= pressure

$X_6$=Training

$X_7$=Store

$X_8$=Pay

$X_9$=Method

$X_{10}$=Safety

$X_{11}$= Other

$X_{12}$=Concern

$X_{13}$= Waste

**Results and Discussion**

A total of 150 observations, all with complete information on the variables included in the empirical model, were analysed. As valid percent only 80% of the respondents are willingness to adopt for chemical leasing service. The other respondents are 20% are not willingness to adopt for chemical leasing service. From frequencies of 150 respondents 120 responders willing to accept this new strategic model and other 30 responders are not willing.

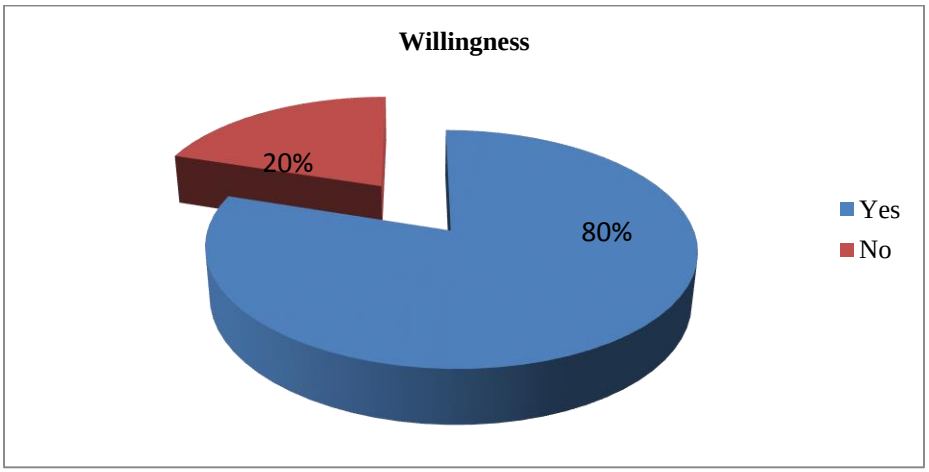


Figure 2: Descriptive Statistics Results of willingness to adopt chemical lasing service

Regression Model yielded following results.

The relationship between the willingness to adopt chemical leasing service and the selected demographic characteristics and other factors are shown in Table 5. Results suggest that there are statistically significant relationships between willingness to adopt chemical leasing service and essential prerequisites with chemical leasing service. The age and area were measure as range and the other all the variables were measure using five point liket scale.

Table 4.8: Estimated parameters and their statistical significance levels

| | | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|---|
| Step 1[a] | Age | -3.537 | 1.649 | 4.603 | 1 | .032* | .029 |
| | Area | 4.811 | 2.480 | 3.762 | 1 | .052 | 122.844 |
| | Outcome | 3.538 | 1.508 | 5.503 | 1 | .019* | 34.407 |
| | Cost | 3.005 | 1.383 | 4.719 | 1 | .030* | 20.178 |
| | Pressure | 5.111 | 2.232 | 5.246 | 1 | .022* | 165.850 |
| | Training | 5.951 | 2.569 | 5.368 | 1 | .021* | 384.132 |
| | Store | 4.532 | 1.967 | 5.310 | 1 | .021* | 92.903 |
| | Pay | 6.757 | 2.995 | 5.091 | 1 | .024* | 859.808 |
| | Method | 6.550 | 2.863 | 5.233 | 1 | .022* | 699.300 |
| | Safety | 8.334 | 3.537 | 5.552 | 1 | .018* | 4161.546 |
| | Other | 4.168 | 1.924 | 4.694 | 1 | .030* | 64.598 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Concern | -.634 | .676 | .878 | 1 | .349 | .531 |
| | Waste | 7.264 | 3.140 | 5.353 | 1 | .021* | 1428.196 |
| | Constant | -135.053 | 55.980 | 5.820 | 1 | .016* | .000 |

a. Variable(s) entered on step 1: Age, Area, Outcome, Cost, Pressure, Training, Store, Pay, Method, Safety, Other, Concern, Waste.

* = Statistically significant at the 0.05-level

Consequently farmer's age groups, expected outcome, cost of agrochemicals, family pressure, trained people, storing facilities, paying method, service method, safety concern, other inputs given and waste disposal method's easiness variables are the affected predictors. However all the factors which are considered in study were significant and affect to the farmers' willingness to adopt chemical leasing service.

Logit (Probability of willingness to adopt) = -135.03 -3.537(Age) + 3.538(Outcome) + 3.005(Cost) + 5.111(Pressure) + 5.951(Training) + 4.532(Store) + 6.757(Pay) + 6.550(Method) + 8.334(Safety) + 4.168(Other) + 7.264(Waste)

## Conclusion

Sri Lankan agro chemical consumption has grown rapidly while increasing harms to environment and health. The objectives of this study were to assess consumers' socio-economic/demographic characteristics, attitudes and perceptions on the willingness to adopt chemical leasing service. For estimation technique, Chi-square and binary logistic model were specified and analyzed using survey data in Nuwera Eliya district, Sri Lanka.

This study showed that about 78.9% of consumers in the sample willing to adopt this new innovative strategic model.

The findings of this study indicated that farmer's age, expected outcome of agrochemicals, cost of agrochemicals, and Farmers' family pressure, trained people in chemical application, agro chemicals storing facilities, are the demographic and socio economic factors determining significant of consumers' willingness to adopt chemical leasing service.

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# Analysis of combining ability and heterosis in tomato (*solanum lycopersicum)* using full diallel cross

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## Introduction

Tomato (Solanumlycopersicum) is the second most important vegetable crop next to potato. Tomato being one of the popular vegetable crops in Sri Lanka is preferred by farmers due to high economic returns, export potentials and nutritive value. Tomato is a rich source of vitamin A, C and minerals like Ca, P and Fe (Dhaliwalet al., 2003). Tomatoes are major contributors of antioxidants such as carotenoids (especially, lycopene and β-carotene), phenolics, ascorbic acid (vitamin C) and small amounts of vitamin E in daily diets (Raiet al., 2012).

In Sri Lanka, tomato is cultivated in more than 7137 ha, producing nearly 73917 t/year. (Department of Agriculture, 2010) The record lower yields are attributed to multiple of factors inclusive of elevated and frequent incidences of pest and diseases and inadequate accessibility to quality seeds (Ceylon Chamber of Commerce, 2011).

Most improvement programmes of many crops use diallel analyses as they provide breeders information on the genetic value of varieties as parents and to assess the gene action which can be directed at improving yield and other related quantitative characters (Vianaet al., 2001). Therefore, an understanding of the genetic control of characters and role of non-allelic interaction is essential to the breeder when deciding of the selection method and breeding procedure to follow (Esmail, 2007). From diallel analysis, plant breeders are able to gather information on heterosis and effect due to maternal, General Combining Ability (GCA) and Specific Combining Ability (SCA) of parents in crosses (Glover et al., 2005).

## Materials and method

Parents were obtained from the germplasm of the Plant Genetic Resource Centre (PGRC), Gannoruwa, Peradeniya.Seeds of the all possible crosses, reciprocals and Bhathiya were obtained from the Horticultural Crop Research and Development Institute (HoRDI), Gannoruwa from the maha season 2013/2014. All possible crosses and parents were shown in table 01.

Table 01: Table of diallel analysis

| M \ F | PH 12561 | PH 12585 | PH 12696 | PH 12835 |
|---|---|---|---|---|
| PH 12561 | | PH 12585 X PH 12561 | PH 12696 X PH 12561 | PH 12835 X PH 12561 |
| PH 12585 | PH 12561 X PH 12585 | | PH 12696 X PH 12585 | PH 12835 X PH 12585 |
| PH 12696 | PH 12561 X PH 12696 | PH 12585 X PH 12696 | | PH 12835 X PH 12696 |
| PH 12835 | PH 12561 X PH 12835 | PH 12585 X PH 12835 | PH 12696 X PH 12835 | |

These experiments included four parents, twelve F1 hybrid crosses and one reference line as Bhathiya. During the yala seasons of 2014 field experiments were conducted at HoRDI, Gannoruwa, only with total of 294 plants (Parents, F1 hybrids and Bhathiya as reference line).

The experiment was conducted in randomized complete block designs with two replications. All the management practices were done according to the department of agriculture recommendations. Finally fully ripened fruits were harvested.

Minitab 17 (1.0 version) software was used to analyse the variance of the twenty quantitative characters followed by the General linear model at the 0.05 probability level as mean separation technique. Analyzed mean values of the characters showing significant differences were further subjected to the analysis of combining ability by Griffing's (1956) Method, heterosis and heritability calculations.

**Data collection**

Phenotypically similar five tomato plants were selected from each variety at the seedling stage for data collection. Quantitative data were collected from those selected five plants under the vegetative, reproductive, yield and fruit quality traits for each variety.

**Results and discussion**

According to study PH 12561 X PH 12835 $F_1$ hybrid involved poor female into high male general combiner and performing positive specific combining ability with increase vigor of $F_1$ over the mid parent, better parent and standard variety. Therefore, it expressed as non-additive into additive gene interaction by performing low to moderate narrow sense heritability with slight environmental effect for the vegetative traits and yield traits. Similar results found by Frimpong*et al*., 2006.

Interpretation of the reproductive traits indicated the PH 12585 X PH 12835 $F_1$ hybrid involved average female into high male general combiner and executing positive specific combining ability through increase vigor of $F_1$ over mid parent, better parent and standard variety with

expression of the additive into additive gene interaction by performing low narrow sense heritability with low environmental effect.

In pursue of the research study, PH 12561 X PH 12696 $F_1$ hybrid elaborated poor female into high male general combiner and performing positive specific combining ability with increase vigor of $F_1$ over the mid parent, better parent and standard variety. Therefore, it interpreted as non-additive into additive gene interaction by performing low to moderate narrow sense heritability with slight environmental effect for the fruit quality traits.

Most of the considered quantitative traits were slightly affected by the environment due to the estimation of moderate narrow sense heritability values.

**Conclusion**

In pursue of the research study, PH 12835 parent interpreted as the best open pollinated parent. PH 12561 X PH 12835 $F_1$ hybrid indicated as the best $F_1$ hybrid for the vegetative and yield traits. PH 12561 X PH 12696 $F_1$ hybrid indicated as the best $F_1$ hybrid for the fruit quality traits.

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# Preservation of tomato (*Lycopersicon esculentum*) by dehydration for product development and utilization

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## Introduction

Tomato growers in the world experience high postharvest losses of fresh tomato supported by high perishability and low price of tomato during the peak production seasons due to production surplus and low product utilization of preserved tomato. Compared to the trends in the food industry the demand for dehydrated tomato is increasing rapidly both in domestic and in international markets (Purseglove *et al*., 2001). Dehydrated tomato topping is a condiment comprises with dehydrated tomato slices use to enhance the flavor and texture of salads, ranging from simple green salads to more elaborate versions.

Main objective of the study is the Preservation of Tomato (*Lycopersicon esculentum*) by dehydration for product development and product utilization. Specific objectives are dehydration using hot air drying, analysis of sensory, microbial and physiochemical parameters of dried samples and possibility of using dehydrated products for new product development and product utilization.

## Materials and methodology

The material used for this study is just ripen tomato (*Lycopersicon esculentum*) belongs to variety "Pathma".Preliminary studies were carried out to determine the best methods steaming and non-steaming methods. Best salt concentration was selected based upon the microbial counts and the moisture content. Best Sodium Meta bisulphite was selected based upon the organoleptic properties.

10g of dehydrated tomato, 50g of sugar, 400mL of water, 20g of Corn flour, 15mL of vinegar, 10mL of citric acid were used according to the developed methodology. Dehydrated tomato topping with brix value 25 was developed using the methods developed through the preliminary trials. Brix value was adjusted to 25 during cooking. Final product was stored under room temperature in sterilized glass bottles.

The microbial evaluation, proximate analysis, analysis for organoleptic properties and physico - chemical analysis for final product was conducted to ensure the product safety and quality.

## Results and Discussion

### Microbiological tests

Microbiological tests were carried by the Veterinary Research Institute (VRI), Peradeniya to ensure the safety of the final product for the consumers.

Table: Results of the microbiological tests for dehydrated tomato topping with brix value 25

| Microbiological test | Results (CFU/g) |
|---|---|
| *Salmonella* spp. | Negative |
| *Staphylococcus aureus* | Negative |
| *E.coli* | Negative |
| Aerobic Plate Count(APC) | $5.0 \times 10^0$ |

Based on the Sri Lankan standards for the microbiological tests the Aerobic Plate Count should be less than $5\times10^5$.The absence of the pathogenic bacteria is a requirement of Sri Lankan standards for microbial tests.

**Proximate Composition of the Final Product**

Table: Proximate composition of the final product

| Parameter | Composition |
|---|---|
| Appearance | Normal |
| Moisture % | 73.0 |
| Ash % | 0.1 |
| Crude protein % | 0.5 |
| Ether extract (Fat) | 0.0 |

The most important feature of the product is free from Ether extract. Most toppings are rich in fats. Hence, the developed product is a favorable substitute for toppings rich in fats as a food additive for people who are advised to use fat free diets for therapeutic purposes. The standards for proximate composition of Tomato toppings are not mentioned in Sri Lankan Standards.

**Sensory Data of Shelf Life Evaluation**

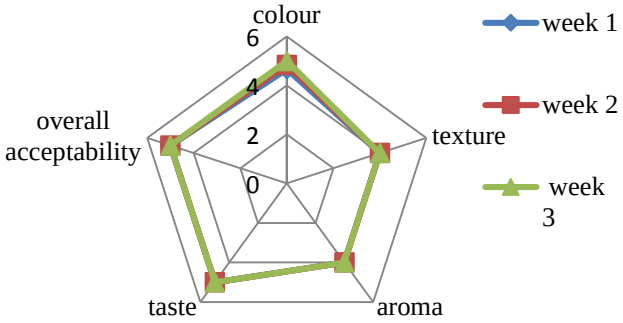


Figure 1: Web diagram illustrates the changeability of sensory attributes with time

The dehydrated tomato topping with the brix value of 25 has obtained the highest acceptability for overall appearance and taste for the duration of three weeks. The acceptability for the aroma and the texture of the product has decreased continuously for three sensory evaluation tests. The acceptability for the colour has increased from week one to week three due to the gradual increment of the brix value, pH and titratable acidity of the product with the time.

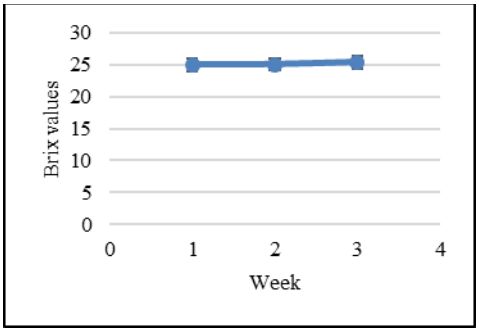


Figure 2: Change in mean Brix value of dehydrated tomato topping during the storage period under refrigerated conditions

**Physico-Chemical Analysis**

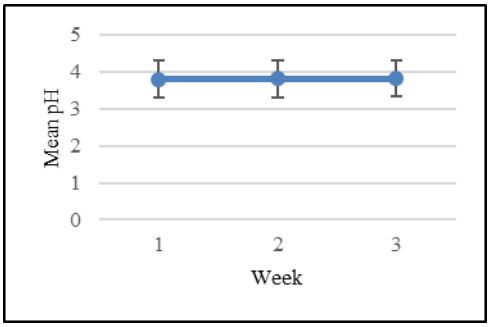


Figure 3: Change in mean pH value of dehydrated tomato topping during the storage period under refrigerated conditions

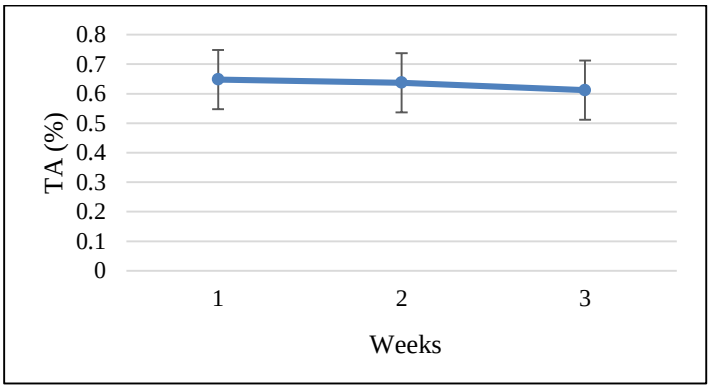


Figure 4: Change in mean TA value of dehydrated tomato topping during the storage period under refrigerated conditions

Brix values and pH values of the final product has increased slightly from first week to third week with the aging of the product while the titratable acidity of the product has decreased. At the end of the third week the pH lays on the value of 3.82.Hence it lays below the value of 4.4 which is recommended as the maximum pH value for the food products. Hence the product is safe for the consumption for three weeks period. The reason for the overall reduction of titratable acidity of the product is the increment of the pH value of the product with aging.

## Conclusion

The preservation of tomato is very much important to address the market gap in between the market demand and supply. Dehydration can be identified as one method of preservation. The tomato samples should be pretreated with 2% salt to enhance the efficiency of the dehydration process. The dehydrated tomato topping with the brix value of 25 gives the best sensory attributes. The brix value is the main parameter adjusted in the dehydrated tomato topping by addition of sugar.50g of sugar is required for the production of 200ml of the dehydrated tomato topping. The pH value is adjusted to the value of 3.8 by addition of citric acid. The pH should be kept below the value of 4.4.The dehydrated tomato topping is a fat free food additive which extends the range of value addition to tomato fruits.

## Acknowledgement

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# Study on response of rice varieties to different nitrogen fertilizer levels

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## Introduction

Rice (Oryza sativa L.) is the single most important crop and the staple food of more than three billion people or more than half of the world's population. Paddy is cultivated as a wetland crop in all districts. Direct or indirect involvement for paddy sector is more than 30 % of the total labour force (Wickramasinhe and Wijewardena, 2000). Rice provides 45% total calorie and 40% total protein requirement of an average Sri Lankan (Department of Agriculture,2010).The areaunder paddy production in yalaand maha was 1,671,054 Mt and 2,629,566 Mt respectively (Department of Census and Statistics, 2010). Nitrogen, phosphorous and potassium are the three major nutrients required for the rice plant. Nitrogen (N) is one of the essential macro -nutrients for rice growth and one of the main factors to be considered for developing a high-yielding rice cultivar. Nitrogen increases plant height, panicle number, leaf size, spikelet number, and number of filled spikelets, which largely determine the yield capacity of a rice plant. Panicle number is largely influenced by the number of tillers that develop during the vegetative stage. Rice plants require nitrogen during the tillering stage to ensure a sufficient number of panicles and reproductive to grain filling. Nitrogen imbalance in soil produces low fertilizer use efficiency, low yields and low farmer profit.Main nitrogen loss mechanisms are volatilization of ammonia (NH3), leaching loss of nitrate (NO3-), loss through denitrification and soil erosion (Choudhury and Kennedy, 2005).Therefore, optimum level of nitrogen fertilizer should be applied to get maximum yield of paddy cultivation and utilize nitrogen fertilizers effectively (Fageria and Baligar, 2003).

## Materials and Methods

This study was conducted at the Rice Research Development Institute (RRDI) at Batalagoda in Kurunagala district, Sri Lanka. Fertilizers used were urea as the Nitrogen source, and others; Triple super phosphate and Murate of Potash. The experiment was comprised with sixteen treatments. Nitrogen fertilizer was applied as 0, 50, 100 and150 kg N ha-1. Four rice varieties, Bg 1350 (V1), Bg 997 (V2), Bg 379-2 (V3) and Bg 450 (V4) were tested. These four rice varieties are in age group of four to four and half months.Sixty four plots were arranged according to the split plot design with sixteen treatments and four replicates.

Plant height, number of tillers per hill, plant greenness, number of days for 100 % flowering of rice varieties, dry weight of shoot parts, plant nitrogen content, number of panicles per hill and grain yield were measured against different nitrogen levels.

**Result and Discussion**

As the results showed (Table 1) there was a significant effect ($P<0.005$) among the treatments for the plant height, number of tillers per hill, plant greenness, number of days for 100 % flowering of rice varieties, plant nitrogen content, number of panicles per hill and grain yield. There is no statistically significant difference among the levels of nitrogen and variety with dry weight of shoot parts.

Table 1:Means of plant parameters for different treatments

| Treatments | Plant height | Number of tillers | Plant SPAD reading | Dry weight of shoot parts | Grain weight | Number of dates of 100 % flowering | Nitrogen content of shoot parts | Number of panicles per hill |
|---|---|---|---|---|---|---|---|---|
| N0V1 | 64.86$^{a}$ | 7.26$^{a}$ | 27.49$^{a}$ | 11.43$^{a}$ | 2.35$^{a}$ | 79.30$^{b}$ | 2.12$^{a}$ | 7.73$^{a}$ |
| N1V1 | 75.46$^{ab}$ | 9.66$^{a}$ | 33.21$^{ab}$ | 21.16$^{a}$ | 3.58$^{ab}$ | 79.33$^{a}$ | 2.70$^{a}$ | 9.66$^{a}$ |
| N2V1 | 78.33$^{a}$ | 12.13$^{a}$ | 36.90$^{b}$ | 24.12$^{a}$ | 3.71$^{c}$ | 78.70$^{bc}$ | 3.17$^{a}$ | 9.53$^{a}$ |
| N3V1 | 83.13$^{a}$ | 12.40$^{a}$ | 38.32$^{b}$ | 26.55$^{a}$ | 4.21$^{b}$ | 80.70$^{a}$ | 3.26$^{b}$ | 11.46$^{a}$ |
| N0V2 | 64.80$^{a}$ | 6.60$^{a}$ | 28.25$^{a}$ | 12.66$^{a}$ | 2.75$^{a}$ | 72.00$^{c}$ | 2.56$^{a}$ | 7.26$^{ab}$ |
| N1V2 | 77.73$^{a}$ | 8.33$^{a}$ | 34.73$^{a}$ | 19.12$^{a}$ | 3.91$^{a}$ | 71.00$^{b}$ | 3.15$^{a}$ | 8.66$^{a}$ |
| N2V2 | 78.00$^{a}$ | 9.80$^{ab}$ | 37.55$^{b}$ | 25.74$^{a}$ | 4.91$^{a}$ | 75.70$^{c}$ | 3.50$^{a}$ | 9.00$^{a}$ |
| N3V2 | 80.33$^{ab}$ | 10.93$^{b}$ | 38.09$^{b}$ | 28.79$^{a}$ | 5.31$^{a}$ | 75.33$^{b}$ | 3.78$^{a}$ | 9.86$^{a}$ |
| N0V3 | 51.40$^{b}$ | 7.26$^{a}$ | 28.15$^{a}$ | 14.69$^{a}$ | 2.45$^{a}$ | 85.00$^{a}$ | 2.54$^{a}$ | 7.13$^{ab}$ |
| N1V3 | 61.93$^{c}$ | 9.66$^{a}$ | 30.54$^{a}$ | 22.2$^{a}$ | 3.65$^{ab}$ | 81.33$^{a}$ | 3.29$^{a}$ | 9.00$^{a}$ |
| N2V3 | 61.13$^{b}$ | 10.86$^{ab}$ | 34.10$^{c}$ | 22.01$^{a}$ | 3.65$^{c}$ | 85.00$^{a}$ | 3.52$^{a}$ | 9.13$^{a}$ |
| N3V3 | 69.06$^{c}$ | 12.60$^{a}$ | 38.16$^{b}$ | 28.53$^{a}$ | 5.00$^{a}$ | 81.70$^{a}$ | 3.59$^{ab}$ | 11.06$^{a}$ |
| N0V4 | 62.73$^{a}$ | 6.26$^{a}$ | 30.37$^{a}$ | 12.39$^{a}$ | 2.56$^{a}$ | 80.00$^{b}$ | 2.52$^{a}$ | 5.60$^{a}$ |
| N1V4 | 68.73$^{bc}$ | 9.26$^{a}$ | 32.98$^{ab}$ | 19.75$^{a}$ | 3.16$^{b}$ | 80.33$^{a}$ | 3.19$^{a}$ | 8.93$^{a}$ |
| N2V4 | 76.46$^{a}$ | 9.20$^{a}$ | 40.26$^{a}$ | 22.30$^{a}$ | 4.20$^{b}$ | 81.00$^{b}$ | 3.29$^{a}$ | 8.93$^{a}$ |
| N3V4 | 76.73$^{b}$ | 11.53$^{ab}$ | 43.72$^{a}$ | 24.95$^{a}$ | 4.76$^{ab}$ | 83.33$^{a}$ | 3.75$^{a}$ | 9.93$^{a}$ |

Means followed by the same letter in the same column are not significantly different at $P< 0.05$.

**Conclusions**

The results showed that the responses to application of nitrogen fertilizer vary among the rice varieties.

Plant height , number of tiller per hill, plant greenness, dry weight of shoot parts, plant nitrogen content of shoot parts, grain yield and number of panicles per plant of four rice varieties increase with increasing level of nitrogen fertilizer and respond positively.

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# Factors affecting on the integrity and sealing of flexible packaging

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## Introduction

In biscuit manufacturing, quality assurance plays a significant role in order to deliver a product that will attract the customers and profit gaining of the industry is closely related with the quality of packaging operations (Manly, 2002). There are various types of packaging materials that is being used for biscuit packaging but at present, flexible packaging materials are used prominently because of its good barrier properties, space saving, ease of operation and disposability etc. End product package integrity is important when assuring quality of the product throughout the shelf life (Robertson, 2012). At packaging, sealing defects may result damaged end products which will eventually absorb moisture and the biscuits may become stale and deteriorated along with shelf life. To prevent that, suitable machine settings of the packaging machine should be maintained and monitored.Objectives of this study are to find the best suitable machine setting range for two types of wrappers, metalized wrapper and laminated wrapper and to find the effect of Accelerated life testing on the package integrity, moisture absorbance and rancidity.

## Methodology

In this study, the integrity of end products belonged to two different types of flexible packaging materials (metalized and laminated wrapper), which was produced to different sets of temperature settings were monitored. From the selected wrappers, material combination of metalized wrapper (trade name Metalized BOPP/ CPP film) is 20 BOPP/ 25 MCPP and laminated wrapper (trade name BOPP/ CPP) consist 30 BOPP/ 25 CPP. Selected metalized wrapper is being using for Soft dough type 1(round) 75g product and laminated wrapper is being using for Soft dough type 2(rectangular) 100g product. The integrity of biscuit package is measured by subjecting the samples in to Leak tester. The sample packet was submerged in the water chamber of the leak tester and gradually the vacuum of the head space of the water chamber was created and was increased which resulted the expansion of the packet. The value of the vacuum pressure at which the package integrity gets terminated (either by bubble emission from the weakest point of seal or bursting of the package) was taken as the response measurement. Preliminary data base was created for five weeks by testing sixty biscuit packets of metalized and laminated wrapper each from morning and evening shift for its integrity by subjecting those to leak tester. The treatment was taken as the machine setting values (sealing temperature values) at which the biscuit packages were produced(RL1= roller 1, RL2= roller 2, UJ= upper jaw, LJ= lower jaw). The response variable was the vacuum pressure value at which the package integrity was terminated when subjected to leak tester.Those best treatments from each metalized wrapper and laminated wrappers were then subjected to accelerated life testing (ALT) by incubating under 45°C for eight weeks. Weekly the biscuit packet samples from each wrapper were tested for its integrity, moisture content, pH and rancidity.

**Results and Discussion**

Table 01: Preliminary analysis results for metalized wrapper

| Date | Shift | Treatments | RL1 (°C) | RL2 (°C) | U J (°C) | L J (°C) | Mean (kPa) | p value | Significance |
|---|---|---|---|---|---|---|---|---|---|
| 4.6.14 | 1st | MS1 | 186 | 192 | 164 | 161 | 39.34 | 0.996 | Not significant |
| | | MS2 | 182 | 192 | 162 | 160 | 39.69 | | |
| | | MS3 | 183 | 192 | 164 | 161 | 39.31 | | |
| | 2nd | MS1 | 184 | 192 | 164 | 161 | 39.46 | 0.039 | Significant MS2-MS1 |
| | | MS2 | 189 | 197 | 164 | 163 | 50.14 | | |
| | | MS3 | 191 | 198 | 164 | 163 | 47.43 | | |

There was significant effect from treatment in the second shift as the p value is 0.039 and difference between the treatments MS2 and MS1 in the second shift was significant.

Table 02: Preliminary analysis results for laminated wrapper

| Date | Shift | Treatments | RL1 (°C) | RL2 (°C) | U J (°C) | L J (°C) | Mean (kPa) | p value | Significance |
|---|---|---|---|---|---|---|---|---|---|
| 14.7.2014 | 1st | MS1 | 191 | 194 | 148 | 152 | 23.76 | 0.161 | Not significant |
| | | MS2 | 195 | 199 | 160 | 162 | 31.42 | | |
| | | MS3 | 194 | 199 | 159 | 162 | 32.15 | | |
| | | MS4 | 193 | 199 | 160 | 161 | 23.23 | | |
| 15.7.2014 | 1st | MS1 | 192 | 196 | 160 | 163 | 37.48 | 0.719 | Not significant |
| | | MS2 | 192 | 196 | 162 | 163 | 37.74 | | |
| | | MS3 | 193 | 196 | 164 | 162 | 40.97 | | |

As obtained p values for the treatments, 0.161 and 1.719 there were no significant effect from the treatments. To prepare samples for accelerated life testing, MS3 treatment value in first shift of 15.7.2014 was taken as best treatment because it had the highest mean of response variable (RL1= 193°C, RL2= 196°C, UJ= 164°C, LJ= 162°C).

When the biscuit samples with metalized wrapper were subjected to accelerated life testing, for the best machine setting it showed low moisture absorbance and vacuum pressure values at the termination of package integrity were above 40 kPa. Mean vacuum pressure values increased from 43.64 kPa to 48.91 kPa up to fifth week and it was gradually decreased to 36.16 kPa on last and eighth week of accelerated life testing.Moisture absorbance was low up to sixth week from 2.66% to 2.91% then it was increased to 3.48% at the end of eighth week. pH variations of the sample were low which was between 7.07 and 7.55 for the tested eight weeks and it showed negative results when tested for rancidity.

There was no treatment effect from the laminated wrapper and samples for accelerated life testing were produced according to the machine setting which gave the highest mean vacuum pressure value when checked for the package integrity. In accelerated life testing, mean vacuum pressure values showed minimum variation unlike the data obtained for metalized wrapper and the mean vacuum pressure values were within the range of 40.57 – 41.54 kPa. Moisture content gradually increased from 2.36% to 2.69%but pH values decreased from 7.84 to 6.68. There was slight indication of rancidity on the last week of testing

**Conclusions**

Best machine setting for metalized wrapper was MS2 with temperature values in °C, RL1= 189, RL2= 197, UJ= 164, LJ= 163 and best machine setting for laminated wrapper was RL1= 193°C, RL2= 196°C, UJ= 164°C and LJ= 162°C.

Weakest sealing point for metalized wrapper was middle of center seal and for laminated wrapper it was the serrated edge of cutter seal.

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Packaging of Cereals, Snack Food and Confectionary. In: Robertson, Gordon L. (ed) (2012). Food Packaging: Principles and Practice. CRC Press, USA

# Selection of an effective biofilmed biofertilizer formulation and best potting medium for anthurium (*Anthurium andraeanum*)

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## Introduction

Anthurium is identified as one of the crops prioritized for the development and export promotion in Sri Lanka (Kelegama, 2001). Optimum growth and flowering of Anthurium mainly depend on potting medium, fertilizer and light levels (Higaki et al, 1994). Potting medium rich in nutrients and effective fertilizers can be used for the optimum growth of this plant. Beneficial biofilm based biofertilizers called biofilmed biofertilizers (BFBFs) have been introduced recently (Seneviratne et al., 2010). Present study was focused to select an effective biofilmed biofertilizer formulation and evaluate the comparative effect of different potting media on vegetative growth of Anthurium andreanum plant.

## Methodology

The present study was carried out at the Royal Botanic Gardens, Peradeniya. Two experiments with different treatments were conducted during this study. First experiment was conducted under shade house conditions with different fertilizer treatments; 50 % chemical fertilizer (CF), 50 % CF + BFBF and100 % CF recommended for Anthurium was selected as the control. In the second experiment, four different potting media (inert particle mixture, coir chips, leaf litter with sand, control) were used and the existing potting medium, which was used at the Royal Botanic Gardens, Peradeniya was taken as the control. Different BFBF with 50 % CF application was under taken at one week interval for the plants of the first experiment and 50 % CF application was under taken at one week interval for the plants of second experiment. Initial data were collected before the plants establishment and final vegetative growth parameters were measured after three months of plant establishment in both experiments. Plant height (cm), plant weight (g), total root length (cm), leaf number, leaf area, root number and the chlorophyll content were considered as the vegetative growth parameters. Treatments were arranged in a Complete Randomized Design (CRD). Mean separation was conducted using the Tukey method ($P< 0.05$). MINITAB 16 statistical package (Minitab Inc.) was used for data analysis in both experiments.

## Results and Discussion

### Experiment 01

As indicated in the Table 1, treatment 16 (BF4 alone treatment) recorded the highest rank value over the other 16 treatments. Thus, the treatment 16 was effective in the increment of all

vegetative growth parameters in Anthurium plant. As indicated in Table 1, treatment 13 (50 % CF) significantly contributed to increment of plant growth and development than treatment 14 (100 % CF).

Table 1: Ranked data (increment percentages of vegetative growth parameters) of experiment 01

| Treat-ments | Fresh Weight (g) | Number of Roots | Total Root Length (cm) | Number of Leaves | Plant Height (cm) | Chloro-phyll Content | Leaf Area | Sum of Rank | Final Rank |
|---|---|---|---|---|---|---|---|---|---|
| $BF_1$ + 50 % CF | 1 (58 $^{e}$) | 2 (15$^{c}$) | 1 (0$^{b}$) | 1 (0$^{d}$) | 1(33$^{abcd)}$ | 6 (13$^{b}$) | 3 (42$^{b}$) | 18 | 1 |
| $BF_2$ + 50 % CF | 2 (62 $^{de}$) | 6 (58$^{abc}$) | 2 (1$^{b}$) | 2 (53$^{abcd}$) | 12 (49$^{abcd}$) | 9 (26$^{ab}$ | 9 (40$^{b}$) | 43 | 3 |
| $BF_3$ + 50 % CF | 12 (197$^{ab}$) | 12 (84$^{abc}$) | 3 (25$^{ab}$) | 3 (18$^{bcd}$) | 4 (60$^{abc}$) | 13 (26$^{ab}$) | 8 (80$^{ab}$) | 62 | 7 |
| $BF_4$ + 50 % CF | 15 (250$^{ab}$) | 17 (134$^{a}$) | 13 (111$^{a}$) | 13 (32$^{bcd}$) | 8 (42$^{abcd}$) | 7 (61$^{a}$) | 17 (60$^{b}$) | 96 | 13.5 |
| $BF_5$+ 50 % CF | 11 (198$^{abcd}$) | 8 (66$^{abc}$) | 8 (66$^{a}$) | 8 (37$^{bcd}$) | 9 (44$^{abcd}$) | 8 (29$^{ab}$) | 6 (11$^{ab}$) | 68 | 8 |
| $BF_6$ + 50 % CF | 8(169$^{ab}$) | 1(13$^{bc}$) | 10 (81$^{a}$) | 10 (28$^{bcd}$) | 7 (21$^{cde}$) | 4(9$^{b}$) | 2 (98$^{ab}$) | 50 | 4 |
| $BF_7$ + 50 % CF | 5(110$^{ce}$) | 14 (105$^{a}$) | 16 (131$^{a}$) | 16 (4$^{cd}$) | 2 (10$^{de}$) | 2 (2$^{b}$) | 1 (56$^{b}$) | 61 | 6 |
| $BF_8$ + 50 % CF | 3(94$^{cde}$) | 15 (116$^{ab}$) | 6 (58$^{ab}$) | 6 (9$^{cd}$) | 3 (3$^{e}$) | 1 (24$^{ab}$) | 7 (42$^{b}$) | 43 | 2 |
| $BF_9$ + 50 % CF | 10 (190$^{abcd}$) | 13 (96$^{ab}$) | 14 (119$^{ab}$) | 14 (71$^{ab}$) | 16 (20$^{bcde}$) | 3 (30$^{b}$) | 13 (106$^{ab}$) | 92 | 12 |
| $BF_{10}$+ 50 % CF | 6 (123$^{bcde}$) | 9 (73$^{abc}$) | 9 (70$^{a}$) | 9 (27$^{bcd}$) | 6 (63$^{abc}$) | 14 (38$^{ab}$) | 16 (53$^{b}$) | 73 | 9.5 |
| $BF_{11}$+ 50 % CF | 4 (109$^{cde}$) | 7(64$^{abc}$) | 7 (62$^{a}$) | 7 (40$^{abcd}$) | 10 (60$^{abc}$) | 12 (30$^{ab}$) | 12(171$^{a}$) | 73 | 9.5 |
| $BF_{12}$ +50 % CF | 17 (293$^{a}$) | 4 (41$^{abc}$) | 11 (95$^{a}$) | 11 (93$^{a}$) | 17 (59$^{abc}$) | 11 (26$^{ab}$) | 11(78$^{ab}$) | 96 | 13.5 |
| 50 % CF | 13 (218$^{abc}$) | 11 (79$^{ab}$) | 1 (100$^{a}$) | 12 (57$^{abc}$) | 13 (53$^{abc}$) | 10 (28$^{ab}$) | 10 (216$^{a}$) | 99 | 15 |
| 100 % CF | 7 (127$^{bcde}$) | 3 (35$^{abc}$) | 4 (33$^{ab}$) | 4 (25$^{bcd}$) | 5 (21$^{bcde}$) | 5 (33$^{ab}$) | 5 (146$^{ab}$) | 53 | 5 |
| $BF_3$ alone | 14 (249$^{ab}$) | 5 (35$^{abc}$) | 15 (129$^{a}$) | 15 (51$^{abcd}$) | 11 (122$^{a}$) | 17(35$^{ab}$) | 17 (208$^{a}$) | 108 | 16 |
| $BF_4$ alone | 16 (270$^{a}$) | 16 (57$^{abc}$) | 17 (186$^{a}$) | 17 (66$^{ab}$) | 14 (91$^{ab}$) | 16 (18$^{b}$) | 16 (165$^{ab}$) | 113 | 17 |
| $BF_{10}$ alone | 9 (172$^{abcd}$) | 10 (77$^{abc}$) | 5 (53$^{a}$) | 5 (68$^{ab}$) | 15 (78$^{abc}$) | 15 (19$^{b}$) | 15 (160$^{ab}$) | 76 | 11 |

**Experiment 02**

According to the Table 2, the highest rank recorded in treatment 1 (Inert particle mixture). Treatment 3 (Leaf litter with sand) was better than the treatment 4 (control) for the growth of Anthurium andreaenum plant under prevailing climate condition. Coir chips potting medium was seen to prove less effective for better plant growth due to its less contribution for the availability of nutrients.

| Treatments | Fresh Weight (g) | No. of Roots | Total Root Length (cm) | No.of Leaves | Plant Height (cm) | Chloro-phyll Conte-nt | Leaf Area | Sum of Rank | Final Rank |
|---|---|---|---|---|---|---|---|---|---|
| Inert Particle Mixture | 4 ($197^{a}$) | 2 ($23^{a}$) | 3 ($61^{a}$) | 3 ($36^{a}$) | 4 ($50^{a}$) | 4 ($33^{a}$) | 4 ($142^{a}$) | 24 | 4 |
| Coir Chips | 1 ($81^{a}$) | 1($5^{a}$) | 1 ($22^{a}$) | 2 ($35^{a}$) | 1 ($3^{c}$) | 2 ($10^{a}$) | 1($48^{b}$) | 9 | 1 |
| Leaf Litter with Sand | 2 ($124^{a}$) | 3 ($32^{a}$) | 2 ($46^{a}$) | 4 ($41^{a}$) | 3 ($29^{ab}$) | 3 ($12^{a}$) | 3 ($68^{b}$) | 20 | 3 |
| Control | 3 ($132^{a}$) | 4 ($54^{a}$) | 4 ($67^{a}$) | 1 ($19^{a}$) | 1($10^{bc}$) | 2 ($8^{a}$) | 2 ($49^{b}$) | 17 | 2 |

Table 2: Ranked data of (increment percentages of vegetative growth parameters) experiment 02

**Conclusions**

According to the first experiment, BFBF alone treatments (BF4 alone treatment and BF3 alone treatment) improved the vegetative growth of *Anthurium andreanum* plant. Thus, BFBF alone treatments highly influenced than the BFBF combined with 50 % CF. In apparent, that the 50 % CF significantly contributed to increment of plant growth and development than 100 % CF. This indicated, reduction of 50 % CF not negatively affected to vegetative growth parameters in Anthurium. Results of second experiment suggested that potting medium of inert particle mixture (charcoal, coir dust, sand and bricks particles (1:1:1:1) can be recommended as a standard potting medium for *Anthurium andreanum* to maintain satisfactory plant growth, development and ultimately plant quality.

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# Studying the effects of *Paracoccus marginatus* (Mealybug) attack on forming of *Tagets spp.* (Indian Marigold) flower

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## Introduction

Merigold (Asteraceae: *Tagets spp.*) is native plant to America and Mexico which is introduced to Sri Lanka for ornamentation. Widely grows in home gardens throughout the country, cultivates for cut-flowers and use as insects repellant (Vennila *et al*., 2011). The plant use to medicinal remedies and cultivates as a food crops in some other countries but not in Sri Lanka.

Managing Mealybug (Hemiptera: Pseudococcidae; *Paracoccus marginatus*) insects presents unique challenges. Mealybugs are polyphagous and multiply on different hosts. These have been recorded on many plant species including field crops, vegetables, ornamentals, weeds, bushes and trees in Sri Lanka. Important host plants include okra, holly hock, brinjal, potato, maize, sorghum, groundnut, pigeon pea, sunflower, beetroot, mulberry, Amaranthus spp, Marigold and cucurbits (Anon, 2008). The severity of problem may be estimated from the fact that this insect produces as many as 15 generations per year. The nymphs and adults suck plant sap from tender shoots, leaves and even hard tissues including main stem and branches and cause damage (Anon, 2008) which cause direct plant injury by feeding on plant fluids or sap in the vascular tissues, primarily the phloem or mesophyll or both, with their piercing-sucking mouthparts. In addition, Mealybugs excrete a clear sticky liquid called honeydew which serves as a growing medium for black sooty mold fungi that is secreted on to the leaves which interferes with photosynthesis (Lysandrou *et al.*, 2012). As a result of Mealybug attack, plants become stunted and in severe cases may die. They may also inject a toxin. This may cause leaf yellowing, plant stunting, and wilting. Mealybugs are also capable of transmitting diseases, including viruses. Mealybugs tend to congregate in large numbers at leaf junctures where the petiole meets the stem, on leaf undersides, on stem tips, and under the leaf sheaths. Mealybug is origin in Central America (Williams and Granara, 1992) has its spread at the Caribbean and Ecuador, Chile, Argentina, Brazil, Pakista, India, Nigeria, China, Australia and Sri Lanka (Prishanthini and Laxmi, 2009). Such a vast and fast distribution of Mealybug across the globe largely during the past few years and its economic damage to several crops make it necessary to characterize the ecological factors associated with the pest. In this study, evaluate Mealybug attack on the damage of marigold flower forming.

## Materials and Methods

Seeds of Indian Merigold were purchased from the Seed and Planting Material Division, Huggala botanical garden, Sri Lanka. In this study was conducted in green house at the Department of Agriculture Biology, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka. Four pot replicates were conducted on Merigold plants that was

infested with Paracoccus marginatus. Two pots were used as controls. Potting medium was taken 1:1:1 Sand, compost and topsoil and two Merigold plants were cared in each pot. At the flowering stage, two adults of Paracoccus marginatus were taken from infected Papaya plant (*Carica papaya*) and introduced to the every branch of Merigold plant. Data were collected from maturity stage of the flower (after blooming 3days). Data regarding Merigold flowers diameter reduction were subjected to analysis mean average value and compared with the control. Experiment was repeated 3 times.

**Results and Discussion**

Mean average flower diameter in control pots was 5.85 cm and average mean flower diameters of the infected plants were 3.5 cm. It showed significant reduction of flower formation which were attacked by mealy bug. Merigold flowers were used as insects repellant in biologically. In this study, 59.8% of flower were damaged by Mealy bugs' activities (Figure 1;d,e,f,). Same result was also showed in many ornamental plant species (Vennila *et al*., 2011; Janet *et al*, 2009). Merigold flowers infected by Mealy bug showed reduction of number of petals, decrease the bud size and further infected changed the colour to brown and died.


**Figure 1:** Different stages of Mealy bug infected flowers
( a, Mealybug infected flower; b, Indian Merigold Plant(control); c, Indian Merigold flower without infected Mealybug; d, Mealybug associated with ants; e and f, reduction of flower formation of infected flowers)

The present results of the ants association with mealybug ( Figure1;d) were in close conformity with the report of earlier workers who reported the association of *S. geminate* with *Phenacoccus solenopsis* Tinsley association of *S. geminata* with homopterans (Gowda *et al.*, 2014). During the present study different ant species were found to transfer the mealybugs from one plant to another. This finding is in agreement with Genter (1925) who found that the ant, *Camponotus lineolatta* (Say) transferring the grape mealybug, *Pseudococcus maritimus*. Saini *et al.* (2009)

also noticed that ants were responsible for quick colonization of *P. solenopsis* to new areas. Smith (1928) reported that ants collected during the surveys comprised *Tapinoma sessile* Say, *Pheidole* sp., and *Technomyrmex* sp. (Hymenoptera: Formicidae).

**Conclusion**

Mealybugs severly damage to Indian Merigold flower production. Researchers and farmers should have to use control measures to prevent Mealybug and ants entering to the plantation. Special attention should be paid when growing Marigold in the crop field as an insect repellant.

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# Consumer preference for quality attributes of rice

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## Introduction

Paddy cultivation serves as the major coping strategy for 800,000 families in Sri Lanka. The average paddy productivity has reached to 4.3 t/ha in 2013 while the annual per capita consumption is 116 kg/year (DCSL, 2013). Rice remains as the staple food of the country and the consumers have different preference for different quality attributes of rice through which they derive consumer utility. Hence, it is important to identify the quality attributes of rice preferred by different consumer segments. This information is of vital importance for farmers to enhance the supply catering to the consumer demand. Therefore, the main objective of this study was to identify different rice quality attributes and their levels as valued by the consumer choice.

## Methodology

The study was conducted in Gampaha District in 2014 with 63 consumers selected using stratified random sampling. Four quality attributes and three levels per each were selected using focus group discussion. A fractional factorial design (1/3) was used to reduce the full profile. Data was collected using Semi structured pre-tested conjoint questionnaire. The significance of the selected attributes was tested using ANOVA and part-worth utilities were estimated by a logistic regression. The relative importance of each attributes was also calculated.

## Empirical model

Consumer preference is non parametric attribute. Conjoint analysis (CA) is the most widely used method to analyse consumer preference. A set of hypothetical products is defined by combining product attributes at various levels. Consumers are asked to evaluate their overall preference rating or ranking of the hypothetical products. The final step of CA involves choosing an appropriate composition model and estimating the buyer's part-worth utilities (Harrison, 1998).

***Part-Worth Utility Model***

$R_i = G + W_1D_1 + W_2D_2 + W_3D_3 + W_4D_4 + W_5D_5 + W_6D_6 + W_7D_7 + W_8D_8 + e_i$ ……(4)

$R_i$ = preference rating for the i$^{th}$ respondent

$W_i$ , i = 1,2..n are part-worth estimates associated with respective levels of product attributes.

$D_i$ , i = 1,2..n are dummy variables for significant levels of attributes

$e_i$ = error term

***Relative Importance (RI)***

RI = (Utility Range/ Σ utility ranges of all attributes) *100

## Random Utility Theory

Once the data are choice-based, researchers use random-utility models in which the basic idea is the assumption of utility maximization (Hauser and Rao, 2002). The attributes and levels are

described in Table 1. Attributes were selected using focus group discussion. Each selected attributes consist with 3 levels.

Table 1: Description of attributes

| | Attributes | | | |
|---|---|---|---|---|
| | Degree of Milling | Shape | Tenderness | Price |
| Levels | Brown | Short Round | Soft | <Rs.60/kg |
| | Partially Polished | Long Bold | Average | Rs.60-70/kg |
| | Fully Polished | Long Slender | Hard | >Rs 70/kg |

**Results and Discussion**

Among the Selected 63 rice consumers there was a large portion of female rice consumers (65%) where as a little portion of male rice consumers (35%) were participated for the survey. Most of the consumers (65%) were between the age of 25 – 50 years, 25% of participants were below 25 years and remain 10% was over 50 years old.

When consider about the rice consumption majority (56%) of the sample is consuming rice for all three meals and 44% of consumers consume rice only twice a day. Among the respondents 52% make the decision to purchase rice for their families. The significance of the selected attributes are shown in Table 2.

Table 2: ANOVA Results for quality attributes

| Attribute | Degrees of Freedom | Sum of Squares | Mean Sum Squares | F Value | Pr>F |
|---|---|---|---|---|---|
| Degrees of Milling | 2 | 1045.25 | 522.62 | 96.46 | <0.0001 |
| Shape | 2 | 6.81 | 3.40 | 0.63 | 0.53 |
| Tenderness | 2 | 8.43 | 4.21 | 0.78 | 0.46 |
| Price | 2 | 5.13 | 2.56 | 0.47 | 0.62 |

P=0.05, N=63

According to the results (Table 2), degrees of milling attribute was significant ($p<0.05$) while shape, tenderness and price attributes were not significant ($p<0.05$). This indicates that, degree of milling is highly valued by the consumers when they purchase rice. Further, interaction effects were not significant at 95% confidence interval.

According to the results (Table 3), "Brown" and "fully polished" levels were significant while none of the rest of the attribute levels were significant. Consumers have negative preference over brown rice and positive preference for fully polished rice. Once a consumer purchases one unit of brown rice in his consumer basket, the utility is decreased by 1.74 units. On the contrary, fully-polished rice is placed in the market basket his utility is increased by 1.62 units.

Table 3: Part-worth estimates of levels in quality attributes

| Attribute | Level | Estimate | Z value | P>Z |
|---|---|---|---|---|
| Degree of milling | Brown | -1.74 | -12.77 | 0.000 |
| | Partially-polished | 0.12 | 1.13 | 0.260 |
| | Fully-polished | 1.62 | 11.64 | 0.000 |
| Shape | Short-Round | 0.06 | 0.56 | 0.577 |
| | Long-Bold | -0.01 | -0.14 | 0.888 |
| | Long-Slender | -0.04 | -0.42 | 0.577 |
| Tenderness | Soft | -0.13 | -1.25 | 0.211 |
| | Medium | 0.05 | 0.51 | 0.608 |
| | Hard | 0.08 | 0.74 | 0.211 |
| Price | < Rs.60/kg | 0.05 | 0.46 | 0.648 |
| | Rs.60-70/kg | 0.07 | 0.63 | 0.526 |
| | > Rs.70/kg | -0.02 | -1.09 | 0.526 |

Pseudo $R^2$ = 0.0918. P=0.05, N=66

**Relative Importance of Attributes**

Table 4: Relative Importance of each attribute

| Attribute | Utility Range | Relative Importance (%) |
|---|---|---|
| Degree of Milling | 3.354 | 89.3 |
| Shape | 0.102 | 2.7 |
| Tenderness | 0.206 | 5.4 |
| Price | 0.094 | 2.4 |

The most important attribute among the selected, is degree of milling. Consumers do not pay much attention on other quality attributes of rice: shape, tenderness, and price in this particular consumer segment.

**Conclusions**

The study revealed that, degree of milling is the most important factor while the shape, tenderness and price of rice were not significantly affecting consumer choice in this market segment. Since this consumer segment is from urban profile, consumer choice has become price insensitive. They pay more attention over rice processing in making a purchasing decision. Consumers have negative preference for brown rice and positive preference for fully polished rice. Although, shape of the grain, tenderness of cooked rice, and price attributes were not significant, testing the same with different consumer segments while incorporating differently selected attributes may shed lights on estimating consumer preference more coherently.

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# Determination of microbial quality and quantity of stored cinnamon quills

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## Introduction

Since Cinnamon is one of the major spicecrops in Sri Lanka, maintenance of the quality of the processed cinnamon is very important. Microbial infection of processed cinnamon quills makes lowquality final product leading the product less demandedand high post-harvest losses. The prevailing solution for the microbial infection is fumigation of sulfur and it is not acceptable in many countries due to its harmful effects for consumer health. Therefore identification of common types of microbes on quills and determination offavourable conditions for microbial growth is very important to apply effective control measures.

## Methodology

Experiments were conducted to identify the particular types of fungi that thrive on cinnamon quills and the effect of moisture content, relative humidity, temperature and the storage period to the microbial growth. Cinnamon quills were collected from three different placesjust after processing. The moisture contents of the samples were measured in three days interval using gravimetricmethod. Average relative humidity and ambient temperature were also recorded each period. In quantification process, the number of colony forming units of fungi and bacteria in cinnamon quills were counted separately using colony counter.1g of powdered sample of cinnamon was dissolved in 10ml of distilled sterilized water and 200µl of the solution was poured in to the culture plates. It was allowed to incubate under the room temperature for about three days and colony count of fungi and bacteria were taken.The culture plates with microbial colonies were allowed to incubate further to obtain pure cultures of fungi by frequent sub culturing. Colony characteristics were observed with the time.The pure cultures of fungi were used to prepare slide cultures for microscopic identification highlighting the distinguishing characteristics (Funder, 1953; Cappuccino and Sherman 1996).

## Results and Discussion

According to the morphological and microscopic observations, *Rhizopus sp.*, *Penicillium sp.*, *Aspergillus niger*, *Aspergillus flavus* were the most common types of fungi encountered on cinnamon quills. In addition to those types *Trichoderma sp.* was appeared in the samples taken from one farmer place. It may be happened when peeled cinnamon had been kept in ground for drying and due to bad sanitary conditions in processing place.

*Rhizopus* sp. was rapidly growing white coloured fungus with cottony and fuzzy aerial mycelium. The color of the colony was white initially and turned grey to yellowish brown with time. It was grown as filamentous, branching coenocytichypha without cross-walls. Sporangia were developed on the long stalks raised as groups from nodes directly above the rhizoids. Unicellular ovoid, hyaline and striated sporangiospores were produced by *Rhizopus* species and they were grown as root like rhizoids initiallyand finally grown as large mycelium. *Penicillium* colonies were initially appeared in white colourand become blue green, gray green and then gray in colour respectively. It was grown as a thallus with typical characteristic of a highly branched network of multinucleate, septate, and usually colorless.Many-branched conidia sprout on the mycelia, bearing individually constricted conidiospores. *Aspergillus flavus* colonies were initially appeared in yellowish whitecolour and changed to olive green, dark green and brownish green respectively.Hyphae grew as a thread-like structure and they were septate and hyaline. The asexual spores,conidispores, produced in conidia were rough and dark.*Aspergillus niger* colonies were initially white and become brownish with white reverse and brownish black colour respectively covering the entire plate.Morphology of *Aspergillus niger* showed large, globose, dark brown conidial heads, which become radiate. Conidiophores are smooth-walled, hyaline or turning dark towards the vesicle. Conidial heads are biseriatewith the phialides, often septate. Conidia are globose, dark brown and rough-walled.*Trichoderma* colonies were wooly and the initialcolor is white. As the conidia are formed, yellow-green patches become visible making concentric rings.Conidiosphores were erect, smooth and penicillately branched. Globose conidia were developed on philides produced in the opposite direction in each point.

At the beginning the fungal infections of stored cinnamon were very low due to lack of enough inoculums, even though preferable higher moisture contents for fungal growth were retained in stored cinnamon quills. Next 10 days rapid increments of fungal colony forming units were observed because preferable moisture contents were retained further in cinnamon quills. Fungal infection was increased at 10 to 20 days also, but in negative rate due to desirable moisture contents were still remained in the cinnamon quills. Moisture content in the cinnamon quills were below 20 % after 20 to 30 days after processing and in this period fungal contaminations were gradually declined. When the moisture content was reached below 12% in storage cinnamon, fungal infection was at a minimum level. If the moisture level is reduced to below 12% in storage cinnamon as soon as possible, fungal infection can be controlled efficiently.

The most interesting phenomenon was the symbiotic relationship between fungal growth and bacterial growth (Figure1).There was very strong significant positive correlation between fungal and bacterial infections ($r = 0.912$, $p = 0.0001$). Bacterial contamination never had been occurred without fungal infection. Bacterial colonies were appeared in the culture plates used to have the fungal colonies separately, even though those were treated with antibiotics to retard the bacterial growth.When fungal infection is terminated by managing moisture content, the bacterial infection **is** automatically reduced (Figure 2).

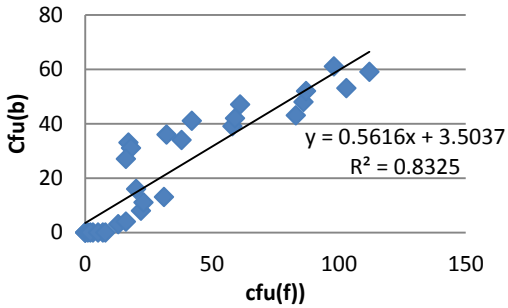


Figure 1. Relationship between number of fungal colony forming units [cfu(f)] and bacterial colony forming units [cfu(b)] during the period of storagein cinnamon

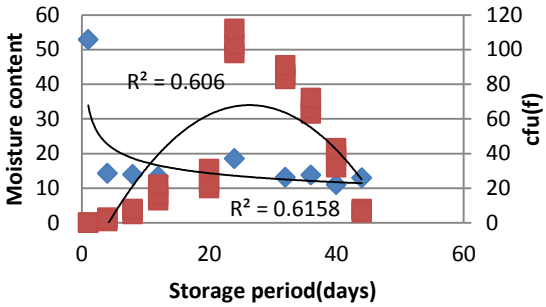


Figure 2. Relationship of moisture content and Fungal colony forming units during the period of storage

The number of fungal and bacterial colonies has been increased with the increment of relative humidity. These relationships were stronger in sample collected from processing center and farmer's place1 than farmer's place 2. Cultivated cinnamon was not belonging to individual variety and some cinnamon plants may have more resistance to microbial contaminants. Furthermore, fungal growth had stronger correlation with relative humidity than bacterial growth. In general, fungi and bacteria both were well grown and the spread in high relative humidity levels and it provided more favorable conditions for microbes' development in stored cinnamon.

The number of fungal and bacterial colony forming units makes a moderate negative relationship with temperature. Maximum number of fungal and bacterial colonies can be observed within the temperature range of 28 to $31^0$C and the most favorable temperature range for post-harvest microbes on cinnamon quills may be 28 to $31^0$C. This experiment was conducted Matara and the fluctuation of temperature was very low. Daily temperature was retained at 28 to $31^0$C mostly during the study period and this range of temperature was optimum to growth of fungus in stored cinnamon. High temperature (35 $^0$C) with low relative humidity (20 %) and low temperature (20 $^0$C) with low relative humidity (10%) are the most suitable conditions for keeping insects and microbial contaminants away from stored cinnamon quills (Jayasinghe, 2012). Ambient temperature alone not affected microbial growth in stored products. When it is unified with other factors such as RH, moisture content, it will play major role to increase or decrease the microbial contaminants in stored cinnamon. In other hands, microbial contaminants attract the invertebrates concurrently such as frugivorous mites when the cinnamon is contaminated with fungus making the quality of the cinnamon quills lower furthermore.

**Conclusion**

Rhizopus sp., Penicillium sp., Aspergillus niger, Aspergillus flavus were the most common types of fungi encountered on cinnamon quills. The most favourable conditions for microbial growth was 80% to 90% of relative humidity, 28 to 310C of temperature, moisture levels above 20% and 20 to 30 days of storage period.

**Acknowledgement**

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# Development of ready to serve drink from gotukola (*Centella asiatica)*

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## Introduction

Gotukola (*Centellaasiatica*) is one of the valuable medicinal herbs and it has several food and beverage applications in many countries of the world. It is used by Sri Lankan people mainly as a leafy vegetable. *C. asiatica* is a good source of antioxidants and famous for its neuroprotective effect (Hashim, 2011). In addition, this herb is also used for treating in numerous kinds of diseases due to its rich phytochemical composition mainly asiaticoside, asiatic acid, madecassoside and madecassic acid (Tiwari et al., 2011). However, there is no any value added product in Sri Lankan market purely produced from Gotukola. Ready to serve drinks (RTS) are becoming popular recently in all over the world. This is an effort to develop leaf based ready to serve drink from Gotukola with acceptable quality standards. Creeping typeGotukola (HeenGotukola) was used for this study due to its nutritional value and to reduce its wastage by introducing a value added product.

## Materials and Methods

Current study was carried out at Food Research Unit, Gannoruwa, Peradeniya. Laboratory analysis was conducted at Laboratories of UvaWellassa University and laboratories of Veterinary Research Institute, Gannoruwa. Six preliminary trials were carried out to develop four different recipes by changing the percentage of leaf amount by mass as 5%, 7.5%, 10% and 12.5% with constant amount of other ingredients. First quality leaves were selected with stalk and washed properly. Leaves were dipped in Clorox (Sodium Hypochlorite / NaClO) added water for one minute. Then leaves were washed from pure water and leaf extract was separated after grinding. Leaf extract was mixed with prepared sugar syrup and heated up to 80˚C. Citric acid was added while preparing the sugar syrup. In each recipe quality standards of RTS drink like pH, brix and titratable acidity were tested according to SLS 729: 2010, to ensure whether product is fulfilled the quality requirements of RTS drink. Sensory evaluation was carried out using 5 point hedonic scale to select the best recipe from the developed four recipes. It was conducted for colour, taste, odour, mouth feel and overall acceptability using 25 semi trained panelists. Proximate analysis was carried out according to the method of AOAC for the product selected through sensory evaluation. Total polyphenol content was determined according to the method of ISO 14502 -1. Determination of yeast and mold, *Escherichia coli* and total plate count test were carried out under the microbial analysis of the final product. Shelf life evaluation for the final product was carried out for one month period under refrigerated storage conditions.

Total plate count test and sensory evaluation were conducted weakly as a part of that procedure. In addition to that, pH, brix and titratable acidity values were tested weakly.

**Result and Discussion**

Recipe with 7.5% of leaf amount by mass was selected as the best recipe from sensory evaluation. Percentage of polyphenol in the final product was 0.0712 mg / ml GAE.Proximate composition of the final product is shown in the Table 01. According to that, zero percentage of ash reveals the product is free from heavy metal contaminations. There is comparatively high amount of crude fiber than fat and crude protein.

Table 010: Proximate composition of the final product

| Parameter | Moisture | Ash | Crude protein | Fat | Crude fiber |
|---|---|---|---|---|---|
| Composition | 97.1% | 0% | 0.1% | 0.1% | 0.4% |

Brix, pH and percentage of tiratable acidity values of the final product are shown in the Table 02. According to that, both brix and pH values are inaccordance with the requirements for a RTS drink by Sri Lanka Standard Institute.Only percentage of titratable acidity is somewhat deviated from that. But pH value was mainly concerned in case of product safetythan percentage of titratable acidity and it was maintained at optimum level.

Table 02: Results of physicochemical properties of the final product

| Test | Mean Value |
|---|---|
| pH | 3.8 |
| Brix | 12.5 |
| Titratable acidity (%) | 0.5 |

According to the Table 03, yeast, mold and *Escherichia coli* in the final product are zero in 1 mL of the product. It is complied with the microbiological limits for a RTS drink by Sri Lanka Standard (SLS). Therefore product is safe for consumption.

Table 03: Results of microbial tests

| Test | Colony Count |
|---|---|
| Yeast and mold test | 0 CFU / 1 mL |
| *Escherichia coli* | 0 CFU / 1 mL |

Shelf life evaluation of the final product was conducted for one month period by evaluating the change in physicochemical properties and microbiological changes.Results of change in physicochemical properties are shown in Table 04. According to that, pH value has increased gradually during the first three weeks. In the fourth week there is a slight increase and fifth week there is no change in pH value. In order to prevent the microbial growth in the product, pH value should be lower than 4.2. That requirement for a RTS drink has not violated according to the pH values of the product during the one month period.Therefore product is microbiologically safe for consumption. A gradual decrease can be seen in percentage of titratable acidity of the final product. Brix value has not changed for first two weeks. It has increased gradually during last three weeks of the month. But the change in brix value has occurred within the acceptable range (12-16) according to the requirements of Sri Lanka Standard (SLS) for a RTS drink.

Table 04: Change in physicochemical properties of the product under shelf life evaluation

| | Physicochemical properties | | |
|---|---|---|---|
| Days | pH | Brix | Titratable acidity (%) |
| 0 | 3.7 | 12 | 0.52 |
| 7 | 3.8 | 12 | 0.48 |
| 14 | 4 | 12.3 | 0.41 |
| 21 | 4.1 | 13 | 0.36 |
| 28 | 4.1 | 13.6 | 0.34 |

Results of total plate count test conducted for three weeks under shelf life evaluation are shown in Table 05. According to that,there is a gradual increase in total plate count for three weeks. But that change complied with the requirements of Sri Lanka Standard (SLS) of total plate count (TPC) for RTS drink (Less than 50 in 1 mL of the product).Therefore product is safe for consumption.

Table 05: Change in total plate count of final product for three weeks

| Days | Mean plate count (CFU) |
|---|---|
| 7 | $9 \times 10^3$ |
| 14 | $18 \times 10^3$ |
| 21 | $28 \times 10^3$ |

## Conclusions

Product can be introduced to the consumers as a healthy leaf based beverage purely produced from Gotukola comprised with polyphenols. All the tested physicochemical and microbial parameters are fulfilled the requirements of Sri Lanka Standard (SLS) for RTS drink and therefore safe for consumption. According to the conducted shelf life evaluation,product has a one month shelf life.This is a good solution to reduce the wastage of "HeenGotukola" and to add value for this herb.

## Acknowledgement

Materials and laboratory facilities provided by the Food Research Unit, Gannoruwa are acknowledged.

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# Satisfaction of Low Country vegetable farmers about the agricultural extension service in Sri Lanka

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## Introduction

In Sri Lanka public sector organizations are the major party of extension delivery. The agricultural extension service in Sri Lanka was a greater service offering to all type of the farmers equally, irrespective of scale of farming. This service was started with the establishment of Department of Agriculture (DOA). The service was given by the DOA, agricultural research institutions and other agricultural related institutions in the state sector as public commodity. But this has reached to the critical stage. Large sum of public funds need to maintain and conduct the service. Due to the shortage of funds, government has to continue this service under big pressure. In this situation, due to lack of efficiency, effectiveness and not devoting sufficiently to the agriculture development of country government extension services are criticized as wasting public money (Mahaliyanarachchi, 2002)

This study was completed to find the satisfaction of low- country vegetable farmers on agriculture extension service in Sri Lanka. Objectives of the study were to determine satisfaction of farmers about the extension services, investigate factors which affect the satisfaction of farmers and find out extension needs of low- country vegetable farmers.

## Materials and methodology

This study was conducted in Anuradhapura and Monaragala districts where high productions of low- country vegetables are taken place throughout the year. Sample size was 200 farmers. Data were gathered using semi structured questionnaire. Semi- structured questionnaire was consisted to sought information on demographic characteristics of farmer (age, gender, education level, marital status etc.), information related farm (land extent, type of labour *etc*), information related to the extension service (frequency of the visit by the extension agent, methods of extension, teaching skills of the agent, communication skills of the agent and satisfaction of the farmers etc.)

Independent variables which were used to test hypotheses were subjected to judge by the respondents. The statement on a 5 point Likert scale of Strongly Agree (SA), Agree (A), Undecided (U), Disagree (D) Strongly Disagree (SA) and scores of 5, 4,3,2,1 were assigned to the corresponding responses for positive statement and the reversed scores for the negative statements. Using the minimum score of (1) and maximum score of (5): Dependent variable was Satisfaction of farmers: Satisfaction is the dependent variable which was inquired from the respondents directly. Farmers were asked to mention overall satisfaction about extension service. (1) Satisfied (2) Not Satisfied.

Data collection was done by the researcher. Personal interview was used to collect data according to the semi structured questionnaire. Sampled farmers of two districts were interviewed through field survey. Collected data were arranged, coded and analyzed through the use of Statistical Package for the Social Sciences (SPSS) computer programme. Both descriptive

and inferential statistical tools were used to analyze the data.Descriptive statistical tools used were frequency counts, percentages and mean.Inferential statistical tool was used to test the hypotheses of the study.Chi-squire test was used to measure the significant relationship between independent variables in the model and dependent variable in the model.

Logistic Regression Analysis used to test amount of variability of the dependent variables that could be explained by the independent variables. The regression coefficients identified and estimated how variable input included in the model best explained the variability on output.

The model is:

Log (p)= $\beta$0+ $\beta$1 X1+$\beta$2 X2+ $\beta$3X 3+$\beta$4 X 4 +$\beta$5X5+ $\beta$6X6+$\beta$7X7, $\beta$8X8, ...$\beta$12X 12

Log (p) – probability of being satisfied or not

$\beta$1…….$\beta$12 – Coefficients

$\beta$0 - Constant

X1- Extension source 1

X2- Frequency of visit

X3- Appropriateness of Extension method

X4- Perceived Qualifications of extension Agent

X5- Perceived practical knowledge of extension agent

X6- Adequate information delivery

X7- Timely information delivery

X8- Trustworthiness of extension agent

X9- Peer presence for decision making

X10- Continuity of extension service

X11- fairness of extension service

X12- Dealer presence for decision making.

**Results and Discussion**

Demographic characteristics of farmers

Majority (42% of total sample) of farmers is more than 50 years and 78% of farmers are male respondents. According to the findings only 5% of the farmers are single where 95% of the farmers are belongs to the married group. Highestproportion (48% of the total sample) of the respondents is able to get secondary education. Only 26% of the total sample is in no formal education group. 67.5% of the total sample is highest proportion in experience more than 15 years. Majority of the farmers are engaged in farming in full time. Approximately 84% farmers are members of any kind of agricultural organization. Approximately 35.5% of the sample of farmers has 1.5- 2.5 acres of land extent. Most of the farmers use family labours for their farming activities. According to the results own land percentage is 82.5% and other land percentage is 17.5%.

Extension Source Related Characteristics

Highest proportion (57%) of the farmers is get information from government extension source only. Nearly 30.5% of farmers useonly their own experience for cultivation. Approximately 4.5% of farmers areget information from both government and private input supply companies while 3.5% of farmers are get information only from private input supply company. And also 3% of farmers areget information from both government and non-government organizations. Only 1.5% of farmers are get information from non- government organization.Nearly 60% of farmers are experienced no visits by extension agents of their fields. Nearly 19.5% of farmers are able to get extension agent's visit when farmers required. Approximately 10% of total farmers arevisited by the extensionagent once per month while 5.5% of the farmers are visited by the extension agent twice per month. Only 5% of the farmers are experienced extension agent's contact thrice per month. Most (57%) of the farmers are required information regarding pest and diseases only. All information is needed by the 39.5% of total sample while agronomic practices and irrigation information required by 1% of total farmers and selection of crops for cultivation are required by 0.5% of total farmers. Most of the farmers use new hybrid varieties for their cultivation..

Social Behavior of Farmers

Approximately 45.5% of total farmers were strongly agreed that they rely on peer farmer's decision. Nearly 32% of farmers were agreed that they considered peer farmers as good decision body. Only 17% of farmers were disagreed about above condition while 3% and 5% of farmers had no idea and strongly disagreement accordingly.According to the data 20% of farmers were agreed that dealer was considerable decision making body for their cultivation. Approximately 14% of farmers were strongly agreed about above condition. Nearly 10% of farmers had no idea. Majority of farmers were disagreed. It was approximately 50%. Nearly 6% of farmers were strongly disagreed about above statement.

Satisfaction of Farmers on Agricultural extension sources

Most of the farmers were not satisfied about the extension sources. It was about 66.5%. Minority of farmers were satisfied about the extension sources. It was nearly 33.5%.According to the chi-squire test Extension source, frequency of visit by extension agent, appropriateness of extension methods, perceived qualification of extension agent, perceived practical knowledge of extension agent, adequate information delivery, timely information delivery, trustworthiness of extension agent, peer presence for decision making, continuity of extension agent, fairness of extension service, buyer presence for decision making variables were significant at 95% confident interval. From above variables Binary Regression was run.

Binary Regression Model yielded following results.

According to the model summery pseudo $R^2$ is 62.9% and 87.2%. -2 Log likelihood also smaller and near to zero. Therefore goodness of model is in considerable level.

Table 01: Variables in the Equation

| | | B | S.E. | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|---|
| Step 1[a] | EX.SOURCE * | .659 | .296 | 4.967 | 1 | .026 | 1.933 |
| | VISIT | -.171 | .271 | .400 | 1 | .527 | .843 |
| | METH | -.969 | .657 | 2.177 | 1 | .140 | .380 |
| | QUALI * | 1.705 | .591 | 8.325 | 1 | .004 | 5.499 |
| | PRAC | -.400 | .386 | 1.070 | 1 | .301 | .670 |
| | ADQINF | -.298 | .579 | .266 | 1 | .606 | .742 |
| | TIMINF * | 1.296 | .459 | 7.957 | 1 | .005 | 3.655 |
| | TRUST * | 3.264 | .865 | 14.231 | 1 | .000 | 26.165 |
| | PEER | .513 | .313 | 2.676 | 1 | .102 | 1.670 |
| | DEALER | -.597 | .339 | 3.092 | 1 | .079 | .551 |
| | CONTIN * | .972 | .359 | 7.337 | 1 | .007 | 2.644 |
| | FAIR | .383 | .359 | 1.140 | 1 | .286 | 1.467 |
| | Constant | -20.884 | 4.662 | 20.065 | 1 | .000 | .000 |
| Variable(s) entered on step 1: EX.SOURCE, VISIT, METH, QUALI, PRAC, ADQINF, TIMINF, TRUST, PEER, DEALER, CONTIN, FAIR. Significant at 0.05- * | | | | | | | |

Under 95% confident intervals

According to the results Extension source is significantly affect to the satisfaction of farmers about the extension source. Sig. is 0.026. Coefficient of perceived qualification of extension agent is + 0.659. It explains positive relationship with satisfied farmers and extension source. Frequency of visit by extension agent and Appropriateness of extension methodsis not significantly affect to the satisfaction of farmers about extension sources. The sig. values are in accordingly 0.527 and 0.140. Both of values are higher than p value. (0.05). It shows there is no relationship between Appropriateness of extension methods and satisfied farmers.

Perceived qualification of extension agent is significantly affect to the satisfaction of farmers about extension services since the sig. is 0.004. Coefficient of extension source is +1.705. It explains the positive relationship with satisfied farmers and perceived qualification of extension agent. It shows tendency of farmers to be satisfied about extension services when extension agents are with perceived educational qualifications.Above results highlighted Practical Knowledge of extension agent and adequate information delivery by the extension agent is not significantly affect to the satisfaction of farmers about the extension sources. The sig. values are 0.301 and 0.606 in accordingly.

According to the results timely information delivery by the extension agent is significantly affect to the satisfaction of farmers about the extension services. Sig.is 0.005. Coefficient of extension source is 1.296. It explains the positive relationship with satisfied farmers and timely information delivery by extension agent. It shows tendency of farmers be satisfied about extension services when extension agents are deliver timely information to the farmers.Trustworthiness of extension agent is significantly affecting to the satisfaction of farmers about the extension services. Sig is 0.000. Coefficient of extension source is 3.264. It explains the positive relationship with satisfied farmers and trustworthiness of extension agent. It shows the tendency of the farmers to be satisfied about the extension services when extension agents are trustworthy.

Peer presence for decision making, Dealer presence for decision making and Fairness of extension service is not significantly affect to the satisfaction of farmers about the extension services. Sig Values are accordingly 0.102, 0.079 and 0.286. Continuity of extension service is significantly affected to the satisfaction of farmers about the extension services. Sig is 0.007.

Coefficient of continuity of extension service is 0.972. It explains the positive relationship with satisfied farmers and continuity of service. It shows tendency of farmers to be satisfied about extension services when extension agents are increase continuity of service.

Equation

Logit(Satisfaction) = -20.884 + 0.659(Extension source) + 1.705(Perceived qualification) + 1.296(Timely information delivery) + 3.264(Trustworthiness of agent) + 0.972(continuity of service)

**Conclusion**

Majority of low country vegetable farmers are not satisfiedabout agricultural extension services in Sri Lanka. According to the finding of the study, Timeliness of information, trustworthiness of extension agent, perceived qualification of extension agent, extension source and continuity of extension source are the variables which are significantly affect to the satisfaction of extension service.

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# Nitrogen and potassium fertilizer response on growth and yield of hybrid Luffa –Naga f1 variety

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## Introduction

Luffa is a tropical and subtropical vegetable, belongs to family Cucurbiteceae. It is predominantly monoecious in sex expression and provides an ample scope for utilization of hybrid vigor. Hybrid varieties develop through open pollination, produce higher yields due to its hybrid vigor. Naga F1 hybrid variety consists number of desirable traits other than higher yield such as strong and vigorous plants, fruits with long deep ridges, attractive green color fruits ,better fruit weight, length and early maturity compared to the local Luffa cultivars.Unavailability of fertilizer recommendations for hybrid cucurbit vegetables leads to an excess fertilizer application causing a vital environmental issue that creates undesirable impacts on nature and the human health.

Main Objective of this research is to determine effect of different nitrogen and potassium fertilizer rates on growth and yield of Naga F1 Variety. Other objectives are, to evaluate specific growth parameters and yield, to identify the optimum nitrogen and potassium fertilizer levels based on growth and yield of hybrid Luffa variety. As well as to formulate the general fertilizer recommendation for hybrid Luffa -Naga F1 variety.

## Methodology

Hybrid Luffa - Naga F1 variety seeds were used as planting material. The experiment consisted of nine treatments involving three nitrogen fertilizer levels and three potassium fertilizer levels based on recommendation of the Department of Agriculture for local Luffa varieties. Recommended dosage of phosphorous fertilizer level was applied for each treatment.Fertilizers were applied at the basal dressing and two top dressings in three week intervals accordingly. Fertilizer sources for N, K and P are Urea, Muriate of Potash (MOP) and Triple Super Phosphate (TSP) respectively. The study was carried out in randomized complete block design.

Field experiment was conducted in order to obtain growth and yield parameters of Naga F 1 variety. Plant growth parameters were leaf number per vine and vine length at 1st, 2nd and 3rd weeks after planting intervals. Yield attributes were fruit girth, fruit length, yield per vine, yield per hectare up to ten consequent harvest. Laboratory analysis were performed in order to determine initial soil composition andnitrogen and potassium contents in leaves and fruitsat peak harvesting stage. Data were analyzed using Minitab 17 statistical software. Treatment means differences were evaluated by Tukey mean comparison tests at 0.05 significant level.

**Results and Discussion**

According to growth performances, significantly (P<0.05) highest mean vine length (14.8, 62.3, 118.7) was observed with T5 at 1WAP, 2WAP and 3WAP intervals respectively. T5 consisted with 75% (56.25Kg/ha) urea and 75% (45Kg/ha) muriate of potash fertilizer levels. Researches has proven slightly contrasting results regarding nitrogen fertilizer application rates in cucurbits. Das et al. (1987) observed significant increase in length of vine with the application of 90 kg nitrogen per ha compared to lower doses (0, 30 and 60 kg ha-1) of nitrogenin pointed gourd.

Table 01: Effect of N and K fertilizer levels on vine length

| | Mean Vine Length (cm) | | |
|---|---|---|---|
| Treatment | 1WAP | 2WAP | 3WAP |
| T1 N (0%) K (0%) | $14.0^{bc}$ | $57.2^{b}$ | $83.3^{g}$ |
| T2 N (75%) K (0%) | $12.9^{d}$ | $57.2^{b}$ | $106.0^{bc}$ |
| T3 N (150%) K (0%) | $14.2^{ab}$ | $39.6^{g}$ | $93.2^{ef}$ |
| T4 N (0%) K (75%) | $14.0^{bc}$ | $43.5^{e}$ | $96.7^{de}$ |
| T5 N (75%) K (75%) | $14.8^{a}$ | $62.3^{a}$ | $118.7^{a}$ |
| T6 N (150%) K (75%) | $14.5^{ab}$ | $48.3^{d}$ | $88.0^{fg}$ |
| T7 N (0%) K (150%) | $13.6^{c}$ | $43.6^{e}$ | $97.7^{cde}$ |
| T8 N (75%) K (150%) | $14.1^{bc}$ | $53.6^{c}$ | $103.4^{bcd}$ |
| T9 N (150%) K (150%) | $14.0^{bc}$ | $42.0^{f}$ | $111.3^{ab}$ |
| CV | 89.86 | 99.99 | 99.97 |

Values followed by the same letters are not significantly difference at $P \leq 0.05$

According to the yield performances exhibited in Table 02 , highest yield per ha (23.09 t) ) was recorded with the application of 150% (112Kg/ha) urea and 75%(45Kg/ha) muriate of potash fertilizer levels.Main effect of nitrogen fertilizer was significant ($P$<0.05) on yield per hectare.
This results were supported by Suresh and Papaiah (1991) that observed significantly higher fruit weight, number of fruits, fruit yield and fruit yield per ha with the application of 80 kg nitrogen per ha compared to lower doses of nitrogen (0 and 40 kg $ha^{-1}$) in bitter gourd.Umamaheswarappa*et al.* (2003) recorded increase in fruit yield with increased level of nitrogen in bottle gourd.

Table 02**:** Effect of N and K fertilizer levels on yield per ha

| Treatment | Yield per ha (t) |
|---|---|
| T1 N (0%) K (0%) | 12.26 [a] |
| T2 N (75%) K (0%) | 16.10 [a] |
| T3 N (150%) K (0%) | 17.59 [a] |
| T4 N (0%) K (75%) | 13.92 [a] |
| T5 N (75%) K (75%) | 21.36 [a] |
| T6 N (150% )K (75%) | 23.09 [a] |
| T7 N (0% ) K (150%) | 12.19 [a] |
| T8 N (75%) K (150%) | 21.64 [a] |
| T9 N (150%) K (150%) | 19.83 [a] |
| CV | 56.38 |

Values followed by the same letters are not significantly difference at $P \leq 0.05$

**Conclusions**

Naga F1 variety exhibited positive growth and yield responses at different nitrogen and potassium fertilizer levels in significant manner. At vegetative growth, better vine length was observed with the application of 75% (56.25 kg ha-1) urea and 75% (45 kg ha-1) muriate of Potash fertilizer combination level.According to the yield attributes, maximum yield per hectare was exhibited with the application of 150% (112 Kg/ha) urea and 75% (45 Kg/ha) muriate of potash fertilizer levels. A general fertilizer recommendation can be concluded as 150% (112 Kg/ha ) urea, 100% (65 Kg/ha ) triple super phosphate and 75% (45 Kg/ha )muriate of potashfor the selected Luffa hybrid - Naga F1 variety.

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# Patterns of fresh fruit consumption of households in Kurunegala

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## Introduction

Agriculture is the most common vocation of the Sri Lankan. Different varieties of fruits are cultivated in Sri Lanka's varied agro-climatic regions. Fruits play a major role in the well-being of consumers. Consumption of fruits contributes to an increase in the nutritional level of people. The food pyramid developed by the United States Department of Agriculture (USDA) recommends, 2-4 servings of fruits per day (Life clinic international, 2010). According to MRI the daily per capita requirement of fruits for a balanced diet should be 30-40 g (edible portion), which is approximately equivalent to 25-40 kg fresh fruit per head per year. However, Sri Lanka's per capita consumption of fruits and vegetables remains far below the required average daily intake (Ceylon Chamber of Commerce, 2010). In the process of enhancing fruit consumption, it is very useful to consider the needs, preferences and behavior of consumers. The main objective of this study is to find demand for different fruit types and the factors that influence households consuming of different fruit types.

## Methodology

A deductive research approach was followed. Survey strategy was used as a research strategy. Primary Data were collected through an interviewer administered questionnaires and most research questions had descriptive purposes. Before collecting data pilot test was used to identify the problems while responding to the questionnaires. Kurunegala District in North Western Province, was selected as the research area. It consists of 30 Divisional Secretariats, 1610 Grama Niladari Divisions and 4476 total Villages (Department of Census and Statistics, 2009). Kurunegala district has 412,897 households (District Statistical Branch, Kurunegala). The sample size was about 153 households which are from Kurunegala District. The stratified random sampling technique was used as sampling method to select households Types of fresh fruit consumption among different households and consumption frequency of different fruit types were analyzed by descriptive analysis. Chi-square Test was the statistical analytical tool applied in identification of consumption pattern of across various household groups. Microsoft Excel and Minitab 14.0 Software programs were used to analyze the data.

## Results and Discussion

Results reveal that there is no significant difference between three types of locality groups (urban, semi urban and rural) when they are consuming fruits. But rural residents had low expenditure on fruits compared to the urban and semi-urban resident, due to varieties of local fruit available in their home garden. Banana, papaw, mangoes and pineapple are the major fruits consumed in the Kurunegala District. The majority of the respondent did not intake fruit as daily consuming food. In Household fruit consumption, those who do not consume fruits daily, consume fruits around 3-4 days per week. In the study household banana consumption was 3 days per week while papaya, mango, and pineapple are consumed 2-3 days in a week. According

to the food pyramid developed by USDA, Kurunegala district household's fruit consumption is lower.

**Relationship between Social, Economic Characteristics and Fruit consumption**

Studies prove that age, gender, household size, income, occupation, education level, marital status significantly affects household fruit consumption (Whichelow and Prevost, 1996; Mirmiran *et al.*, 2009; Billson, 1999). The data were in line with previous findings from the USDA, that the major factors affecting fruits consumptions were income, age and education of consumers (Biing, 2004). Table 01, shows there are significant relationships between marital status, occupation, education level, income with household fruit consumption at the 0.05 significance level. At the same time, there were no significant relationship between gender, household size and age towards household fruit consumption at the 0.05 significance level. Therefore, in this study, household income, occupation, marital status, and education level have a significant relationship with household fruit consumption and age, household size and gender did not significantly affect the household fruit consumption.

Table 1: The Association between Socio Economic Characteristics and Fruit consumption

| Factor | Chi Square value | D F | P value |
|---|---|---|---|
| Marital Status | 99.000 | 9 | 0.000* |
| Occupation | 10.763 | 4 | 0.029* |
| Education level | 148.665 | 4 | 0.000* |
| Income | 18.416 | 4 | 0.001* |
| Gender | 7.307 | 4 | 0.121 |
| Household size | 7.169 | 4 | 0.127 |
| Age | 8.939 | 6 | 0.177 |

* Significant at 0.05 significance Level

Considering the preference to consume fruits, according to the gender, males consume same amounts of fruit as females. Age also seem to be indifferent in fruit consumption in households. Children, young, middle age, and adult group have the same preference to consume the fruits.

The study proves income has a significant effect on household fruit consumption. Besides the financial aspect just indicated – higher education generally means higher income. This could be correlated with greater knowledge and awareness of healthy eating habits in those households with higher education levels. The study also shows the marital status to have a significant effect on household fruit consumption at the 0.05 significance level. Being married positively impacts on the amounts of fruit consumed due to the Women seem to have a positive influence on their family intake, frequency, amounts and variety of the fruit eaten.

**Social environment and Personal factors affecting to fruit consumption.**

Availability of and access to fruit in the home garden is important for consumption of fruit. Similarly, the availability of and access to fruit and vegetables in the home is important for consumers in both children and adults. Also, concerning of fruit has high nutritional value, fruit can be taken as fast fruit and taste of different type of fruit, household member encourage them to eat fruit had an impact on their fruit consumption.

**Conclusion**

Banana, papaw, mangoes and pineapple are the major fruits consumed in the Kurunegala District. In Kurunegala district, Household fresh fruit consumption is averagely five to six fruit species per 3-4 days a week. Results showed that fruit servings per week have a significant relationship with education, monthly income, marital status, and occupation. Gender, Household size and age do not significantly affect the consumption of fruit. Marital status seems to play a significant role in the consumption of fruit. Being married is associated with increased fruit intake while being single/ divorced/ separated is associated with lower levels of fruit consumption. Low-income households spend less than higher income households on fruits. Therefore, understanding the consumption difference between income groups is important for targeting interventions for healthy eating. However, high costs may negatively impact on fruit intake levels. This does not only concern low income groups. Also, people with higher incomes perceive price as a barrier to consumption of these foods. Individual preferences, parental intake and home availability/accessibility towards fruit have an impact on consumption levels. The study proved Home gardens are a rich source of fruits, and have the potential of improving both intake and diversity of fruits in the diet.

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# Farmers perception on cultivating medicinal plants as an agribusiness venture: a study at Pambahinna agrarian services division

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**Abstract**

Medicinal plants have been used in Sri Lanka for many purposes since early civilization. Recently both national and international demand for ayrvedic medicinal materials has been increased due to increased health awareness. But unfortunately Sri Lankan cultivations presently do not at least provide for the demand for the country itself, this leads to import many plants from countries like India, Pakistan and Dubai. Therefore the propose of this research was to identify farmers perception on medicinal plant cultivation as an agribusiness which could be an important perspective to develop this sector. This research was particularly carried in Pambahinna Agrarian Services Division. In the research questions farmers experience and knowledge on medicinal plant, awareness on markets, potentials and constrains of this industry was discussed. A survey was conducted among randomly selected sample of 111 farmers within 10 GN (gramasewa niladari) divisions and obtain information through an interviewer administrated structured questionnaire. Data analyzing was done using mini tab 14 and MS Excel using descriptive statistics, graphical explanations, and *chi square* test. Concerning on awareness, many farmers were aware about the value of medicinal materials but they lack information about such agribusinesses so they lack motivation and inspiration
***Key words:*** Perception, Medicinal plants, Agribusiness

## Introduction

Common medicines like ginger, garlic, and coriander were used by ancient physicians and used by the people even today. In fact the chemicals used in western drugs were originally extracted from medicinal plants. There is a current trend evolving in many developed and developing countries to move back to old traditions in medicine and especially in beauty culture. The national demand for medicinal plant materials was 3,864,760 kg in 2000 and approximately 1,509,201 kg of this amount were imported to meet the national demand at a cost of about Rs. 13 million (Abeywardana, N and Hettiarachchi, J. K., 2001). Hence great potential exists to organize the cultivation medicinal plants on commercial scale to increase the domestic supply of raw materials (Joseph and Abeysekera, 2004; Gunasena *et al*., 2004). This paper looks at the farmers' willingness to cultivate medicinal plants as an agribusiness venture and to find out the potentials and constraints in medicinal plant cultivation.

## Objectives

### Broad objective

My broad objective is to find out farmer perception on planting medicinal plants as an agribusiness.

### Specific objectives

- To find out the level of experience and knowledge available within the farmer community on medicinal plant cultivation that would help them for easy adaptation process.
- To assess the level of farmer awareness on market demand, price and buyers of medicinal plants.
- To discover the potentials and constrains of this agribusiness in farmers point of view.
- To determine the farmers perception towards this business.

## Methodology

Research Design

- Research approach - Deductive research approach
- Type of the research - Descriptive
- Research strategy - Survey strategy

Target Population

- Target population was farmers in ten GN divisions in Pambahinna agrarian services division

Sampling Technique

- Systemic sampling

## 4. Results and Discussion 4.1 Demographic factors of farmers

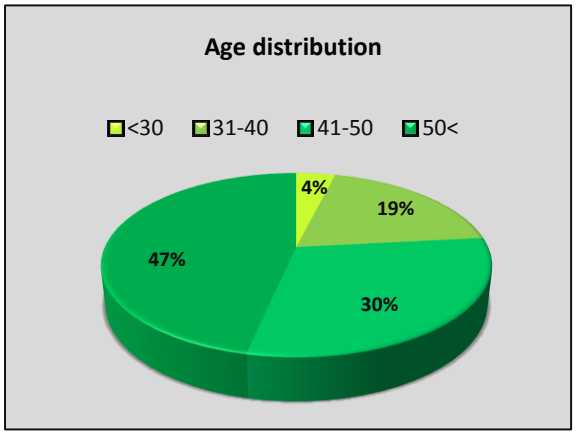


**Figure 4.1: Percentage of farmers based on age**

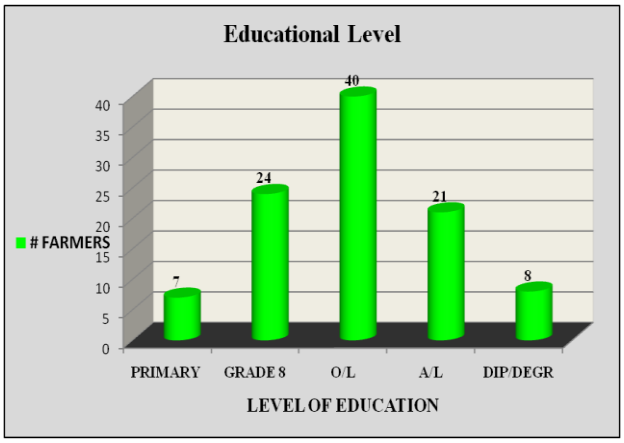


**Figure 4.2: Education level of farmers**

**Objective 1: Experience and knowledge available within the farmer community on medicinal plant cultivation**

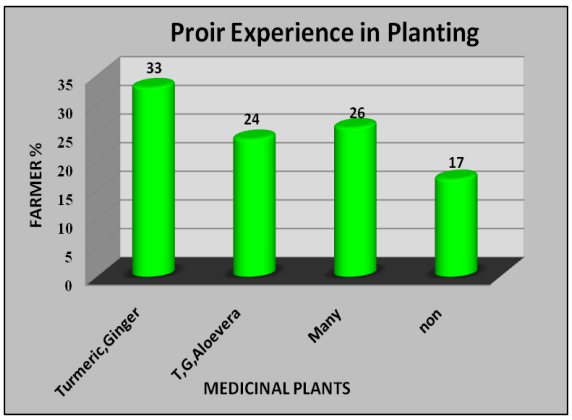


**Figure 4.3: Prior experience in planting**

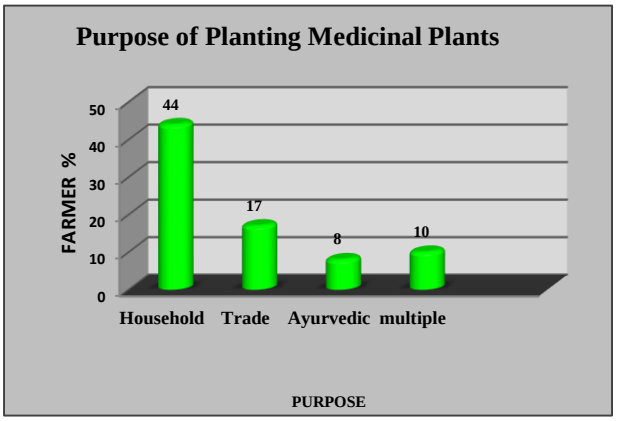


**Figure 4.4: Purpose of planting herbal**

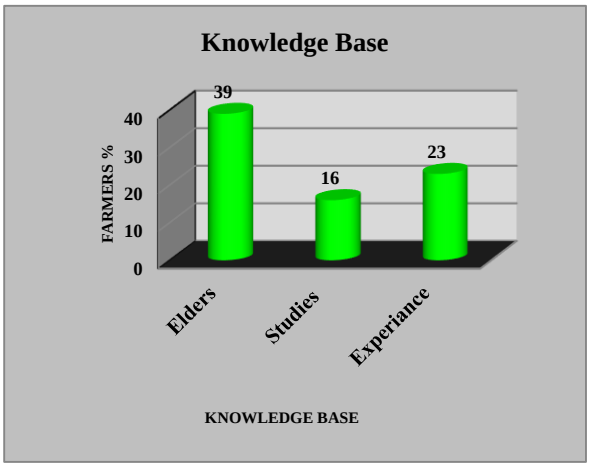


**Figure 4.5: Knowledge base**

**Table 3**: Factors effecting experience and knowledge

| Factor | Chi square | D.F | P. Value |
|---|---|---|---|
| Age | 29.221 | 1 | 0.000 |
| Farming experience | 12.936 | 6 | 0.008 |
| Gender | 11.851 | 3 | 0.044 |
| Level of education | 10.263 | 6 | 0.114 |

4.2.2 Relationship between factors effecting experience and knowledge on medicinal plant cultivation

**$H_0$**: There is no relationship between following demographic variables and experience and knowledge on medicinal plant cultivation.

**Objective 2: Farmer Awareness on Medicinal Plant Businesses and Its' Market.**

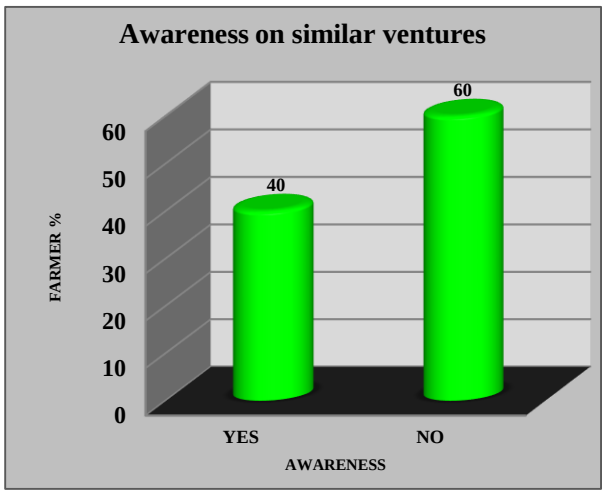


**Figure 4.5: Awareness on similar ventures**

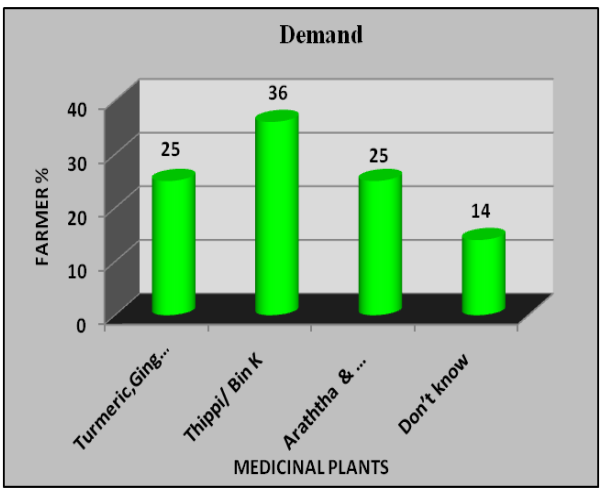


**Figure 4.6: Familiarity with demanded medicinal plants**

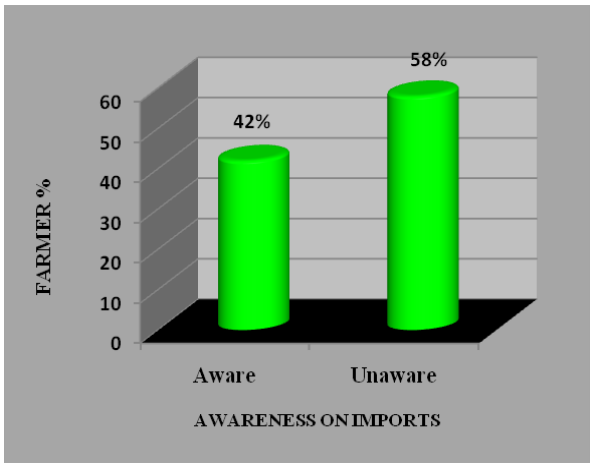


**Figure 4.6: Awareness on medicinal plant material importation.**

Objective 3: Potentials and Constrains of This Business in Farmers Point of View

Table 5: Reasons for the willingness to adopt

| Reasons | Mean | Mode | S D |
|---|---|---|---|
| Can find planting materials easily | 4.21 | 5 | 2.844 |
| This is high profit generating business | 1.746 | 1 | 2.496 |
| High plant vigor and easy to maintain | 5.25 | 4 | 2.08 |
| Supportive climatic condition | 2.713 | 3 | 1.853 |
| As a secondary source of income | 2.234 | 2 | 1.772 |

Table 6: Reasons for not to start this venture

| Reasons | Mean | Mode | S D |
|---|---|---|---|
| Land limitation | 1.246 | 1 | 1.573 |
| Demand uncertainty | 2.231 | 2 | 1.363 |
| Loopholes in value chain and theft | 2.385 | 3 | 1.387 |
| Hesitance to change from current business | 4.231 | 4 | 2.006 |
| Lack of knowledge on medicinal plants and their cultivation | 5.231 | 5 | 1.964 |

Objective 4. Farmer Attitudes in Practicing Medicinal Plant Cultivation as a New Business.

| STATEMENT | Disad. | Nura. | Agre.. | mode | mean | S.D |
|---|---|---|---|---|---|---|
| Medicinal plants are easy to maintain | 13 | 20 | 67 | 4 | 4.18 | 0.697 |
| There is a high demand for medicinal plants | 2 | 25 | 73 | 4 | 3.7 | 0.435 |
| This is a potentially profitable business | 13 | 38 | 49 | 4 | 3.39 | 0.704 |
| This business will be a good industry in future | 12 | 45 | 43 | 3 | 2.5 | 0697 |
| I would like to try this new venture | 14 | 25 | 58 | 4 | 3.46 | 0.736 |

## Conclusion

Majority of the farmers have enough capacity and will to engage in this business. If they are provided with a slight assurance on buyers, necessary information on the market. And if they are aware of the shortage of supply in national level, there could be a possibility of getting more farmers involved in medicinal plant cultivation as a venture or as an additional income source. Therefore, it is recommended from this study to create awareness on the potential of growing medicinal plants as a venture will encourage them to grow medicinal plants.

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# Technical Session - Palm & Latex Technology and Value Addition

## Table of Contents

## Oral Session

# Poster Session

# Effect of vulcanizing and antioxidant systems on aged tensile properties of MicrOptic gloves

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## Introduction

MicrOptic glove is a powder free surgical glove which is made out from the natural rubber latex. Thin nature of MicrOptic glove facilitate exceptional dexterity and tactile sensitivity and at the same time outstanding strength and barrier protection (Ansell Medical GBU, 2014).Aged tensile properties of the glove cannot be maintained in a stable level due to the thin nature of the glove. Natural rubber vulcanizates can be given adequate heat-aging resistance by a suitable choice of vulcanization and by using ammine or phenolic antioxidants (Morton, 2010). The study was conducted to disclose the effect of vulcanizing system, antioxidant system and their combined effect on aged tensile properties of MicrOptic glove.

## Materials and Methodology

The study was carried out centralizing to Ansell Lanka (Pvt) Ltd, EPZ - Biyagama. Aged tensile test was done at Quality Control (QA) laboratory at Ansell Lanka (Pvt) Ltd. Nine trials with different treatments were conducted during this study. 0.5 pphr elementary sulphur(V1), 0.25 pphr elementary sulphur with 0.5 pphr sulphur donor compound (V2) and 0.25 pphr elementary sulphur with 1.0 pphr sulphur donor compound (V3) were utilized as three different vulcanizing systems in MicrOptic formula. 1.5 pphr primary antioxidant (A1), 1.0 pphr primary antioxidant with 0.25 pphr secondary antioxidant (A2) and 1.0 pphr primary antioxidant with 0.5 pphr secondary antioxidant (A3) were utilized as three different antioxidant systems in MicrOptic formula.

All the dispersions of vulcanizing agents and antioxidants were made by using laboratory scale ball mill. Nine glove compounds with three replicates were produced according to MicrOptic glove formula except the vulcanizing agent and antioxidant system. Vulcanizing agents and antioxidant were added according to the treatment combinations.The compounded latex was kept for 36 hours to obtain optimum degree of crosslinks. 65 - 75 % toluene swelling index (TSI) was used as optimum degree of crosslinks.Sample gloves are made under laboratory conditions.Clean former was heated up to 65 ºC by using an oven and then former was dipped in a MicrOptic glove coagulant solution at 65 ºC with constant time of 22 seconds. Coagulant solution was dried by using an oven and heated up to 55 ºC. Then former was dipped in latex solution with constant time of 23 seconds and bead of the glove made by manually. After that gloves were leached in hot water (70 ºC) for 2 minute. Finally, formers with gloves were cured at 120 ºC for 35 minutes.

Aged tensile properties (ATP) such as force at break (FB), elongation at break (EB) and 500 % modulus (MOD) were measured according to the BS EN 455-2:2000 standards. Factor factorial in complete randomized design was conducted and data obtained from aged tensile properties were subjected to analysis of variance (ANOVA) using the general linear model procedure of

MINITAB 16. Significant means of treatments were separated using the least significant difference (LSD) ($P< 0.05$) test.

**Results and Discussion**

The study revealed that the effect of vulcanizing system on force at break, elongation at break and 500 % modulus were significant ($p < 0.05$). Also combine effect of vulcanizing system and antioxidant system on force at break, elongation at break and 500 % modulus were significant($p < 0.05$).Further, this study disclosed, the effect of antioxidant system on elongation at break was significant ($p < 0.05$). However, effect of antioxidant system on force at break and 500 % modulus were not significant at 5% significant level.

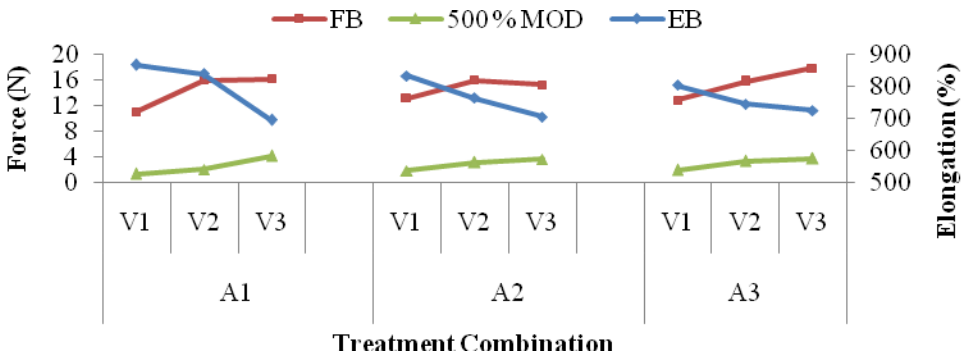


*Figure 01: Effect of Vulcanizing Systems on ATP under different Antioxidant Systems*

All the antioxidant systems show gradual recession of elongation at break, when increasing the amount of sulphur donor content while reducing elementary sulphur content in MicrOptic formula. But, the elongation values were significantly different for different vulcanizing systems separately in all antioxidant systems. Also, all the antioxidant systems (except A2 antioxidant system) showed gradual development of force at break, when increasing the amount of sulphur donor content while reducing elementary sulphur content in MicrOptic formula. Further,all the antioxidant systems show gradually development of 500 % modulus, when increasing amount of sulphur donor content while reducing elementary sulphur content in MicrOptic formula.

According to Subramaniam (2002), elementary sulphur is more prone to produce poly-sulphide crosslinks among rubber molecules. Further, higher number of poly-sulphide crosslinks contribute to increase stretching ability of the vulcanizate. Lesser amount of elementary sulphur cause to reduce number of poly-sulphide crosslinks and it abates stretching ability of the glove and lesser force is required to stretch the vulcanizate. Also, Morton (2010), showed that the amount of cyclic sulphur and the excessive sulphur in the crosslinks contribute to the poor aging properties of the vulcanizate.

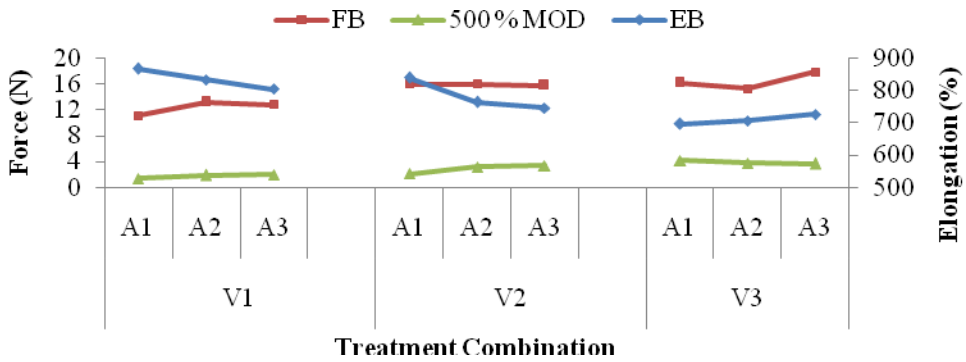


Figure 02: Effect of Antioxidant Systems on ATP under different Vulcanizing Systems

V1 and V2 vulcanizing systems showed gradual recession of elongation at break, when increasing the amount of secondary antioxidant content while reducing the primary antioxidant content in MicrOptic formula. But, the V3 vulcanizing system showed development of elongation at break, when increasing the amount of secondary antioxidant content while reducing the primary antioxidant content in MicrOptic formula. Also,V2 and V3 vulcanizing systems showed development of force at break, when increasing the amount of secondary antioxidant content while reducing the primary antioxidant content in MicrOptic formula. Further, V1 and V2 vulcanizing systems showed development of 500 % modulus, when increasing amount of secondary antioxidant content while reducing primary antioxidant content in MicrOptic formula. But, the V3 vulcanizing system shows recession of 500 % modulus, when increasing the amount of secondary antioxidant content while reducing the primary antioxidant content in MicrOptic formula.

According to Brydson (1988), polyphenolic antioxidants are bound with the rubber molecules and a heavy network is produced compared to hindered phenolic antioxidants. Inducing a heavy network nature among the rubber molecules was reduced the stretching ability of the vulcanizate. According to Subramaniam (2002), the simple hindered phenolic antioxidants do not show particularly good heat resistance and equivalent molecular weight are more volatile than the polyphenolic antioxidants. He also presented that higher molecular weight and less volatile polyphenols show better antioxidant properties compare to simple hindered phenols.

## Conclusions

The study revealed that the possibility of improving aged tensile properties of MicrOptic glove manufactured using only elementary sulphur and primary antioxidant by combining elementary sulphur with sulphur donor compound as the vulcanizing system and primary antioxidant with secondary antioxidant as the antioxidant system.

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# Property variation of centrifuged latex at different maturity stages in glove manufacturing

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## Introduction

In the glove manufacturing industry, quality of the centrifuged latex is highly concerned. Properties of the centrifuge latex can be deviate from the acceptable level with the maturity. Therefore study of the variation of both chemical and physio mechanical properties of centrifuge latex with the maturity is very much important for the manufacturers of latex products (Riyajan, 2009). Normally it is not possible to obtain the required amount of field latex for the centrifugation due to the rainy season in the country. But the manufactures of latex gloves have to maintain their production without discarding any order of the buyers. To overcome this problem, manufacture has to concentrate an alternative way for the glove manufacturing. Therefore low matured latex is also used in some extent while mixing with the matured latex during the compounding.

Main objective is to determine the usage of low maturity latex (before 21 days maturity) for the production of house hold glove manufacturing while studying the properties of centrifuged and compounded latex at different maturity stages.

## Methodology:

Centrifuged latex was obtained from the Centrifuge unitof Lalan Rubbers pvt Ltd at Warakapola. Freshly produced centrifuged latex was selected to conduct the research activities. Different maturity periods were set as treatments for research study and seven treatments were applied to get results. During this experiment, changes of both chemical and physiomechanical properties of centrifuged latex were evaluated at different maturity stages. Experiment was started after 5 days maturity of centrifuged latex and continued up to 65 days maturity periods.

Table 01: Treatment combination of the research

| Treatments | Description (Maturity days) |
|---|---|
| Treatment 01 | 05 |
| Treatment 02 | 15 |
| Treatment 03 | 25 |
| Treatment 04 | 35 |
| Treatment 05 | 45 |
| Treatment 06 | 55 |
| Treatment 07 | 65 |

Centrifuge latex was obtained according to ISO 123:2001 sampling procedure from the latex storage tank. Latex was taken from the top, middle and bottom part of the centrifuged latex storage tank. Then they were homogenized and three replicates were taken to continue the test procedures. Total solid content(TSC), dry rubber content(DRC), viscosity, alkalinity, mechanical stability time(MST), volatile fatty acid content(VFA), non-rubber content and KOH number were measured as chemical properties of centrifuged latex by following ISO standards.

To evaluate physiomechanical properties, 10 kg of centrifuged latex were separated and latex compound was prepared according to the standard house hold glove formulation at Lalan Rubber factory. Tensile strength, tear strength, aging properties and crosslinking density were measured as physio mechanical properties. The experiment was conducted in Complete Randomized Design with three replicates. Minitab 16 statistical software was used to analyze the variance of the quantitative characters followed by the Tukey test at the 0.05 probability level as mean separation technique.

**Results and discussion**

The results obtained in the study and there explanations can be summarized as follows.

Table 02: Chemical properties variation with maturity

| **Treatment** | **Description (Maturity day)** | **Measured values** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Viscosity (cps)** | **Alkalinity (%)** | **DRC (%)** | **MST (s)** | **VFA** | **TSC (%)** | **KOH** |
| 1 | 05 | 76.00[a] | 0.650[b] | 60.29[a] | 272.7[d] | 0.0153[c] | 62.07[a] | 0.50[b] |
| 2 | 15 | 64.66[b] | 0.590[d] | 60.41[a] | 1035.0[c] | 0.0183[b] | 61.97[a] | 0.50[b] |
| 3 | 25 | 60.33[c] | 0.586[d] | 60.22[a,b] | 1160.0[b,c] | 0.0216[a] | 61.83[a] | 0.69[a] |
| 4 | 35 | 54.66[d] | 0.619[c] | 60.00[b] | 1240.0[a,b] | 0.0213[a] | 61.26[b] | 0.67[a] |
| 5 | 45 | 57.66[c] | 0.593[d] | 60.33[a] | 1261.7[a,b] | 0.0220[a] | 61.85[a] | 0.68[a] |
| 6 | 55 | 58.50[c] | 0.589[d] | 60.17[a,b] | 1363.0[a] | 0.0216[a] | 61.80[a] | 0.71[a] |
| 7 | 65 | 50.00[e] | 0.723[a] | 59.37 [c] | 1234.3[b] | 0.0226[a] | 60.94[c] | 0.71[a] |
| | Standard | 50-60 | <0.75 | 60.0 | >600 | <0.02 | 61.5 | <1 |

| **Treatment level** | **Description (Maturity days)** | **Means of tensile strength** | **Means of 100% modulus** | **Means of 300% modulus** | **Means of Elongation @ break** | **Aged tensile strength** |
|---|---|---|---|---|---|---|
| 1 | 5 days | 19.96[b c] | 1.3846[a] | 3.8024[c] | 538.4[b,c] | 21.61[d] |
| 2 | 15 days | 19.43[c d] | 1.42980[a] | 7.1604[a] | 425.3 [e] | 26.77[a] |
| 3 | 25 days | 19.98[b c] | 1.115[b] | 3.5224[c] | 569.3 [a] | 20.17[e] |
| 4 | 35 days | 20.81[b] | 1.0652[b] | 5.5456[b] | 523.2 [c] | 20.36[e] |
| 5 | 45 days | 18.54[d e] | 1.0956[b] | 2.7886[d] | 452.6 [d] | 21.13[d] |
| 6 | 55 days | 18.10[e] | 0.8828[c] | 2.7886[d] | 551.2[a b] | 23.63[c] |
| 7 | 65 days | 22.45[a] | 1.0802[b] | 5.3224[b] | 518.2 [c] | 24.65[b] |

Table 03: Physio mechanical properties variation with maturity

Viscosity of the centrifuged latex decreased with the maturity time. According to the literature hydrodynamic influence, DRC and temperature affect to deviations of viscosity value (Sashidaran, 2005). Alkalinity was also maintained at the standard level. DRC is also maintained at standard level for the centrifuged latex and deviation can be seen in 65 days DRC value. Addition of ammonia could be a reason to that result. MST values are maintained at standard level from 15 days maturity to 65 days maturity period. Lipid hydrolysis of the latex was a prominent reaction that contributing higher fatty acid (HFA) to the medium. Then these HFA can contribute to increase the stability of MST in the latex sample. VFA and KOH were gradually increase with the maturity time and maintained in the standard range. Acid content of the centrifuged latex can be increased due to activities of the microbes (Bleckley, 1997). Microbes can feed on proteins and other non-rubber particles while producing fatty acid.TSC values were maintained in the acceptable range of the centrifuged latex. But some fluctuations could be seen in TSC at 35 and 65 days values due to addition of ammonia liquid in to the latex. Non rubber content of the centrifuged latex was below the acceptable range (less than 01) of the centrifuged latex.

According to the results, there was a significant difference (P=0.000) in physio mechanical properties and aging properties of the Latex with the maturity times. The standard values for

tensile strength before and after aging for household gloves are minimum 10 MPa ($N/mm^2$) and minimum 7.5 MPa respectively. According to the results both unaged and aged tensile strength values were higher than standard values. Maximum tensile strength can be seen in 65 days matured latex film. Crosslinking density was between $1\times10^{17}$ - $3\times10^{17}$ crosslinks/g after 25 days maturity.

## Conclusions

The results achieved through the research showed that the chemical and physio mechanical properties of 15 days matured centrifuged latex were also in the ideal range for the house hold glove manufacturing. Therefore, it is not needed to delay the production until 21 days maturity of centrifuged latex and then it will help to reduce the cost of storage, improve the cash flow and to increase the efficiency of production.

Further, ideal chemical and physio mechanical properties were showed up to 65 days maturity of the centrifuged latex. Therefore, centrifuged latex could be used between the 15 to 65 days maturity range for the house hold glove manufacturing.

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# Effect of different types of fillers on properties of natural rubber latex foam

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## Introduction

Natural Rubber Latex Foam (NRLF) is a cellular rubber, which is made directly from centrifuged latex with 60 % dry rubber content and it gives a cushioning effect for a wide range of applications such as mattresses, pillows, cushions, upholstery, carpet backing and shoe arches. If there is a possibility of replacing a certain amount of natural rubber latex in these products, while maintaining the expected physico mechanical properties by incorporating another low cost material (filler), it would reduce the cost of production. Therefore a study was conducted to develop different natural rubber latex foam by incorporating five types of commercially available mineral fillers in five different loading levels. Fillers can stiffen the rubber phase of the foam. Therefore comparable load bearing characteristics can be obtained at higher expansion with the incorporation of filler (Blackley, 1966). There by material cost can be decrease.

## Methodology

Samples were prepared by incorporation of talc, dolomite, calcite, 50:50 blend of dolomite and calcite and china clay as filler materials. Each of these fillers was incorporated in NR latex foam at 5 phr, 10 phr, 15 phr, 20 phr and 25 phr loading levels.Latex foam was prepared using a batch technique. The foam preparation was carried out in a Hobart type planetary mixer.
To develop twenty five different foams all of these were replicated three times and they were arranged in Complete Random Design. Indentation hardness index, compression set, tensile strength and density properties of the test samples were compared against the reference sample which was prepared without incorporating fillers.

## Results and discussion

Hardness of the compound increases with the increase of calcium carbonate filler loading up to 20 phr and it decreases beyond this filler loading. The increase in hardness may be due to fillers acting as hardening agents in rubber compounds and uniform filler distribution in the rubber phase. At higher filler loadings beyond 20 phr, the decrease in hardness is probably a result of aggregation of calcium carbonate.

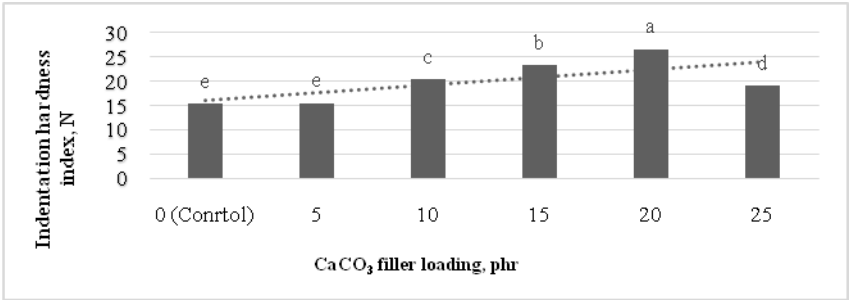


Figure 01. Variation of Hardness of NRLF with $CaCO_3$ Filler Loading Levels

Increasing the filler loading in foam compound simultaneously increases the mass of the compound, while having an equal volume. Therefore, density of the compound is increased along with the calcium carbonate loading.

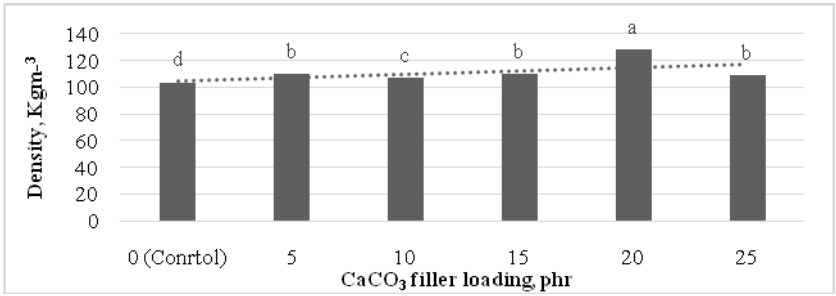


Figure 02. Variation of Density of NRLF with $CaCO_3$ Filler Loading Levels

The gum compound shows the lowest compression set due to better recovery after the force on the test piece is released and can be attributed to more rubbery nature of the compound. However, addition of filler causes to reduce the rubbery nature of the compound. Therefore, filler loaded compounds show a lower recovery after the force on the test piece is removed.(Ramasamy *et al*., 2013)

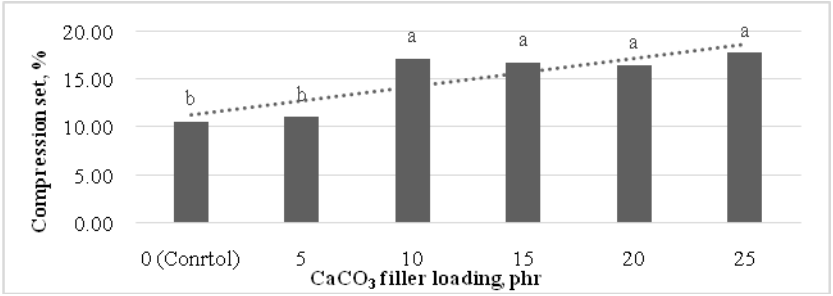


Figure 03. Variation of Compression set of NRLF with $CaCO_3$ Filler Loading Levels

Calcium carbonate, which is known to be a non-reinforcing(particle size more than 5000 nm)filler. Therefore calcium carbonate has poor dispersion in the rubber matrix. Therefore, the reinforcement given by calcium carbonate to the compound is less, which eventually results in low tensile strength.

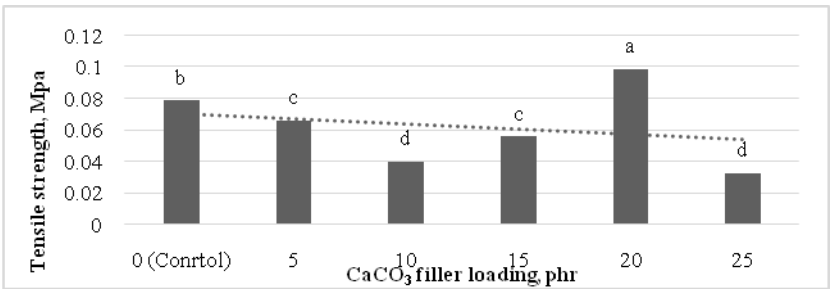


Figure 04. Variation of Tensile Strength of NRLF with $CaCO_3$ Filler Loading Levels

Testedphysico mechanical properties of all fillers which are comparable with the reference are summarized in Table no 01.

Table 01. Tested Physico Mechanical Properties of all Fillers against Control

| | **Hardness (N)** | **Density ($kgm^{-3}$)** | **Compression set (%)** | **Tensile strength (Mpa)** |
|---|---|---|---|---|
| **Reference (control)** | 15.3 | 103.3 | 10.60 | 0.079 |
| **Calcite - 5 phr** | 15.5 | | 11.10 | |
| **Talc - 10 phr** | 15 | 102.9 | | 0.055 |
| **Dolomite - 10 phr** | 11.9 | | | 0.079 |
| **Calcite + Dolomite 5 phr** | 15.4 | | 12.36 | 0.084 |
| **China Clay 20 phr** | | | 12.00 | 0.085 |

**Conclusions**

The compression set and the indentation hardness index of foam which contains 5 phr of calcite was comparable with those of the reference foam made without any filler. Density, tensile strength and indentation harness index of the foam which was loaded with 10 phr of talc was comparable with those of the reference foam. Moreover, the tensile strength and indentation hardness index of the foam which was loaded with 10 phr of dolomite was comparable with those of the reference foam. Further, hardness, compression set and indentation hardness index of the foam which contain 5 phr of 50:50 blend of dolomite and calcitewas comparable with those of the reference, whilst the foam containing 20 phr of china clay exhibited similar compression set and tensile strength to those of the reference foam. Also the results indicate that, upto 20 phr filler loading level, most of the required properties could be maintained in all filler types.

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# Factors Affecting Farmers' Willingness to Pay for Jatropha Biodiesel

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## Introduction

Sri Lanka in its principle policy aims to produce at least 20% of energy requirement by renewable energy source by 2020. Still not much attention has been paid on bio fuels. *Jatropha curcas* L. is found to be a potential alternative source of renewable energy since its cultivation and oil extraction contribute to sustainable development, poverty alleviation, combating of desertification, reduction of greenhouse gas emissions and women empowerment in developing countries (Pushpakumara et al, 2008, and Francis et al, 2005). *Jatropha* has various socio-economic benefits which makes it more economical when cultivated on commercial scale. Like other vegetable oils, *Jatropha* oil can be used directly in modified diesel engines for automobile applications. Its adaptability to marginal conditions is an advantageous feature, which other oil producing crops do not have (Pushpakumara et al, 2008), thus it has the ability to reclaim problematic lands and restore eroded areas (Francis et al 2005). *Jatropha* originated biodiesel is less expensive to produce than other energy crops such as rapeseed and soybeans. This study looks at the demand for *Jatropha* produced biodiesel. Initially, it is unlikely to be used as a substitute for diesel. *Jatropha* biodiesel or Straight oil can be used at village level to operate farm machinery and for day to day activities at small scale. If there exist a willingness from farmers to use biodiesel at least in short term then *Jatropha* could be used as an additional income source. By-products of *Jatropha* biodiesel can also be sold. Thus this study looks at what factors affect rural farmers' willingness to pay for *Jatropha* biodiesel.

## Methodology

Welfare estimation is based on Indirect utility and Minimum expenditure functions. Lancaster's (1971) theoretical model for demand estimation is expanded to include other empirical variables. Contingent Valuation Method (CVM) can be viewed as a direct measure of welfare change. WTP as a function of,

$$WTP = F(Y, P, Z, Q_0, Q_1) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where, Y income, P is a price vector, Z is a vector of socioeconomic variables, and $Q_0$ and $Q_1$ are the environmental quality at status quo and improved levels respectively.

Since bid is a binary outcome a logit regression was employed assuming binomial distribution.

$$WTP * \begin{cases} 1 & if\ yes\ for\ bid \\ 0 & otherwise \end{cases}$$

$$WTP^{*} = X_j'\beta + \varepsilon_j \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Denoting the willingness to pay determinants as a vector, *X*, then for each respondent *j=1 …. N in* the sample, the latent variable, WTP*, can be written as in equation above for a single bounded model. β is the vector of parameters estimated. In this model the dependent variable was the level of willingness to pay for Jatropha Biodiesel. Numeric value of one was assigned to respondents who were willing to pay for Jatropha biodiesel and zero was assigned to the respondents who were not willing to pay for Biodiesel. Socio economics characteristics and attitudes about environment were used as independent variables. A survey was conducted in Hasalaka, Kandy covering 310 farmer households to estimate the WTP for *Jatropha* diesel and the factors affecting their decisions.

**Results and Discussion**

The below table 1 summarizes the results of the logit regression for WTP for Jatropha biodiesel. According to the results, males are 49% less likely to go for Jatropha biodiesel than females. People with higher age are less likely to pay for Jatropha biodiesel when compared to younger respondents. A one year increase in age decreases the likelihood to select biodiesel by 0.4%. Socioeconomic variables like marital status, total income, and employment did not show any significant relationship. Respondents who have heard about global warming are 11% less likely to pay for biodiesel and people know about global warming are 36% less likely to buy biodiesel than the reference group. They may be educated and knows about global warming. Thus, they might have an idea about other alternative fuels which might affect their answers. It is human nature that when people are presented with information, the uneducated might buy without any scepticism, whereas educated people may be having doubts as they too think about the possibility of making biodiesel once they are informed about this. Proper income earners might not want them into risks. So, they might stick to the conventional diesel given its availability around the country. Some may already get an additional income through other investments in their land.

People who have land to cultivate other crops are 11% less likely to go for Jatropha biodiesel. When the energy cost increase by one rupee likelihood of choosing biodiesel increases by 0.011%. It should be reminded that energy cost is a continuous variable and it accounts for the expenditure incurred in fuel plus monthly electricity expenditure. When people spend too much on an item, they will seek for any alternative substitutes at lower price. Rational people with limited resources will buy those resources which are highly demanded even by paying some additional amounts. Households where women participate in household decision making are 18% more likely to choose biodiesel. In Sri Lanka, household chores are governed by females they may be more cautious to reduce their total family expenditure per month. An Rs 1000 increase in energy cost will increase the likelihood to pay for biodiesel by 11%. Households with food insecurity are 22% less likely to choose biodiesel. The intuition here is whenever a

household is at a position where they cannot meet their basic needs with what they are receiving as income then, those household will always tries to maximize their utility for basic needs. An inverse relationship exists between food insecurity and WTP for biodiesel. People who have considerable amount of social capital are 26% more likely to choose biodiesel. Social capital measures the connection a household has with the society. Social capital is an important asset as the individual can use this resource to generate profit by careful delegation.

Table 01: Results of logit regression for factors affecting WTP for Jatropha Biodiesel

| DV=WTP(1/0) | Coefficint | P>\|Z\| | Marginal Effect (dy/dx) % |
|---|---|---|---|
| Gender_Male | -2.5227*** | 0.001 | -0.4965 |
| Age | -0.0376** | 0.041 | -0.0048 |
| Education_years | -0.0166 | 0.778 | -0.0021 |
| Marital Status | 0.3452 | 0.701 | 0.0490 |
| Total Income | 1.65e-06 | 0.917 | 2.11e-07 |
| Employment-Farmer | -1.2206 | 0.251 | -0.1303 |
| Employment -Government | 2.5481 | 0.167 | 0.0623 |
| Employment -Self employed | -1.5672 | 0.174 | -0.1912 |
| Employment -Private | -1.2201 | 0.371 | -0.1302 |
| Global Warm_heard | -1.3531*** | 0.002 | -0.1145 |
| Global Warm _know | -2.6574*** | 0.006 | -0.3688 |
| Land for crops | -0.9678** | 0.011 | -0.1175 |
| Energy cost | 0.0008** | 0.014 | 0.0001 |
| Women | 2.3466*** | 0.006 | 0.1816 |
| Food-insecurity | -1.4373 *** | 0.001 | -0.2227 |
| Economic access | 0.2811 | 0.352 | 0.0360 |
| Social well being | -0.1111 | 0.732 | -0.0142 |
| Social capital | 2.0598** | 0.000 | 0.2639 |
| Constant | 3.0221** | 0.098 | |
| N = 305 | LR chi2(20) = 167.96 | | Probability > chi2 = 0.0000 |
| Log likelihood = -118.1111 | | Pseudo R2 = 0.4156 | |

***, **,*Significant at 1%, 5% and10% significance level respectively.

**Conclusions**

This paper examined the factors affecting willingness to pay for Jaropha biodiesel by farmer households. Older male and respondents knowledgeable on global warming, food insecure households are less likely to pay for biodiesel. Higher energy cost, women's role in decision making, higher social capital affect WTP for biodiesel positively. Significant factors are in line with the economic theory and showed expected

signs. One caveat is that when people are given an opportunity to increase their income, farmers might agree even without analyzing the possibility of such a venture given their experiences in farming.

**Acknowledgement**
Authors acknowledge the NSF Grant No: RG/2009/Biofuel 002 to carry out his study.

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# Youth perception to undertake the management of small scale rubber plantations

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## Introduction

Sri Lanka is one of the nine major producers of natural rubber in the world. Kegalle, Kalutara and Rathnapura are the major rubber growing districts in Sri Lanka. These districts recorded the highest significance in terms of cultivated area. Small holders are the persons who are holding below 50 acres in extent. Most of the rubber lands in Sri Lanka are owned by small holders. The extent of land area under small holders is about 79,395 hectares out of total rubber land extent in 2010 (Census of Rubber Lands, 2010).Therefore, smallholder sector is responsible for a major share of Sri Lanka's contribution to world's natural rubber output. However, declining rubber extent is an issue of national concern to Sri Lanka (Wijesuriya *et al.*, 2006). Youth participation in agriculture for its sustained contribution to a nation's development is crucial (Ahaibwe, *et al*,. 2013). Therefore, this research was carried out to determine the perception of youth regarding undertake the management of small scale rubberplantations to maintain the continuity and toidentify the constraints of youth to involve with themanagement of these rubber plantations.

## Methodology

The research was conducted in three Rubber Development Officer (RDO) divisions in Kalutara district which are named as Agalawatta, Bulathsinhala and Dodangoda. The population of this study is all the small scale rubberplantation ownersand their youthwho are in age between 18- 35 years in Kalutara district. One hundred twenty youth and one hundred twenty small scale rubber plantation owners were used as respondents for the study. Forty plantation owners and forty youth were randomly selected from each three RDO divisions forthe data collection. Two questionnaires were prepared for the owners of the plantations and youth in their families. Responsevariable of the study was youth perception of engage with rubber plantation management. The contextual variables were carrer ambition, other job opportunities, attitude, credit feasibility, recognition, parental consent, income, risk, price fluctuation, labour shortage and busy lifestyle. Characteristics of the plantation such as land extent, vision of doing rubber plantation management, gaining of government subsidy and kind ship of the plantation are covered in the questionnaire of owners. Response variable and the contextual variables were measured in five point likert scale(Strongly disagree, Disagree, Not decided, Agree, Strongly disagree). Data analysis was done using Descriptive statistics and multiple regression techniques by Minitab 14 statistical software package.

## Results and Discussion

Around 56 % of youth were already engaged in rubber plantation management and helped to maintain the continuity of their plantations. Other 44 % of youth in the sample were not engaged with rubber plantation management activities.

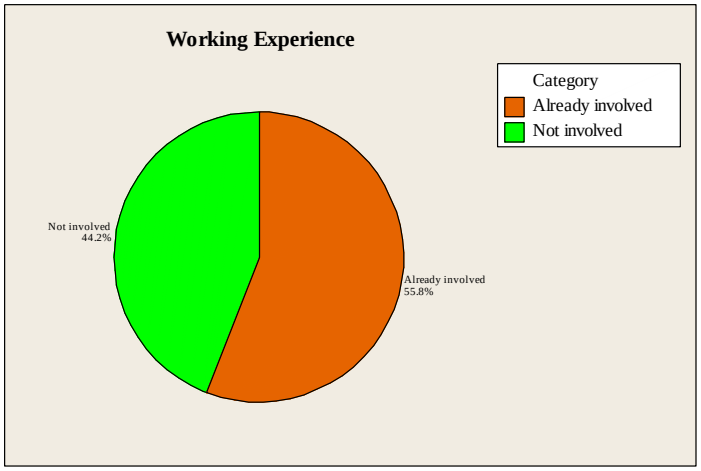


Figure 01: Working experience of youth

Source: - Based on analyzed data

More than 90 % of youth were already involved in management of rubber plantation as a secondary income source. They joined with rubber plantation management as a part time activity while doing another job as the main income source.

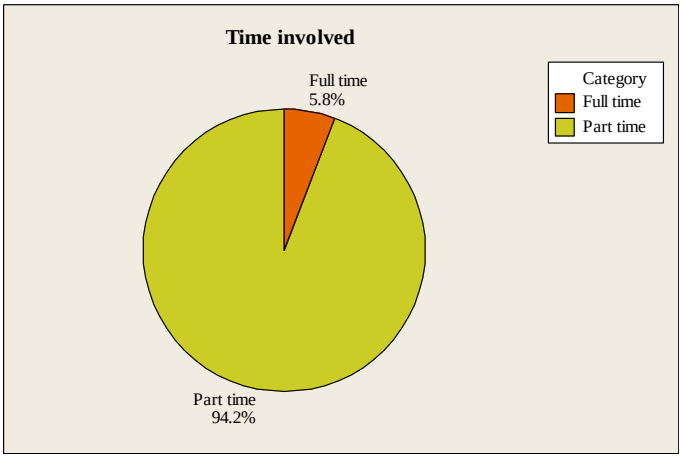


Figure 02: Time involvement of youth in rubber plantation management

Source: - Based on analyzed data

**Regression Analysis**

Table 01: Summary of regression analysis

| Standard Deviation of residuals | R-Sq | R-Sq (adj) |
|---|---|---|
| 0.569319 | 74.3% | 71.7% |

Source: - Based on analyzed data

**Regression equation**

Perception = 0.73 + 0.334 Career ambition - 0.188 other job opportunities + 0.308 Attitude + 0.529 Credit feasibility + 0.0913 Recognition + 0.032 View of parents + 0.367 Income - 0.074 Risk - 0.524 Price fluctuation - 0.438 Labour shortage - 0.105 Busy life + ε

Source: - Based on analyzed data

Table 02: Analysis of contextual variables

| Predictor | Coef | SE Coef | T- Statistics | P-Value |
|---|---|---|---|---|
| Constant | 0.732 | 1.069 | 0.69 | 0.495 |
| Career ambition | 0.33436 | 0.07634 | 4.38 | **0.000** |
| Other job opportunities | -0.18785 | 0.07092 | -2.65 | **0.009** |
| Attitude | 0.3081 | 0.1484 | 2.08 | **0.040** |
| Credit feasibility | 0.52917 | 0.05352 | 9.89 | **0.000** |
| Recognition | 0.09128 | 0.07852 | 1.16 | 0.248 |
| Parental consent | 0.0316 | 0.1143 | 0.28 | 0.783 |
| Income | 0.3669 | 0.1015 | 3.61 | **0.000** |
| Risk | -0.0743 | 0.1153 | -0.64 | 0.521 |
| Price fluctuation | -0.5245 | 0.1378 | -3.81 | **0.000** |
| Labour shortage | -0.4383 | 0.1193 | -3.67 | **0.000** |
| Busy life | -0.1049 | 0.1102 | -0.95 | 0.343 |

Source: - Based on analyzed data

Seven factors were significant at 5 % confident level. These seven factors have P values less than 0.05.Career ambition, other job opportunities, Attitude, credit feasibility, income, price fluctuation and labour shortage were the significantly affected for the perception of youth to engage with rubber plantation management. The factors such as Career ambition, Income, Attitude, Credit feasibility, Parental consent and Recognition are positively affected to the perception of youth while the Other job opportunities, Risk, Busy life, Price fluctuation and labour shortage are negatively affected.

**Conclusions**

Youth were interested to engage the rubberplantation management as a part time activity. Career ambition, other job opportunities, credit feasibility, low income, price fluctuation and labour shortage were the major constraints of youthto undertake the rubber plantation management. These constraintswere directly affected to perception of youth to engage with rubber plantation management.

**Suggestions**

Youth should be encouragedto engage with rubber plantation management to maintain their rubber plantations continuously. Youth should be paid further more attention about the management activities of the rubber plantations such as labour and finance management, practices to obtain quality output to enhance the income.Government intervention is important for having stable market price.

**Acknowldgments**

The thankfulness is conferment to my internal supervisor Mr. M.G.P.P. Mahindaratne, lecturer, Faculty of Animal Science & Export Agriculture, Uva Wellassa University, for the kind supervision and encouragement and the administrative staff of Rubber Development Department in Kalutara district for giving me required information sources.

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# Influence of Socio Economic Factors on Acceptance of Genetically Modified Foods

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## Introduction

Genetically Modified (GM) foods are produced from crops and animals where the genes have been altered in that species for a favorable trait. This trait could be favorable to consumers or for farmers (Wachenheim, 2004). GM foods have become quite common in many countries though they are not available in Sri Lanka. Given the rate of usage of GM foods in the world, in near future Sri Lanka also will be using GM foods in the market. Contrastingly, there is a growing concern in consuming GM foods or related products where GM foods are used as inputs. Since there is no scientific proof for the side effects of GM foods consumption, it is always linked with increasing health problems which occur to millions of people daily in the world. Given this context, this pilot study attempts to study the acceptance of GM foods by Sri Lankan consumers if they are introduced to Sri Lanka and more specifically which cohort of Socio-demographic group prefers GM foods (Deodhar *et al.*, 2007; Kimenju and De Groote, 2008). This would support the companies and policy makers to readjust their preferences and policy formulations (Moro and Boccaletti, 2000; Huang *et al*., 2006.

## Methodology

A group of 120 Agriculture undergraduates from Sabaragamuwa University of Sri Lanka were chosen for the study. Rather than the general consumers university students are familiar with GM foods and most probably they will be the society in the years to come when GM foods become a common good in the market. Further the present consumers might not be familiar with the GM concepts and interviewing the people with understanding on GM is costly and time taking activity. They are also a subset of consumers in the general market. Further university cohort represents different people from different socio-economic background. Participation was voluntary. Questionnaire included sections on socio-economic factors, Knowledge, awareness and perceptions on GM foods, and their willingness to consume GM foods. Descriptive analysis and non parametric tests (chi square analysis and t tests) were performed to check the relationship between preference for GM foods and socio economic and demographic determinants.

## Results and Discussion

Majority of the sample are female (64.4%). About 52% are final year students followed by 32.5% of third year students. Most of them come from Semi urban areas (56.8%) and 27% are ruralites. About 43.2% of the households are earning a monthly income of between Rs. 25,000

to Rs. 40,000. Around 21% of them are getting a monthly house hold income above Rs. 40,000. 56% of respondents think that GM foods are beneficial. If GM foods are introduced in Sri Lanka, 56% say that they will not buy.

Table 1 shows the association between familiarity with GM techniques and factors like gender, income, location/residence and year of study. There exist a relationship between familiarity of GM foods and gender, whereas no relationship with familiarity on recombinant technology and hybrid breeding. As expected all the three statements show an association with year of study. Usually it is expected that with higher education in the sciences field they tend to show much familiarity with subjects like this. Income and residence suggest that there is a mixed result in association with GM foods, Recombinant technology, and hybrid breeding.

Table 01: Chi Square results on Familiarity about GM related techniques

| Variable | Grouping variable | Level | Chi Square | Significance Level |
|---|---|---|---|---|
| Familiarity with Genetically Modified Food | Gender | 2 | 12.142 | 0.002* |
| Familiarity with Genetically Modified Food | Year of study | 4 | 16.295 | 0.012* |
| Familiarity with recombinant DNA technology | Year of study | 4 | 21.111 | 0.002* |
| Familiarity with Hybrid breeding | Year of study | 4 | 15.433 | 0.017* |
| Familiarity with Genetically Modified Food | Monthly Income | 5 | 11.769 | 0.019* |
| Familiarity with recombinant DNA technology | Monthly Income | 5 | 10.692 | 0.220 |
| Familiarity with Hybrid breeding | Monthly Income | 5 | 10.147 | 0.255 |
| Familiarity with Genetically Modified Food | Residence | 3 | 8.060 | 0.089 |
| Familiarity with recombinant DNA technology | Residence | 3 | 14.548 | 0.006* |
| Familiarity with Hybrid breeding | Residence | 3 | 13.444 | 0.009* |

Table 2 depicts the association between gender and perceptions on GM foods. Except statements on a) benefits of GM foods, b) buying nutritionally enhanced food, and c) GM foods can cause damage to health, other statements are not statistically different between male and female respondents.

Table 02: Differences in perceptions on GM foods by Gender

| Statements | t statistic | Sig. (2-tailed) | Mean Difference | Std. Error Difference |
|---|---|---|---|---|
| Heard about benefits of GM Foods | -2.092 | 0.039* | -0.277 | 0.132 |
| Like to buy nutritionally enhanced GM foods | -2.037 | 0.044* | -0.299 | 0.147 |
| Believe GM foods are more nutritious than normal food | -1.105 | 0.272 | -0.158 | 0.143 |
| GM foods can cause toxic effects | -0.613 | 0.541 | -0.107 | 0.175 |
| GM foods could cause allergic reactions | -0.802 | 0.424 | -0.146 | 0.182 |
| GM foods can damage health | -1.814 | 0.072* | -0.320 | 0.176 |
| GM foods are artificial | -0.805 | 0.423 | -0.201 | 0.250 |

Table 3 shows the results for the association between willingness to consume GM foods and factors like gender, income, residence and year of study. Gender and year of study suggest that there exist an association between willingness to consume GM foods in Sri Lanka. Neither income nor the residence shows an association between willingness to consume. It was expected that income and place of residence would show an association. As expected year of study was significantly influencing the decisions. Gender was expected not to have any association given the same levels of knowledge provided.

Table 03: Chi Square results for Willingness to consume GM food

| Variable | Grouping variable | Levels | Chi Square | Significance Level |
|---|---|---|---|---|
| Willingness to consume GM foods if they are introduced in Sri Lanka | Gender | 2 | 6.405 | 0.041* |
| | Year of Study | 4 | 16.072 | 0.013* |
| | Residence | 3 | 1.037 | 0.904 |
| | Income | 5 | 8.229 | 0.411 |

**Conclusions**

This study is on acceptance of GM foods and Perceptions on GM foods using undergraduate students. Though there are differences in perception Gender and year of study shows an association for willingness to consume GM foods. Income and geographic location did not show an association. Yet it seems that still Sri Lankans are not yet ready to accept GM foods as substitutes for non conventional counterparts. Nearly half of the respondents are not willing to consume GM foods if they are introduced. It is wise for firms conduct thorough market studies before they enter in to the Sri Lankan market. This clearly shows that consumers know the pros and cons of GM foods, but when it comes to purchasing intention they take a step backwards.

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# Visco-elastic properties of OMMT filled fractioned bleached crepe rubber

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## Introduction

Natural Rubber (NR) latex tapped from *Hevea brasiliensis* converts into an important engineering material for different applications. NR latex pale crepe, the purest form of NR produced by Sri Lanka, is mainly used in pharmaceutical and surgical applications, infant toys, food contact rubber articles and adhesives, (Senevirthne and Kumara, 2003). Natural Rubber has a higher greenstrength as but it is soft and has lower dimension stability (Cohan and Spielman, 1948) which is one of the major draw backs in NR for engineering application.

Recently, Nanoclays such as montmorillonite clay are attracted as an alternative filler to achieve the reinforcement of rubber compounds by replacing conventional fillers (Ratnayake and Peiris, 2010). Study the effect of Organo-montmorillonite (OMMT) on the visco elastic properties of fractioned bleached crepe rubber will helpful for the advancement of the raw rubber industry as value addition. In this study, OMMT dispersion in the rubber matrix has studied not only by Mooney viscosity and stress relaxation properties but also by the physical properties of vulcanizates. Therefore this study may help to have an advantage for the development of crepe rubber industry and product manufacturing industry in Sri Lanka.

## Material and Methods

NR field latex was obtained from NR processing factory at Rubber Research Institute, Dartonfield, Agalawaththe. Montmorillonite clay modified with quaternary alkyl ammonium salt (OMMT)was used as the nanofiller. Other general chemicals and laboratory equipment were obtained from Rubber Research Institute, Rathmalana.

Initially, 5%(w/w) aqueous dispersion of OMMT was prepared using a surface active agent as a dispersing agent. Latex mixing/intercalation method(Gatos and Kocsis, 2010) was carried out to prepare OMMT filled fractioned bleached crepe rubber (OFBCR). Dry rubber content (DRC) of fractionated bleached latex was diluted up to 10% and subsequently OMMT dispersion was incorporated to latex samples at OMMTloading from 0 to 8 phr with an interval of 2 phr, with simultaneous stirring.Standard latex crepe manufacturing procedure was adopted to prepare OFBCR (Senevirthne and Kumara, 2003). Laces were dried in the drying tower at 34°C for three days. Complete randomized design was applied to assign treatments, $T_0$(0 phr), $T_2$ (2 phr), $T_4$ (4 phr), $T_6$ (6 phr) and $T_8$ (8 phr).

The NR was characterized based on DRC and the OMMT was characterized by the ash content. Money viscosity and stress relaxation of OFBCRs were measured according to the [ISO/R 289-1963] by the Ektron Mooney viscometer. Then the OFBCR samples were compounded according to the pre-determined formulation. Curing characteristics of the OFBCR samples were measured by using MDR 2000 (moving die rheometer, M/S Alpha Technologies, USA) at

150°C according to the ISO 3417:2008 procedure. OFBCR samples were moulded by hydraulic hot press at 150°C temperature and 20MPa pressure for optimum cure time derived from the cure characteristics data.The tensile properties of OFBCR samples were determined by "Instron 3300 Series" material testing machine at a crosshead speed of 500 mm/min as per ISO 37:2011.

The hardness of the samples were determined using Elastocon bares digi hardness tester according to the ISO 48:2010. Compression set at constant strain was measured according to ISO 815-1:2008 test method andtear strength of OFBCR samples were determined by "Instron 3300 Series" material testing machine at a crosshead speed of 500 mm/min according to ISO 34-1:2011. All tests were carried out at 27±2°C and each test was replicated at least 3 times. Data were analyzed by using the Minitab 16 statistical software with the use of General Liner Model (GLM) with Tukey's all pair wise comparison tests at 95% confidence interval.

**Results and Discussion**

Field latex used for the preparation of nano crepe rubber showed the dry rubber content of 30%. OMMT clay has modified with quaternary alkyl ammonium salts. The ignition weight loss of OMMT is 43%–48%. Ash content of clay is 52%-58%. This ash content represents the amount of silicates and other inorganic metal amount in the clay. Ignition weight loss is correlated to the amount of quaternary ammonium alkyl modifier and adsorbed moisture amount in the clay.

Mooney viscometer is an instrument to measure the 'stiffness' of uncured compounds, the result of that viscosity is called as Mooney viscosity at ML 1+4 (100°C). Mooney stress relaxation coefficient is the slope of the power law model when it is in logarithmic scale (log M = **a**(log t) + log k) where M- torque units from the Mooney stress relaxation test, k- a constant equal to torque 1 s after the rotor has stopped, **'a'**- an exponent that measures the rate of stress relaxation and t- testing time. Also elasticity of rubber material is inversely proportionate to the **'a'**andlower elasticity improves the mixing of rubber and processing, especially extrusion and calendaring. Malac J., (2009).

Clay loading level (phr) has significantly affected to the Mooney viscosity expressed as ML (1+4) 100°C of OFBCR samples (p-0.000). Only $T_6$ and $T_8$ has not indicated a significant difference (p-0.0569) between them with respect the Mooney viscosity but all other treatment levels are significantly different among (p-0.000). Mooney viscosities for $T_0$, $T_2$, $T_4$, $T_6$ and $T_8$ are presented in Figure 1. The reason for the reduction of Mooney viscosity is, when increasing the OMMT loading, the plasticization of rubber material by OMMT and may possibly be the chain slippage over the clay platelets (Kader *et al*., 2010).

As reported in Figure 2, the stress relaxation coefficient has increased up to 4 phr and there after it reduces. The maximum stress relaxation coefficient has indicated at the 4 phr clay loading level, therefore, it can be concluded that OFBCR with 4 phr OMMT clay loading has a better processability than other samples. Long relaxation times and high amplitudes of stress relaxation suggest the mechanism of structural relaxation involving large-scale displacements of isolated clusters of nanoparticles within the rubber matrix and vice versa (Dick, 2010).

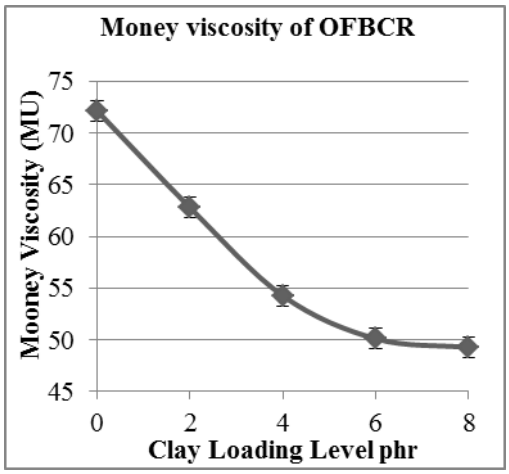


**Figure 1. Mooney viscosity $T_0$, $T_2$, $T_4$, $T_6$ and $T_8$**

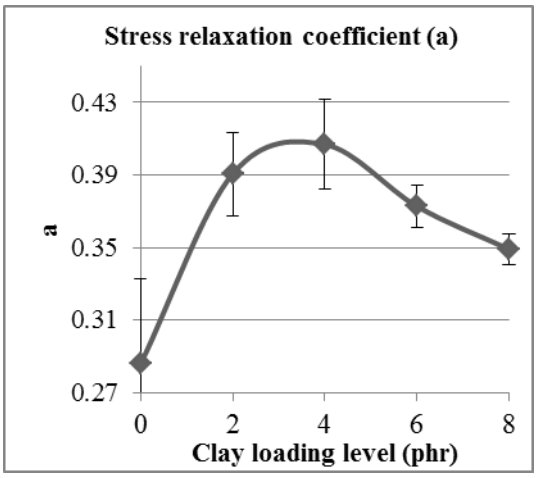


**Figure 2. Stress relaxation coefficient for $T_0$, $T_2$, $T_4$, $T_6$ and $T_8$**

Curing characteristics of OFBCR samples have indicated the increasing cure rate index (CRI), maximum torques (MH) and reducing scorch time ($t_{s2}$) (Figure 3). Reason for the increasing CRI may be the acceleration of curing reaction by organic modifier; simultaneously it can reduce the $t_{s2}$.

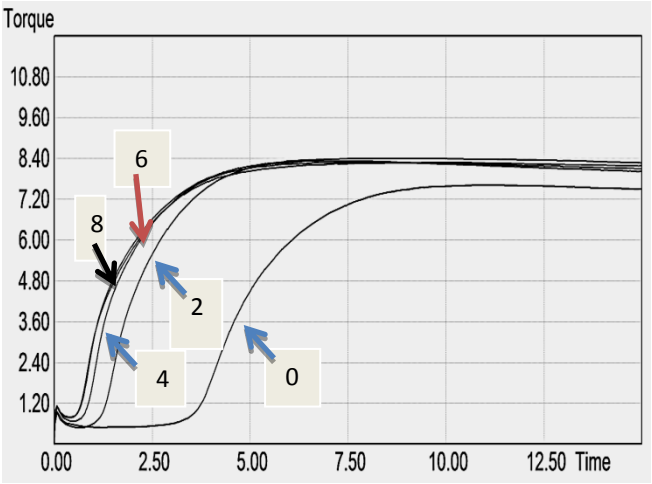


**Figure 3. Cure curves for$T_0$, $T_2$, $T_4$, $T_6$ and $T_8$**

Clay loading level has not significantly affected to the tensile strength of OFBCR materials (0.181). The reason for this may be the uneven distribution of organoclay in the rubber matrix. But 26.56 % increase has indicated at $T_6$ clay loading level compared to $T_0$. Also clay loading level has significantly affected to the modulus at 300 % (0.009). Modulus at 300% has indicated an increasing trend up to $T_6$ and there after it reduces. The modulus has increased by 37.22% at $T_6$ compared to $T_0$. When consider the modulus at 300% at the $T_6$, the reason for this increase may be the optimum dispersion of organoclay in the rubber matrix. Therefore, it can be concluded that the elastic modulus has improved by OMMT at $T_6$. Also the elongation at break has not affected significantly by the clay loading level (0.135).

Compression set percentage has significantly affected by the clay loading level (0.000). Maximum compression set has indicated at $T_6$, but it does not significantly different to $T_4$ (0.090).Compression set indicates the elastic properties of vulcanizates. Compression set has increased up to $T_6$ and then it reduces. Therefore, it can be concluded that the elasticity has reduced when the filler loading is increased up to $T_6$. The reason for increase the compression set may be the better dispersion of the organoclay in the rubber matrix. Hardness of the OFBCR vulcanizate has increased with respond to the clay loading level and has indicated 22% increase at $T_6$ compared to $T_0$. The hardness has increased rapidly up to $T_4$ and thereafter it has indicated more or less same values for $T_4$, $T_6$ and $T_8$ indicating that optimum dispersion of OMMT clay was achieved with 4 phr. clay loading (0.000). Entanglement of rubber molecule with OMMT may be the reason for the improvement of hardness.

**Table 1. Physical properties of OFBCR**

| Property | Clay loading phr | | | | |
|---|---|---|---|---|---|
| | $T_0$ | $T_2$ | $T_4$ | $T_6$ | $T_8$ |
| **Tensile strength (MPa)** | 23.72 | 24.88 | 23.53 | 24.35 | 25.08 |
| **Mod @ 300 %(MPa)** | 4.54 | 5.10 | 5.45 | **6.23** | 5.72 |
| **Elongation @ break** | 448.5 | 433 | 448.84 | 434.3 | 452.3 |
| **Compression set %** | 4.06 | 7.49 | **12.55** | **15.28** | 9.5 |
| **Hardness (IRHD)** | 37.21 | 42.02 | **44.16** | **45.39** | **45.8** |
| **Tear strength (N/mm)** | 31.65 | 32.01 | **35.61** | **34.98** | 33.98 |

Maximum tear strength has indicated at $T_4$. Even dispersion of OMMT could be improved the tear strength. When the filler loading is increased over the 4 phr, the re–aggregation of wide stacks of clay platelets could be taken place. Therefore the crack initiation and propagation can

be accelerated by reducing the tortuous path length.Shortening the stack-stack distance can lead to a greater resistance to crack propagation (Gatos and Kocsis, 2010). Due to the high aspect ratio of the clays their optimum dispersion is reached at a smaller amount (Gatos and Kocsis, 2010).

## Conclusions

According to the Mooney stress relaxation information, clay loading levels at 4 phr ($T_4$) have indicated better processability as filled raw rubber material called OFBCR. Also physical properties have shown that $T_4$ and $T_6$ treatments have given optimum dispersion of OMMT in rubber matrices.

## Acknowledgments

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# Effect of Canopus 100 processing oil on the blooming effect of solid tyres

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## Introduction

Solid tyres are popular in the industrial world. These types of tires are primarilyused for industrial or light commercial applications such as light industrial and personal use vehicles (Blanc *et al*., 1988).

Samson Rubber Products (Pvt) Ltd produces industrial solid tyres by using two rubber compounds namely ST 1125 compound and ST 9048 compound. ST 1125 compound is used to make the inner part of the tyre. ST 9048 compound is used to make the outer part of the tyre. Because, ST 9048 compound is more expensive than ST 1125 compound.

To obtain a good quality tyre, the rubber compound must be calendared on the day itself. Calendering is done to have ancompound sheet of uniform thickness for easy maintenance of the shape of the solid tyre. But, certain time period is needed to calendar the compounds. Sheets cannot be kept more than 24 hours after calendaring. Because some yellowish marks may appear on the surface of the solid tyres after manufacturing which is known as 'blooming effect'. It highly affects on the final quality of the solid tyre.

If the blooming effect can be overcome, the calendared sheets can be kept for certain period until solid tyre manufacturing process is started without affecting the quality of the solid tyre. As a result, the solid tyre manufacturing can be undertaken in a continuous mannar. Generally, blooming effect is occurred during vulcanization after two days of calendaring the compounds. During this period, it will move to the outer surface.

Previous research projects carried out on this topic were found that sulphur is not a root course of the blooming effect. This yellow blooming may occurre due to the ingredients contained in ST 9048 compound. Generally, processing oil is added to improve the processability of the compound. In solid tyre manufacturing, the processing oil called 'Canopus 100' is used which is one of the highly refined paraffinic mineral oils. This research is an attempt to determine the effect of Canopus 100 processing oil which is one of the ingredients contained in the ST 9048 compound on the blooming effect of solid tyres.

## Methodology

Seven ST 9048 compound samples were prepared in various phr(Parts Per Hundred Rubber) level of the Canopus 100. The phr level of the oil was varied in a range of 0phr to 3 phr (0 phr, 0.5 phr, 1.0 phr, 1.5 phr, 2.0 phr, 2.5 phr, 3.0 phr). Each treatment was tested in five replicates. Completely randomized design was used as the experimental design. Response variable was the area affected due to the blooming effect.

Then, compounds were calendared using the calendar machine to make the compounds as sheets for easy maintenance and production. The required amount of the compounds were weighed using the balance. The weight of the 1125 compound sample was 4.9kg and the weight of the

9048 compound sample was 2.3 kg. Those compounds were kept for two days before starting the production. ST 1125 compound (4.9 kg) was wrapped around the rim. Then, the ST 9048 compound ( 2.3 kg) was wrapped on the wrapped ST 1125 compound.The prepared solid tyre structure was inserted in to the press machine at a temperature of $130^0$C for 85 min.A transparent grid paper was kept on the surface of the solid tyre. Then, the affected area was determined by counting the number of grids.

Minitab was used to analyze the data. The method of data analysis was one way analysis of variance (ANOVA). Mean comparison was done using Tukey test at 95% confidence interval.

**Results and Discussion**

According to the statistical analysis, the results obtained in this research can be described as follows. According to the Table 1, there was a significant difference ($p \leq 0.05$) among the treatments. There was a significant difference among the area affected due to blooming effect in treatment 4,3,6,1, and 7. But, there was no significant difference in treatment 5 and 2 in terms of the area affected in due to blooming effect in solid tyres.

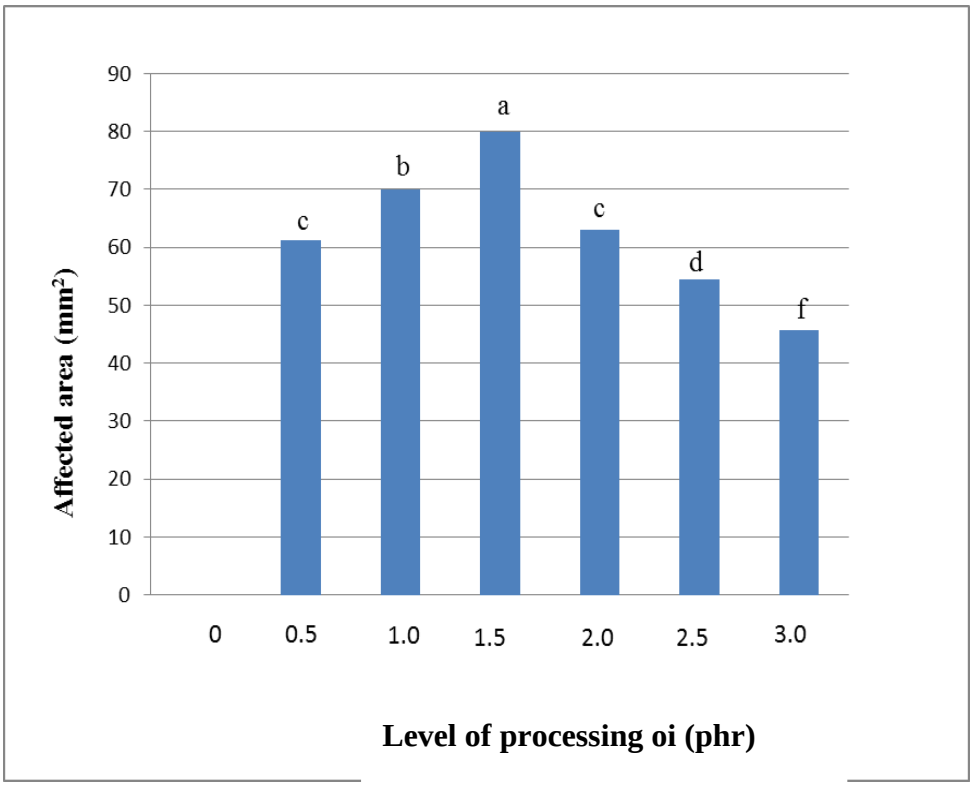


Figure 01: Affected area by blooming depending on the level of processing oil.

*Means denoted in same letter are not significantly different at the 5 % level of significance.

If the affected area is high, the blooming effect is also high and vise versa. Considering the results, the level of processing oil which contributes for the maximum affected area due to blooming effectis not suitable. Because, the quality of the solid tyre reduces when increasing the area affected due to blooming effect. The level of processing oil which recorded the least bloomed area in solid tyres can be identified as the best treatment.

According to Figure1, specific pattern was clearly identified between the level of processing oil and the area affected due to blooming. When the phr level of processing oil was increased, the area affected due to blooming effect was significantly increased. Maximum affected area was observed in the treatment 4 in which the level of processing oil was 1.5 phr. Because, silica bonds are highly activated at the 1.5 phr level of processing oil. Therefore, those silica bonds are made cross links with the processing oil at that range of processing oil. Therefore, the blooming effect can be seen on the surface of the soildtyres (Subramaniam and Encyclo, 1988).When the phr level of processing oil was increased further, the affected area due to blooming was significantly decreased.

The least affected area due to blooming effect was observed in the treatment 7 in which the level of processing oil was 3 phr. Therefore, processing oil with a phr level of 3 was the best treatment out of the seven different levels of Canopus 100 processing oil tested. Also, that is the currently using concentration of processing oil in the solid tyre industry. Because, it is the optimum phr value of processing oil used in solid tyre industry to improve the properties of the compound.

The processing oil used at the level of 3 phrimproves the processability of rubbers and rubber compounds while increasing the bulk of rubber to reduce the cost of oil-extended rubbers. According to *Subramaniam* (2012),following specific requirements namely low viscosity and elasticity, less power consumption and aid dispersion of fillers are shown at the low dosage of 3 phr. In addition to those, the following additional requirements are also met at the level of 3 phr of processing oil such as not affecting the intended properties of finished products and acting at low dosage level.

## Conclusions

The results of the research revealed that there is an effect of Canopus 100 processing oil on blooming effect of solid tyres. Three phr level of processing oil is the best among the different levels of Canopus 100 processing oil tested. And also three phr level of processing oil is the optimum value to incorporate with ST 9048 compound to obtain a high quality solid tyre

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# Improvement of productivity of soft dough biscuits by regulating temperature and quantity of the palm olein

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## Introduction

Biscuit is a small baked product made principally from flour, sugar and fat (Sonia *et al*., 2007). According to the type of the dough biscuits can be categorized as soft dough and hard dough biscuits. Analysis and quantification of the quality, for the purpose of controlling its parameters and acting on it in real time, remain the prime objectives of the biscuit industry. Palm olein is widely used in food manufacturing industry due to its good resistance to oxidation and formation of breakdown products at frying temperatures and longer shelf life of finished products.Usage of palm olein to build up the specific quality on soft dough biscuits is a major concern in the manufacturing plant. In order to maintain the given specification currently add high amount of oil to the dough. Addition of high amount of olein will increase the cost of production. As well palm olein temperatures also contribute to the quality characteristics of final output. Therefore prime objective of this study is to investigate the impact of the palm olein temperature and quantity on soft dough biscuits (Milk Shorties) without compromising the quality of biscuits thereby reducing the cost of production.

## Materials and Methods

Two factors, palm olein quantity and palm olein temperature and their combinations were used to test the effect for the final biscuit quality. In order to study the influence of temperature regulation (34 °C, 32 °C and 30 °C) and the amount of the incorporated palm olein ( 56 kg, 54 kg, 52 kg and 50 kg) on the biscuit characteristics; twelve different treatments were conducted. Palm olein temperature was regulated by using the oil heating system in mixing area. Moreover, all twelve treatments were subjected to similar conditions until biscuits were packed.Samples were collected from three dough of each combination by using simple random sampling method. There were three replicates per each twelve treatments.All treatments were subjected to detect the objective quality characteristics such as raw weight, baked weight, baked height, moisture content (Infra-red moisture analyzer), pH, hardness, total fat content (Soxhlet extraction method) and packet weight. Out of the twelve treatments the best treatment was chosen for the sensory evaluation by 30 untrained panelists.

## Results and Discussion

The effect on twelve different treatments for biscuit quality parameters shown in the Table 1. According to the results with the reduction of amount of palm olein the raw weight, baked weight, moisture content and total fat content of biscuits were gradually decreased while increased the baked height and the hardness of the biscuits.Weight and height were found to be

quite sensitive to the sugar and fat levels of the biscuits (Cronin and Preis, 2000). As well results showed that the amount of palm olein significantly influenced final quality of biscuit(Dunken, 2000). According to the research results, treatment combination which included 54 kg of palm olein at 32 °C temperature was the best treatment among all other twelve treatments combinations. Because the biscuits produced from this treatment have the same quality of Milk Shorties biscuits available in the market. Sensory attributes of colour and taste showed that biscuit produced with reduced amount of palm olein (54 kg) was not perceived when tested by sensory panel. Moreover sensory evaluation results showed that overall consumer acceptability of designated sample and formulated sample are much more similar. Therefore T5 treatment, compromised with 54 kg of palm olein, with 32 °C of temperature was selected as the best treatment by the sensory evaluation and the product had raw weight 56.33 g, baked weight 47.09 g, baked height 60.9 mm, moisture content 2.62 % (db), pH 7.07, hardness 10.97 N, total fat content 15.54 % and packet weight 365.4 g. This treatment combination is important to improve the productivity of the milk shorties biscuit and reduce the cost of production. Thereby increase the profit. Value to reduce the 2 kg of palm olein (per dough) in annum is Rs. 2.8 million.

Table 01: Mean values of four different treatments on biscuit parameters

| | Raw weight | Baked weight | Baked height | Moisture content | pH | Hardness | Total fat content | Packet weight |
|---|---|---|---|---|---|---|---|---|
| Standard range | 54-58 g | 46-48 g | 58-61 mm | 2-3% | 6.9-7.1 | 9-11 | 15-17% | 350-365g |
| T1 | 57.51±0.533 | 47.25±0.254 | 59.33±0.208 | 2.59±0.028 | 7.01±0.013 | 9.99±0.110 | 15.59±0.014 | 378.13±2.150 |
| T2 | 57.68±0.150 | 47.61±0.911 | 59.56±0.416 | 2.66±0.026 | 7.02±0.022 | 9.87±0.220 | 15.62±0.025 | 375.4± |
| T3 | 57.88±0.458 | 48.01±0.768 | 60.36±0.667 | 2.73±0.062 | 7.05±0.017 | 9.79±0.230 | 15.59±0.016 | 370.12±3.618 |
| T4 | 56.33±0.742 | 46.91±0.177 | 60.76±0.577 | 2.59±0.092 | 7.05±0.016 | 10.99±0.408 | 15.51±0.008 | 365.4± |
| T5 | 56.40±0.978 | 47.09± | 60.9±0.793 | 2.62±0.098 | 7.07±0.020 | 10.97±0.322 | 15.54±0.073 | 362.76±3.163 |
| T6 | 56.96±0.799 | 47.19±1.064 | 61.66±0.251 | 2.73±0.096 | 7.08±0.022 | 10.88±0.225 | 15.51±0.032 | 360.2± |
| T7 | 55.33±1.033 | 45.49±0.874 | 62.10±0.551 | 2.54±0.092 | 7.06±0.022 | 11.56±0.206 | 15.39±0.037 | 358.9± |
| T8 | 56.08±1.008 | 46.25± | 62±0.30550 | 2.61±0.094 | 7.07±0.026 | 11.53±0.407 | 15.49±0.041 | 354.32±5.393 |
| T9 | 56.38±1.070 | 46.55±0.457 | 62.2±0.3 | 2.65±0.099 | 7.07±0.020 | 11.28±0.341 | 15.41±0.043 | 350.82±4.425 |
| T10 | 55.22±0.844 | 44.36± | 62.05±0.769 | 2.56±0.093 | 7.04±0.020 | 11.74±0.206 | 15.31±0.038 | 348.92±4.464 |
| T11 | 55.54±0.937 | 44.59±0.148 | 62.3±0.244 | 2.59±0.091 | 7.07±0.028 | 11.64±0.450 | 15.35±0.019 | 345.16±5.3029 |
| T12 | 55.63±0.803 | 45.47±0.113 | 63.03±0.251 | 2.61±0.098 | 7.08±0.023 | 11.60±0.560 | 15.13±0.019 | 340.24±6.710 |

**Conclusions**

54 kg of palm oleinat 32°C is the best treatment to obtain Milk shorties biscuits cost effectively and without compromising final quality of the biscuits.

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# Development of activated carbon included natural rubber latex pillow

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## Introductıon

Latex is a milky white liquid tapped from the trunks of rubber trees (*Hevea brasiliensis*) and then combined with water to create a thick suspension. In manufacturing natural latex foam rubber, the latex suspension is whipped to a froth and poured into carousel moulds, onto a conveyor, or into sheets and then heated to the point of vulcanization (Polyurethane Foam Association, 2000). Activated carbon(AC) is a non-graphite form of carbon which could be produced from any carbonaceous material. AC manufactured from coconut shell is considered superior to those obtained from other sources mainly because of small macro pores structure which renders it more effective for the adsorption of gas/vapour and for the removal of colour and odour of compounds (Coconut Development Board, 2013). AC has numerous applications due to its higher adsorption property. Thus it is capable to adsorbing volatile organic compounds which are also air pollutant in the atmosphere.

The incorporation of activated carbon into natural rubber latex foam pillow can provide volatile organic compounds adsorption property apart from its cushioning effect. Many volatile organic compounds are toxic, posing a high risk to human health as a result of their widespread use and occurrence in laboratory, home and also workplace environments (Magureanu, Mandache, Eloy, Gaigneaux and Parvulescu, 2005).

Therefore natural rubber latex foam pillow currently available in Sri Lankan market can be successfully value added by incorporating coconut shell based activated carbon to get the similar cushioning effects together with air purification ability upto a certain level.

## Methodology

The current study was carried out at Richard Pieris Natural Foam (RPNF) Ltd, Malwana, Biyagama. Laboratory tests were done at RPNF, Richard Pieris Company plc and Bureau Veritas Consumer Product Services Sri Lanka (Pvt) Ltd laboratories. Two experimental trials with different treatments were conducted during this study. Experimental trial I was carried out to find out the appropriate activated carbon level suitable for the natural rubber latex foam pillow. It was compromised with eight treatment levels having 0% to 7% activated carbon levels with other compounding ingredients as different treatments levels. Each treatment was replicated 3 times.

Experimental trial II was done in order to find the air purification ability with respect to acetone adsorption capacity. In experiment II, both the control which has 0% activated carbon and 2% of AC treated pillow were used to investigate the acetone (a VOC) adsorption capacity. Both treatments were replicated 3 times. Complete Randomized Design (CRD) was conducted and

data obtained from both physical properties tests and acetone adsorption capacity was analyzed using analysis of variance (ANOVA) procedure of Minitab 16. Mean comparison of treatments were done using the tukey's test.

**Results and Discussion**

According to the physical properties evaluation (Hardness, compression set, density and tensile strength) the formulation with 2% of activated carbon has given a desirable physical structure and selected in experiment trial I.

Based on the data analysis of hardness, there is significant difference ($P<0.05$) between control (currently manufacturing latex pillow without AC) and the different treatment levels whereas no significant difference between the Control and 2% of AC treatment. Therefore similar hardness can be obtained by incorporating 2% AC into the present latex pillow formulation.

According to the results of compression set value, it is been observed that there is no significant difference between 2%, 3% of AC treatments and control. Whereas more economical benefit through the lower material cost can be obtained by incorporating 2% AC. As a rubber material is compressed over time, it loses its ability to return to its original thickness. This loss of resiliency may reduce the capability of a cushioning pad to perform over a long period of time (Compression Set of Elastomeric Materials, 2014). Therefore lower compression set value is better for the cushioning materials.

However density and tensile strength do not show the significant difference in all the treatments.

Generally, acceptable tensile strengths are above 0.006895 MPa depending to some extent on the final application of the flexible foam. There are some cases where lower tensile strength foams may be used, but it is generally advisable to use foams that have a tensile strength of at least 0.006895 MPa (Polyurethane Foam Association, 1994). In this study it shows that tensile strength for all the treatment levels have values which are more than the acceptable value.

In experimental trial II, activated carbon treated pillow was selected due to its high acetone adsorption capacity.

Table 01: Mean Adsorption Capacity at Different Treatment Levels

| **Treatment Levels** | **AC %** | **Means of Acetone Adsorption Capacity (%)** |
|---|---|---|
| T1 | 0% | $62.667^{a}$ |
| T2 | 2% | $100^{b}$ |

It shows that the treatment levels are significant for acetone adsorption capacity. According to the mean values of the sample, maximum (100%) acetone adsorption capacity was reported from activated carbon treated sample.

Previous study reported that the adsorption capacity of activated carbon increases as the molecular weight of the hazardous air pollutant increase. Cyclical compounds are more easily adsorbed than linear structured materials (Ray and Altshuer, 2002). Therefore volatile organic compounds which have higher molecular weight than acetone can also be adsorb by activated carbon.

**Conclusions**

Presently available natural rubber latex foam pillow can be successfully value added by incorporating 2% of coconut shell based activated carbon to get VOC adsorption capacity upto certain level while maintain the cushioning effect.

The developed AC incorporated pillow can be successfully used as an adsorption source of VOC in environment to reduce the possible air pollution while getting the cushioning effect too.

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# Effect of palmyrah coir dust on physicochemical properties of potting media and on growth and yield of chilli

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## Introduction

Palmyrah (*Borassus flabellifer*) coir dust is a major by-product of the fibre industry. Coir waste or coir pith is generally a mixture of dust, bits and fibres of shortlength that is rejected during the process of coir extraction. Coir dust is a spongy material which can absorb ample quantity of water compared to its weight and it is a valuable carbon source which could be used in agriculture to maintain and improve the organic matter content of depleted soils(Vidhana Arachchi and Somasin, 1997). Organic matter can improve the soil properties in long run (Kularathne *et al*., 2005).Although Palmyrah coir dust is a very useful carbon source for agriculture, it is wasted by burning at the factory. No studies have been undertaken to investigate the beneficial effects of palmyrah coir dust which can be used in agriculture. This research was conducted to study the effect of palmyrah coir dust on physicochemical properties of potting media and on growth & yield of capsicum.

## Methodology

A pot experiment was carried out at Palmyrah Research Institute, Jaffna under greenhouse conditions(temperature 30.1 $^{o}$C and relative humidity 80.9 % during day time). Six treatments were used: T1:-control (soil alone), T2:- palmyrah coir dust: soil (1:1), T3:- palmyrah coir dust: soil (1:3), T4:-palmyrah coir dust: soil: sand (2:1:1), T5:- palmyrah coir dust: soil: sand (1:2:1), T6:- palmyrah coir dust: soil: sand (1:1:2). The experiment was laid in a Complete Randomized Design (CRD) with three replicates. Hungarian Yellow Wax variety was selected as the test crop considering its short harvesting period.Potting media were prepared by mixing palmyrah coir dust, soil and sand in a different ratio on weight basis according to the treatments. All agronomic practices were undertaken according to the guidelines provided by the Department of Agriculture (DAO, 2006). Plant height (cm), crop yield (g), bulk density (g/cm$^3$), porosity (%), water retention (% wt), pH, electrical conductivity (µs/cm), cation exchange capacity (meq/100g), available nitrogen (%), available phosphorus (%), organic carbon (%), exchangeable calcium (%) and exchangeable magnesium (%) were measured. Data was analyzed using SAS software package and the mean separation was done by Least Significant Difference (LSD) at p=0.05 probability level.

## Results and Discussion

Significantly, the highest bulk density (1.41± 0.05 g/cm$^3$) was recorded in the control treatment (T1). As given in Table 1, the lowest porosity (88.63 ± 0.05 %) and the lowest water retention (33.64 ± 0.05 %) were recorded in control treatment (T1). The highest porosity (95.75 ± 0.05 %) and the highest water retention (153.26 ± 0.05 %) were recorded in T4 treatment (palmyrah coir dust: soil: sand 2:1:1) followed by T5 treatment and T3 treatment at 5 % probability level.

Palmyrah coir dust is a light weight material with low bulk density (0.128 g/cm$^3$).Incorporation of palmyrah coir dust increased the porosity and water retention of potting media and reduced the bulk density.

Table 01. Effect of different treatment on physical properties of potting media

| Physical properties | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T5 | T6 |
| Bulk density (g/cm$^3$) | 1.41$^a$ | 0.43$^c$ | 1.18$^b$ | 0.44$^c$ | 0.43$^c$ | 0.18$^d$ |
| Porosity (%) | 88.63$^e$ | 92.13$^c$ | 90.17$^d$ | 95.75$^a$ | 92.72$^c$ | 94.57$^b$ |
| Water retention (%) | 33.64$^f$ | 83.96$^d$ | 101.12$^c$ | 153.26$^a$ | 135.70$^b$ | 70.97$^e$ |

*Different superscripts along the columns are significantly difference at p = 0.05.

As given in Table 2, there was no significant difference in pH among the treatment. The highest EC (2240.0 ± 0.05 µs/cm), CEC (20.266 ± 0.05 meq/100g) and organic C (3.806 ± 0.05 %) were recorded in T2 treatment. The highest available P (0.306 ± 0.05 %) was recorded in T4 treatment. There was no significant difference in available P between T4 and T2. The lowest EC (119.9 ± 0.05 µs/cm), available P (0.03 ± 0.05 %) and organic C (0.352 ± 0.05 %) were recorded in control treatment (T1). Significantly, the highest available N (0.089 ± 0.05 %) and exchangeable Ca (3.60 ± 0.05 %) were recorded in control treatment (T1) at 5 % probability level. The highest exchangeable Mg (3.613 ± 0.05 %) was recorded in T4 treatment (palmyrah coir dust: soil: sand 2:1:1) and the lowest exchangeable Mg (0.156 ± 0.05 %) was recorded in control treatment (T1). Chemical properties of coir dust, soil and sand vary depending on origin, structural composition and mineral composition. Palmyrahcoir dust has higher CEC value (96.6meq / 100g) and application of coir dust helps to increase CEC of potting media. Palmyrah coir dust is a carbon rich (57.3%) material and characterized with high C: N ratio. Soil taken for the study is calcic red yellow latosol type and it has higher calcium content because of limestone layer below the soil profile in that area. Palmyrah coir dust increased EC, CEC, available P, organic C and exchangeable Mg and reduced exchangeable Ca of potting media when incorporate with soil and sand without change the pH.

Table 02. Effect of different treatments on chemical properties of potting media

| Chemical properties | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T5 | T6 |
| pH | 6.82$^a$ | 6.63$^a$ | 6.74$^a$ | 6.62$^a$ | 6.61$^a$ | 6.74$^a$ |
| EC (µs/cm) | 119.9$^e$ | 2240.0$^a$ | 902.7$^{cd}$ | 1742.0$^b$ | 1022.6$^c$ | 782.7$^d$ |
| CEC (meq/100g) | 8.466$^e$ | 20.266$^a$ | 10.334$^c$ | 9.559$^d$ | 17.400$^b$ | 6.876$^f$ |
| Available N (%) | 0.089$^a$ | 0.0813$^b$ | 0.080$^b$ | 0.059$^d$ | 0.068$^c$ | 0.054$^d$ |
| Available P (%) | 0.030$^d$ | 0.264$^a$ | 0.143$^c$ | 0.306$^a$ | 0.183$^{bc}$ | 0.190$^b$ |
| Organic C (%) | 0.352$^e$ | 3.806$^a$ | 2.858$^c$ | 3.306$^b$ | 2.145$^d$ | 2.048$^d$ |
| Exchangeable Ca (%) | 3.60$^a$ | 3.09$^c$ | 3.516$^b$ | 1.443$^f$ | 2.936$^d$ | 1.803$^e$ |
| Exchangeable Mg (%) | 0.156$^f$ | 2.736$^b$ | 1.283$^d$ | 3.613$^a$ | 1.540$^c$ | 0.996$^e$ |

*Different superscripts along the columns are significantly difference at p = 0.05.

Significantly, the highest plant height (29.46 ± 0.05 cm) and crop yield (132.41 ± 0.05 g) were recorded in T5 treatment followed by T4 and T3 at 5 % of probability level (Table 3).Soil organic matter of which carbon is a major part holds a great proportion of nutrients, cations and trace elements that are importance to plant growth. It prevents nutrient leaching and is integral to the organic acids that make minerals available to plants. T2 treatment had higher organic carbon content hence nitrogen immobilization may occur which leads to reduce the availability of nitrogen and consequently adversely affect the plant growth and yield. In T5 treatment the level

of organic carbon may be optimum hence nutrient availability will increase during time period due to optimum microbial activity which improved crop growth and yield. Variation in chemical and physical properties of the medium and differences in plant sensitivity to a defined root environmental condition might have contributed to the marked differences in plant development. Therefore, the properties of the growing medium affect the plant growth and yield.

Table 03. Effect of different treatment on growth and yield of capsicum

| Growth and yield parameters | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | T1 | T2 | T3 | T4 | T5 | T6 |
| Plant height (cm) | $14.43^{d}$ | $14.80^{d}$ | $21.20^{c}$ | $24.53^{b}$ | $29.46^{a}$ | $19.40^{c}$ |
| Crop yield (g) | $80.53^{c}$ | $49.11^{d}$ | $100.96^{b}$ | $109.56^{b}$ | $132.41^{a}$ | $86.059^{c}$ |

*Different superscripts along the columns are significantly difference at p = 0.05.

## Conclusions

Incorporation of palmyrah coir dust increased the physical and chemical properties of potting media when mixed with soil and sand. Palmyrah coir dust improved growth and yield parameters of *Capsicum annum* when compared to soil. Palmyrah coir dust with soil and sand (1:2:1) medium was the best medium followed by medium including palmyrah coir dust with soil and sand (2:1:1) and palmyrah coir dust with soil (1:3).

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# Effect of graphite derivatives on mechanical and functional properties of nitrile rubber nano composite

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## Introduction

The conducting polymers and polymeric composites have attracted considerable attention in recent years because of their breadth applications in advanced technologies, for example, in antistatic coatings, electromagnetic shielding. For all applications, elastomers are reinforced with fillers to promote their performance by incorporating materials such as silica, clay, carbon blacks, etc. Graphite is a layered material with high aspect ratio in its exfoliated state; it is also considered as one of the strongest materials per unit weight and has unique functional properties such as good electrical and thermal conductivities, and good lubricating properties. In other side graphene have recently received significant attention due to its outstanding electronic, mechanical and thermal properties. NBR-based Nano composite was prepared and mechanical and functional properties were studied. The dispersion of the filler in the polymer matrix was studied using the Transmitted light metrological microscope.

## Methodology

Two different experimental trials (Preparation of NBR/Graphite composite and NBR/Graphene Nano composite) with different treatments (Phr levels) were conducted during this study. Nitrile rubber composites were prepared accordance with Brabender Plasticorder (Model: PL-2000; 26 manufacturers: ArtisanTM Technology Group).

Table 01: Formulation used for the filler loading NBR composite and NBR nanocomposite

| Materials (phr)* | Formulation | | | | | | |
|---|---|---|---|---|---|---|---|
| | NBR0 | NBR3 | NBR6 | NBR9 | NBR12 | NBR15 | NBR18 |
| NBR | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Zno | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| Stearic acid | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Graphene / Graphite | 0 | 3 | 6 | 9 | 12 | 15 | 18 |
| IPPD | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| TBBS | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| TMTM | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Sulphur | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

Phr* - Parts per hundred parts of rubber

## Measurement of Electrical properties of the vulcanizates

Electrical conductivity tests were done with the use of four probe tester, Model 4200-SCS.

**($\sigma = L / RA$)**

**Measurement of Thermal properties of the vulcanizates**

Thermal conductivity tests were done with the use of Lee's disc method. The Thermal Conductivity is determined by follows

$$k = \frac{mc\frac{dT}{dt}}{A\frac{(T_2 - T_1)}{x}}$$

**Result and Discussion**

Table 02: Physio-mechanical Properties of NBR/Graphene nanocomposite

| Physical Properties | 0 phr | 3 phr | 6 phr | 9 phr | 12 phr | 15 phr | 18 phr |
|---|---|---|---|---|---|---|---|
| Tensile Strength (Mpa) | 3.0 | 3.2 | 4.4 | 4.1 | 5.8 | 6.8 | 6.4 |
| Mean Mod@100% (Mpa) | 1.4 | 1.6 | 1.9 | 2.0 | 2.3 | 2.7 | 3.4 |
| Elongation at break (%) | 301.9 | 331.5 | 314.9 | 329.9 | 363.3 | 382.1 | 309.1 |
| Tear Strength (N/mm) | 8.6 | 9.8 | 12.9 | 14.8 | 13.7 | 19.3 | 25.0 |
| Hardness (IRHD) | 49.1 | 51.6 | 53.5 | 55.7 | 56.9 | 59.0 | 60.1 |
| Abrasion Resistance (mm3) | 55.5 | 49.3 | 55.6 | 75.7 | 50.0 | 49.2 | 50.1 |
| Density(g/cm3) | 1.0 | 1.0 | 1.0 | 1.1 | 1.1 | 1.1 | 1.1 |

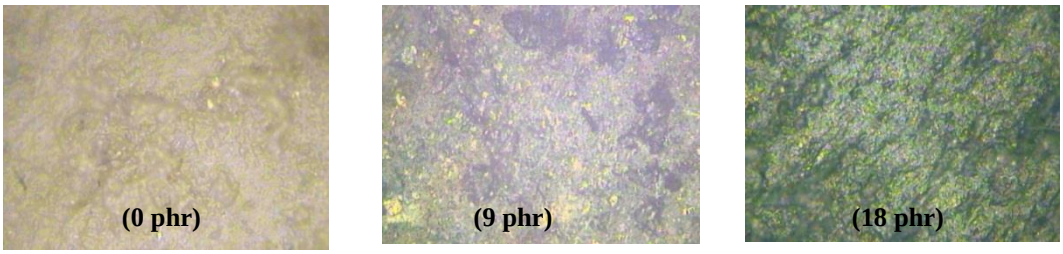


Figure 01: Surface morphology of NBR Nano composites through transmitted light metrological microscope with different graphene powder levels

According to four probe method, no improvement of the electrical conductivity of both NBR composites(4.03x10-8- 5.24 x10-8Scm-1) Considering the images of transmitted light metrological microscope, particle distribution was not uniform, and there was agglomerations of graphite derivatives in the nitrile rubber matrix. Those agglomerations directly affect to the electrical conductivity. Because it reduce the path ways of electrons flowing.

Thermal conductivity of NBR/graphene Nano composite was higher than that NBR/graphite composite. But there was no better improvement to the nitrile rubber. According to literature, the key problem is the scattering of phonons at the interface of the dissimilar phases, the imperfection of particle/particle contacts, may responsible to the observed effects. Usually better results are achieved, if micro- and nano-fillers are combined, where the inter-particle polymer layers may be bridged over by nano-particles. (Minha et al, 2013)

**Conclusions**

Effect of graphite and graphene powder content on physical properties of NBR composite and Nano composites was studied. Overall results show that graphene filled Nano composites exhibited higher mechanical properties than graphite filled NBR composites.

Effect of graphite and graphene powder content on electrical conductivity of NBR composite and nanocomposites were studied. According to the results there was no any better improvement of electrical conductivity of graphite derivatives filled nitrile rubber compounds.

Results clearly demonstrated that thermal conductivity of NBR compound was not largely improved. Uneven dispersion of graphite derivatives through the NBR rubber matrix directly affect to the poor improvement of thermal conductivity.

**Acknowledgements**

Laboratory facilities provided by the Rubber research institute, ratmalana and Moratuwa University are acknowledged.

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# Optimization the physical properties of carbon black filled tread compound by replacement with silica

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## Introduction

In tire industry, carbon black (CB) is a widely used filler all over the world (Studebaker, 1965). Being a product made out of petroleum, there would be scarcity issue with the time, if continue to use in which it is being used today. It is a high time to look at feasibility of replacing CB with an alternative such as silica partially/fully as a solution for foreseen scarcity. Compared to CB, there won't be scarcity as due to the fact it is made out of quartz (SiO2) which is readily available in earth crust. In this research, an attempt has been made to study the feasibility to go for possible replacement with silica while meeting the physical property requirement of a tread compound.

## Methodology

The current study was carried out at Loadstar (Pvt) Ltd, Ekala. This study was conducted as two separate experiments. In experiment I, optimum CB/Silica combination which gives overall physical properties was evaluated. Five tread compounds were prepared. Each compound has the same ingredient except filler amount. Total filler amount was kept constant at 50 phr level. Carbon black and powder silica was varied in the ranged from 0 to 50 phr level to prepare the tread compounds with different CB/Silica ratios. Weight of all ingredients in the recipes was in units of per hundred rubbers. Batch weight was 1100 kg. Compound without silica was treated as the reference compound. The compounds were named as Si0, Si15, Si25, Si35 and Si50 to indicate the amount of silica incorporated in the compounds. Silane was added when incorporation of silica as 1 phr of Silane for 8 phr of silica as the coupling agent. Experiment II was carried out to find out the effective silica type in order to optimize the physical properties. Better treatment combination from the experiment I was selected and it has been treated with three silica types (Powder silica, *Hi-sil 243* and *New-sil 155*). Physical properties such as: tensile strength, tearing, abrasion resistance, 300 % modulus, elongation at break, hardness and rebound resilience and cure characteristics were measured in both experiments. Four replicates were used for each test. Data was analyzed with one way ANOVA using Minitab 16 statistical software and mean comparison was done using Tukey test.

## Results and Discussion

According to the previous studies it shows that the increasing silica loading tends to increase in the cure time ($t_{90}$) and scorch time ($ts_2$) of the rubber vulcanizates (Okel and Waddell, 1994). These properties have increased with increasing silica. At 15 phr level of silica, it tends to reduce the scorch protection. This can be due to the insufficient coupling of silane with silica during compounding. Higher processing safety obtained as silica loading high due to formation of

salicylic acidic at this stage. Maximum torque (MH) tends to decrease as the CB amount decrease.

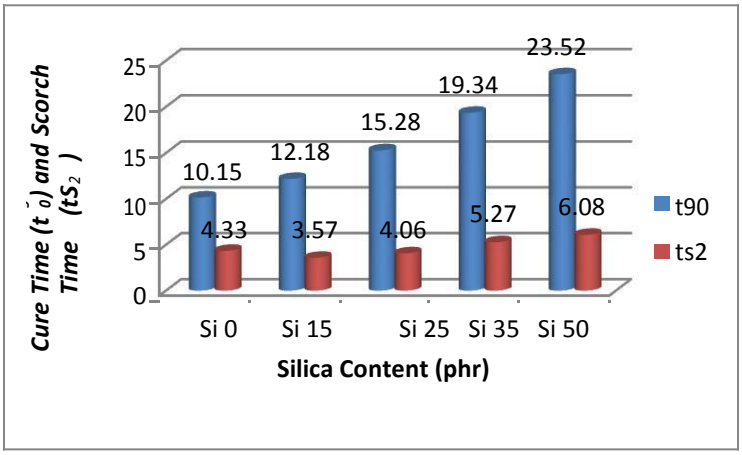


Figure 01: Cure tme and Scorch time at various silica ratios

In experiment I, Tensile strength of the vulcanizates decrease as silica content in increasing. This behaviour is due to the decrease in the cross linking density of the tread compounds. With the increasing of silica content, modulus of the tread compounds were tends to decrease. Decreasing cross-linking density has cause to reduce the modulus. As a consequence of this, rise in elongation at break is observed at high silica content. Tear strength of the tread compounds are significantly difference at various filler loading (P = 0.000). Results shows that abrasion resistance tends to decrease when silica content is high. Good filler dispersion causes to have better wear properties than poor dispersion (Choi, 2002). Therefore poor silica dispersion or high silica-silica interaction has claimed to decrease the abrasion resistance properties. Hardness of the compound and rebound resilience also have increase at high silica loading. Highest resilience is results in the full replacement of CB with silica. Higher the rebound resilience, gives low heat build up.

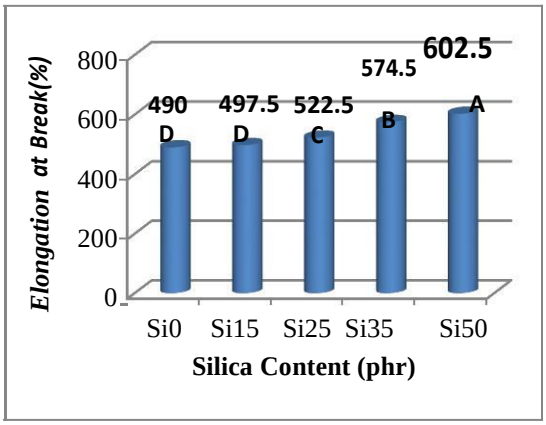


Figure 02: Elongation at break

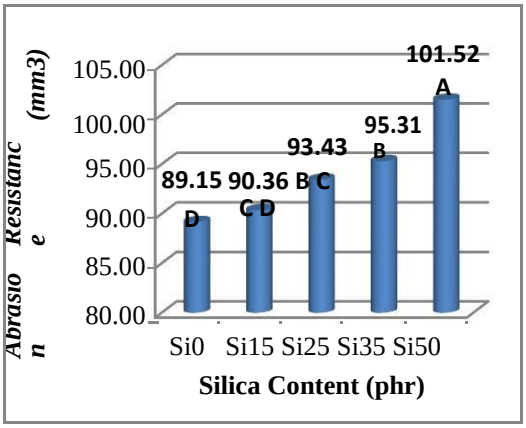


Figure 03: Abrasion Resistance

In experiment II, 25 phr of CB and 25 phr of silica treatment combination was treated with three silica type. Results reveal that tensile strength, tearing, abrasion resistance, 300 % modulus, hardness and rebound resilience show significant difference as P-values are less than $\infty$ according to one-way ANOVA. Apart from these physical properties, elongation at break do not show significant difference.

Table 01: Physical properties of CB 25/ Si 25 compound at different Silica type

| **Properties** | **Powder silica** | ***Hi-sil* 243** | ***New-sil* 155** |
|---|---|---|---|
| Tensile strength | 238.19 | 237.01 | 231.03 |
| Tearing | 64.66 | 62.81 | 67.33 |
| Modulus 300% | 110.47 | 109.69 | 102.86 |
| Elongation | 522 | 513.75 | 510 |
| Abrasion resistance | 93.43 | 103.39 | 93.86 |
| Rebound resilience | 47 | 48.50 | 49.75 |
| Hardness | 65.25 | 64.25 | 61.75 |

**Conclusions**

As CB and silica has two different chemistry, this replacement result both failure and improved properties. Partial silica replacement is better than the full replacement to this tread formulation. It can be concluded that vulcanizate having 25 phr of CB and 25 phr of silica better overall mechanical properties. *Hi sil* 243 is the effective silica type compare to other studied silica.

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# Studies on copra drying for white coconut oil production

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## Introduction

Currently, copra is produced at a relatively small scale using a traditional process which involves a high degree of manual labour. Copra production relatively takes longer time to dry and it is a time consuming process. Sri Lanka, as a copra exporter in the world, it is needed to find out new copra production methods, which give relatively high quality copra in order to produce high quality coconut oil. Therefore it is needed to conduct studies on higher scale production process which is more cost-effective than the current process, and which will give a consistently high quality milling copra. This is to evaluate the effect of de-shelling on the copra drying process compared to previously conducted trials. Therefore de-shelled coconut kernel is to dry in an indirect heated copra dryer in Pannala area which is belong to Adamjee Lukmanjee & Sons (Pvt) Ltd and to obtain good quality product and evaluating the product via standard quality parameters.

## Methodology

Drying experiments were carried out at Adamjee Lukmanjee & Sons (Pvt) Ltd. laboratory and the hot air dryer located at the Pannala area which belongs to Adamjee Lukmanjee & Sons (Pvt) Ltd. The research work was done as two parts. First laboratory scale experiment was done to produce de-shelled copra and the next step was to do a trial run in large scale. In the current study, coconut nuts were de-shelled and separated into three sizes as the cup size, half of the cup and quarter of the cup as three replicates of each treatment. Normal cup size copra was used as the reference. Drying time which takes to remove moisture content upto 6% from the coconut kernel was recorded in each treatment. Then quality parameters of each treatment were evaluated to obtain good quality copra product through the process of drying the de-shelled coconut nuts. These properties such as: Total plate count (TPC), Yeast and mould (Y&M) and Free fatty acid (FFA) content of de-shelled copra was measured by keeping one month period of time under typical storage facilities. Free Fatty Acid levels in each replicates were measured for chemical analysis. Trial was conducted using 10,000 coconut nuts to prepare de-shelled copra. All experimental data with three replicates were analysed with one way ANOVA using Minitab 16 statistical software. All comparisons were based on a 95% confidence interval. Mean comparison was done using Tukey test.

## Results and Discussion

According to the drying time evaluation, there is a significant difference ($P < 0.05$) with the control sample. Cup copra with the shell gives the highest time to dry out the kernel to 6 % moisture. Free fatty acid content in the de-shelled copra is higher than the reference. This can be due do the removal of the shell. But FFA is at the required level of standard milling copra used to make oil. Total plate count is lower in control treatment. It can be noted that highest TPC resulted in the cup copra without shell. This can be due to the external factors affect during the

storage time period. Though TPC is lower in control treatment, Y & M has increased in that treatment. This can be highly susceptible for yeast and mould growth. Half size copra sample is comparable to the control sample and the other two treatments are different. All the treatment levels are at the required range of this quality parameter.

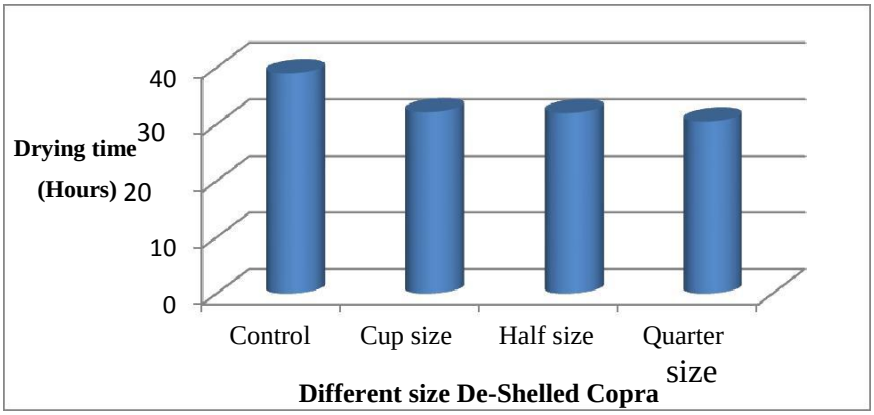
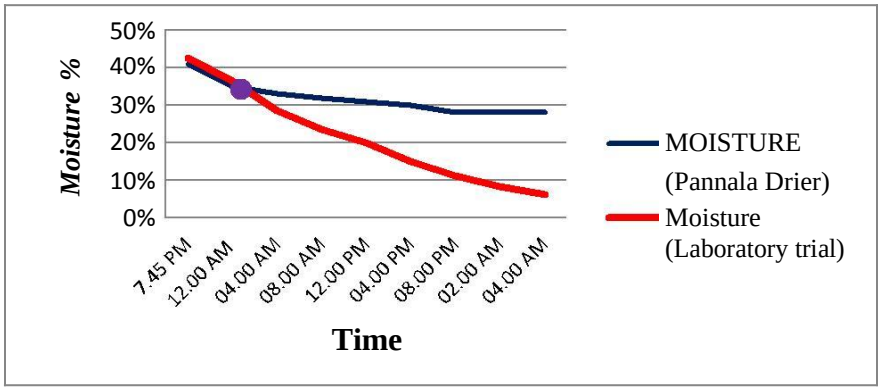



Figure 01: Drying time of De-shelled copra

Table 01: Keeping Quality Parameters of De-shelled Copra

| Parameter | Treatments | | | |
|---|---|---|---|---|
| | Control | Cup size | Half size | Quarter size |
| FFA | 0.83 | 0.64 | 0.54 | 0.18 |
| TPC | 554.00 | 2917.00 | 1763.00 | 1819.30 |
| Yeast and Mould | 20.16 | 14.33 | 23.66 | 11.00 |

In the next part of the study, large scale trial run was done to produce de-shelled copra with the help of indirect hot air dryer. Hot Air dryer performed well at the beginning but, with the time after 4 hours the dryer was malfunctioned. Initially 55 $^{o}$C of temperature showed inside the chamber. When the drier get malfunctioned, temperature fell up to 35 – 40 $^{o}$C of temperature. Therefore, required moisture content of 6 % does not appear within the calculated time.




Pannala dryer get malfunctioned

Figure 02: Comparison of Moisture Reduction

## Conclusions

These studies covers on advance test methods related to copra production. Instead of the conventional process of copra drying, new studies were carried out by using indirect heated hot air dryers. This method helps to produce copra within short period of time compare to conventional drying. Cup size of de-shelled copra is easy of processing and handling compare to other two sizes.

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# Study of later separation time duration of coconut milk in storage tanks during coconut milk powder production

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## Introduction

Coconut milk is a milky fluid obtained by manual or mechanical extraction of fresh coconut kernel with or without addition of water. It is a white, opaque protein-oil-water emulsion and essentially free from fiber. Coconut milk powder is a preservation method for coconut milk and also coconut milk powder substitute for coconut milk. In coconut milk powder production, coconut milk store in milk tanks during storage coconut milk destabilize and separate in to layers (cream phase, fat phase and aqueous phase). This layer separation adversely affect to the quality of the spray dried coconut milk powder. Therefore coconut milk layer separation in storage tanks is a major problem in the production of spray dried coconut milk powder. To overcome this problem some modification of the processing line were studied in the present work.

## Methodology

Effect of homogenization and use of a stabilizer prior to storage were tested. Sodium Caseinate was used as emulsifier. To find out optimum Sodium Caseinate percentage five different Sodium Caseinate percentages were used (0.5%, 1.0%, 1.5%, 2.0%, and 2.5%). With those percentages coconut milk homogenized and stored for 24 hours and separation heights were measured. Quality of the coconut milk powder was compared with the existing production line. All spray dried samples were tested for fat and moisture.

## Results and Discussion

According to the results of this experiment the "p" value of pH was 0.215 ($0.05 < 0.215$). There was no significantly different between pH values of coconut milk treated by different percentages of Sodium Caseinate. The "p" value of separation height of coconut milk was 0.000 ($0.05 > 0.000$). There is a significantly differences between pH values of coconut milk. Separation height of T1 and T2 were significantly different from T2, T3, T4 and T5. T1 and T2 also significantly different from each other. T3, T4, and T5 were not significantly different each other and mean value of T3, T4 and T5 were 0.000. There were no separation T3, T4 and T5. Reason was T3, T4, and T5 were treated with Sodium Caseinate and homogenized**.** (T1, T2, T3, T4, T5 all are different treatment levels)

Table 01: Different Treatments

| Treatments | pH mean | Separation Height |
|---|---|---|
| **$T_1$** | $6.16000^A$ | $1.4000^A$ |
| **$T_2$** | $6.08000^A$ | $0.6333^B$ |
| **$T_3$** | $6.18000^A$ | $0.0000^C$ |
| **$T_4$** | $6.23333^A$ | $0.0000^C$ |
| **$T_5$** | $6.22000^A$ | $0.0000^C$ |

Coconut milk layer separation can be prevented using homogenization with Sodium Caseinate. The optimum Sodium Caseinate percentage was 1.5% to minimize the layer separation of coconut milk in storage There is no significant difference of microbial growth between Sodium Caseinate treated coconut milk and fresh coconut milk storage in cool room temperature (<10 $^0$C) There is no considerable growth of microbes in Sodium Caseinate treated coconut milk storage under $10^0$C. Coconut milk homogenization with Sodium Caseinate can prevent fat accumulation of the top layers in storage. With suggested processing steps change coconut milk powder fat percentage fluctuation can be prevented.

**Conclusions**

Properties of coconut milk (total solid and pH) were not considerably vary day by day**.**Coconut milk layer separation can be prevented using homogenization with Sodium Caseinate**.** The optimum Sodium Caseinate percentage was 1.5% to minimize the layer separation of coconut milk in storage**.** According to the studies there was no significant difference of microbial growth between Sodium Caseinate treated coconut milk and fresh coconut milk storage in cool room temperature (<10 0C).Coconut milk homogenization with Sodium Caseinate can prevent fat accumulation of the top layers in storage.

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# Performance of coconut kernel residue oil as a processing oil in carbon black filled natural rubber composites

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## Introduction

Processing oil is aromatic or aliphatic hydrocarbon used in dry rubber compounding to obtain efficient dispersion of filler in rubber, lower the power consumption during mixing, provides lubrication between rubber molecules. Incorporation of processing oil improves the physical properties of natural and synthetic rubber such as elasticity, low temperature performance, and aid in the dispersion of pigments resulting in improvement of tensile strength and abrasion resistance and rather they decrease hardness, elongation at break, tensile strength, resilience. Mainly aromatic, paraffinic and naphthenic oils are used as processing oils in dry rubber compounding. According to the regulations of European Parliament, use of petroleum based processing oil rich in in polycyclic aromatic hydrocarbon has been banded since 2009 due to carcinogenic. Therefore, scientists are switching onto naturally occurring oils because of restriction on use of fossil fuel based processing oils. An effort was taken to evaluate the performance of the Coconut Kernel Residue Oil (CKRO) as a processing oil in Carbon Black (CB) filled natural rubber composites.

## Methodology

Firstly, the CKRO was characterized with regards to fee fatty acid, moisture, ash and metal ions content ($Fe^{+2}$, $Cu^{+2}$). Then CKRO was incorporated in different treatment levels (0, 2, 4, 6, 8 and 10 phr) as processing oil in carbon black (CB) filled natural rubber composites. Both curing and physico-mechanical properties including tensile strength, tear strength, elongation at break, abrasion volume loss, compression set, rebound resilience and harness of the vulcanizates containing different levels of CKRO were compared against the standard vulcanisate which was prepared by using 6 phr of aromatic oil used in the industry at present and all the tests were carried out according to the ISO standard test methods.

Table 01: Treatment Combinations

| Treatment | $T_C$ | $T_1$ | $T_2$ | $T_3$ | $T_4$ | $T_5$ | $T_6$ |
|---|---|---|---|---|---|---|---|
| CKRO(phr) | - | 0 | 2 | 4 | 6 | 8 | 10 |
| Aromatic Oil phr | 6 | - | - | - | - | - | - |

**Result and Discussion**

Table 02: Characterization of the CKRO

| Parameter | Free Fatty Acid (%) | Moisture Content (%) | Metal Ions (ppm) | |
|---|---|---|---|---|
| | | | Ion | Cupper |
| CKRO | 7.2 | 4.14 | 1.715 | 0.04 |

There is a high amount of free fatty acid content in coconut kernel residue oil, because it has become more rancid with time.

Table 03: Curing Characteristics of Rubber Composites

| Oil phr | MH | ML | $T_{C90}$ | $T_{S2}$ | CRI |
|---|---|---|---|---|---|
| 6a (control) | 26.59 | 4.53 | 9.96 | 3.37 | 15.17451 |
| 0 | 27.62 | 3.82 | 10.12 | 3.02 | 14.08451 |
| 2 | 27.06 | 4.95 | 10.35 | 3.57 | 14.74926 |
| 4 | 25.64 | 3.94 | 10.45 | 3.67 | 14.74926 |
| 6 | 25.85 | 3.83 | 10.27 | 3.44 | 14.64129 |
| 8 | 22.7 | 3.29 | 10.5 | 3.82 | 14.97006 |
| 10 | 21 | 2.73 | 10.45 | 3.88 | 15.2207 |

Results of the present study revealed that, there is a reversion trend in maximum and minimum toque with the increasing of oil phr levels the in compounds. Minimum and maximum toques of the compounds contain2, 4, and 6 phr of oil are comparable those of the reference. $T_{S2}$, $T_{C90}$ and CRI are increasing with the increasing of CKRO phr.

Furthermore, it was found that, oil phr doesn't make any influence on tensile strength, tear strength and the hardness of the compounds whereas the aging properties are better for all compounds due to formula has conventional vulcanizations system. Moduli of the compounds contain 2, 4, 6, 8, and 10 are comparable with reference whilst the elongation is correspondingly increases with oil phr. There is decreasing trend in abrasion volume loss with the increasing of oil phr and 8 and 10 phr showed the lowest abrasion volume loss. Compression set of the rubber composite contain 6 phr of oil is comparable with the reference. Rebound resilience of the compounds contain 2, and 6 are comparable with the reference while 10 phr shows the minimum rebound resilience.

**Conclusions**

The lowest toque and the maximum toque were decreasing with the increasing processing oil content. Scorch time, cure time and cure rate index were increasing with the increasing of oil phr.

Furthermore, there were no significant differences among the oil contents on tensile strength, tear strength and hardness of the compounds within the studied range. Even though, the compression set of all the compounds were not in an acceptable level due to the presence of more free fatty acids. Moduli, tensile stain at break, abrasion volume loss and rebound resilience could be optimized by using coconut kernel residue oil as a processing oil for the tyre tread compound formulation instead of using banded carcinogenic aromatic processing oil.

**Acknowledgements**

Especially, I would like to express my heartfelt gratitude to Mr. Pradeep Fenando, Research and Development Executive at Associated Motor Ways (PVT) Limited, Kaluthara South for facilitating me to compound in their laboratory. Finally I express my sincere thanks to my parent and friends who supported me in numerous ways to complete my research project successfully.

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## Technical Session - Tea Technology and Value Addition

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### Oral Session

## Poster Session

# Impact of good agricultural practices on technical efficiency of Tea small holders

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## Introduction

Tea is pre-eminent among Sri Lanka's plantation crops and it is one of the most important industries in the country in terms of employment and foreign exchange earnings. Sri Lanka's tea small holders, who account for 76% of the national tea output, are the mainstay of Sri Lanka's tea industry, are facing some serious problems like increasing cost of production and reducing marginal profits that will directly contribute towards reducing the national tea output in the future. However, given the high cost of production, there is a belief that it is very difficult to increase profitability without increasing costly inputs (Basnayake *et al*., 2002). Good Agricultural Practices (GAPs) addresses environmental, social and economical sustainability and often in combination with effective input use, is one of the best ways to increase smallholder productivity without costly inputs (Poisot *et al*., 2004). Having identifying the importance of GAPs in tea industry, this study was conducted to find out the impact of GAP adoption on technical efficiency of tea small holders in Sri Lanka

## Methodology

84 tea small holders were selected as the sample, among tea small holders in Kuruvita DS Division using multistage sampling. Four TI ranges (Wewalwaththa, Erathna, Eheliyagoda and Kiriella) in Kuruvita were selected and 21 tea small holders were selected from each TI range.

Data collection was carried out by using structured questionnaire. The questionnaire includes two basic parts, part one is consisted basic inputs to measure technical efficiency and other part is used to collect data to find about the adoption level of tea small holders to Good Agricultural Practices on tea cultivation. To measure GAP adoption level questions were prepared under 14 GAP principles specifically to tea cultivation as recommended by Tea Research Institute (Zoysa, 2008).
Stochastic Frontier Production model was used to measure the technical efficiency. STATA statistical package, Minitab software and Microsoft Excel were used to data analysis.

$$\text{GAP Adoption Level} = \frac{\text{Number of GAP principles adopted by TSH}}{\text{Total GAP Principles}} \times 100 \quad (1)$$

GAP adoption level was measured using above equation for each TSH. Two empirical models were used to measure the factors affect production and to measure technical efficiency.
One of the empirical models is Cobb-Douglas function. In our calculation variables are explained by following Cobb-Douglas equation

$$lnY_{it} = ln\beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + \beta_6 lnX_6 + U_{it} \quad (2)$$

Table 1: Description of variables for Cobb-Douglas model

| Notation | Name of Variable | Remarks |
|---|---|---|
| $\boldsymbol{lnY_{it}}$ | Log value of total green leaves | Kg |
| $\boldsymbol{ln\beta_0}$ | Parameter for intercept of regression line | None |
| $\boldsymbol{ln\beta_1 X_1}$ | Log of tea land extent | Acres |
| $\boldsymbol{ln\beta_2 X_2}$ | Log of family labor | Hours |
| $\boldsymbol{ln\beta_3 X_3}$ | Log of hired labor | Hours |
| $\boldsymbol{ln\beta_4 X_4}$ | Log amount of fertilizer | Kg |
| $\boldsymbol{ln\beta_5 X_5}$ | Log amount of agrochemicals | Rupees |
| $\boldsymbol{ln\beta_6 X_6}$ | Log amount of Dolomite | Kg |
| $\boldsymbol{U_{it}}$ | Stochastic Error term | None |

The other empirical model used was Technical Inefficiency Function. A technical inefficiency effect was defined Battesse and Coelli (1995) and explained according to that explanation.

$$U_i = Z_i\delta + W_i \qquad (3)$$
$$i = 1,2,\dots\dots,N$$

$U_i$ is technical inefficiency, $Z_i$ is the vector of explanatory variables associated with the technical inefficiency effect, δ is the vector of unknown parameter to be estimated and $W_i$ is unobservable random variables.

In the model specification,

$$U_I = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \delta_8 Z_8 + \delta_9 Z_9 + \delta_{10} Z_{10} + W_i \qquad (4)$$

Table 2: Inefficiency Variables

| Notation | Inefficiency Variables | Unit |
|---|---|---|
| $\boldsymbol{Z_1}$ | Age of the farmer | In years |
| $\boldsymbol{Z_2}$ | Education of the farmer | In years |
| $\boldsymbol{Z_3}$ | Occupation of the farmer | Dummy, if tea only = 1, otherwise=0 |
| $\boldsymbol{Z_4}$ | Gender | Dummy, if male=1, female=0 |

| | | |
|---|---|---|
| $Z_5$ | Experience in tea cultivation | In years |
| $Z_6$ | Age of plantation | In years |
| $Z_7$ | Trainings | Number of times attend |
| $Z_8$ | Membership of association of TSH's | Dummy, if member=1, nonmember=0 |
| $Z_9$ | Adoption level to GAP | In percent |

**Results and discussion**

This section summarizes the descriptive statistics of the data and the outcome of the empirical models used to analyze the data. Following table shows summery statistics of GAP adoption level of TSH in the area.

Table 3: Summery Statistics of GAP adoption level

| Respondents | Mean | StDev | Median | Minimum | Maximum |
|---|---|---|---|---|---|
| N= (84) | 55.57 | 8.754 | 56 | 22 | 72 |

Source: Minitab 14 analysis of survey data

There were past studies which have measured adoption levels according to the number of practices respondents have adopted (Bang, 2012; Boz I, *at el* 2011). In my study also I used the number of GAPs TSHs have adopted and divide them into two levels as adaptors and non adopters.

Sample was divided to GAP adopters and non adopters. 43 TSHs who scored 56 or more was grouped as GAP adopters and 41 TSHs who scored below 56 are grouped as GAP non adopters.

The maximum likelihood estimates of the parameters of the stochastic frontier production function are presented in Table 4. The estimate of Γ is 0.926, which indicates that the majority of error variation is due to the inefficiency error Ui. (and not due to the random error Vi). This indicates that the random component of the inefficiency effects does make a significant contribution in the analysis.

Table 4: Estimates of the Stochastic Frontier Production Function

| Variable | Coefficient | Std. Err | $Z$ | $P > \|Z\|$ |
|---|---|---|---|---|
| Land extend | 0.966147*** | 0.0813178 | 11.88 | 0.000 |
| Family labour | 0.045638*** | 0.0156336 | 2.92 | 0.004 |
| Hired labour | 0.0419136** | 0.0189145 | 2.22 | 0.027 |
| Fertilizer | -0.0026291 | 0.030904 | -0.09 | 0.932 |
| Chemicals | -0.027902** | 0.012909 | -2.16 | 0.031 |
| Dolomite | -0.0193065 | 0.017832 | -1.08 | 0.279 |

| | | | | |
|---|---|---|---|---|
| Cons | 8.671964 | 0.248668 | 34.87 | 0.000 |
| $\sigma^2$ | 0.5071351 | | | |
| Γ | 0.9262876 | | | |
| Log likelihood | -48.618234 | | | |

** Significant at 10 % ** Significant at 5 % and *** Significant at 1 %*

Source: from STAT version 11 analysis of survey data

Maximum likelihood estimates of the stochastic frontier model were estimated for green leaf yield as a function of land extend, family and hired labour, fertilizer, agrochemicals and dolomite, using Cobb-Douglas model. Land extend, family labour and hired labour showed significant effect on yield in a positive way, chemicals also were showed a significant effect but in a negative way.

According to Summery Statistics of Technical Efficiency from STATA version 11, mean technical efficiency of TSH in Kuruvita is 63.17

Table 5: Determinants of inefficiency Cobb-Douglas model

| Variable | Parameter | Coefficient | Std Err | p value |
|---|---|---|---|---|
| Age | $\delta_1$ | 0.0321381 | .0263658 | 0.223 |
| Education | $\delta_2$ | -0.0130145 | .126756 | 0.918 |
| Occupation | $\delta_3$ | 0.0596928 | .4865421 | 0.902 |
| Gender | $\delta_4$ | -1.016146** | .486411 | 0.037 |
| Experience | $\delta_5$ | -0.049053 | .0327829 | 0.135 |
| Age of plantation | $\delta_6$ | 0.0268849 | .0411904 | 0.514 |
| Trainings | $\delta_7$ | 0.1533232 | .1161482 | 0.187 |
| Membership of associations | $\delta_8$ | -0.1328316 | .5093004 | 0.792 |
| GAP Adoption | $\delta_9$ | -0.12193*** | .030065 | 0.000 |

** Significant at 10 % ** Significant at 5 % and *** Significant at 1 %*

Source: STAT version 11 analysis of survey data

Gender and GAP adoption level has significant effects on technical inefficiency. The coefficient for GAP adoption level is -0.12193 and significant at 1% level on technical inefficiency.

## Conclusion

Knowledge of TSH's about GAP'S are not in a satisfactory level in this area. The results obtain of the stochastic frontier estimation revealed that, average technical efficiency of TSH's in Kuruvita given by the Cobb- Douglas model is 63.18 per cent. Therefore there is a scope of further increasing output by 36.82 per cent without increasing the level of inputs. From the factors considered which affect technical efficiency, gender of farmer and GAP adoption affect significantly at 5% and 1% levels respectively.

Male TSHs appeared to be more technically efficient than females. This may be due to male TSHs have more contact with society around them, specially with other tea small holders than typical Sri Lanka women in village. Sri Lankan women have more responsibly on house hold work than men, so they have less time to spent in farming may be another reason.

GAP adoption is positively significant at 1% level with technical efficiency. Mean technical efficiency of GAP adopted famers shown to be 71.9% while 54.1% for non adopters. As the definition says Good Agricultural Practices are practices that address not only environmental and social sustainability but also it addresses economic sustainability. By adopting GAPs TSHs can increase their technical efficiency.

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# Factors affecting on tourists' buying behavior of Ceylon Tea

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## Introduction

Worldwide tea production and consumption have increased over the past decades. According to statistics provided by the Sri Lanka Tea Board, Sri Lanka is the 3rd largest exporter and the 4th largest producer of tea in the world (Sri Lanka Tea Board 2011). However, Sri Lanka still continues to retain its position as the main source of orthodox black tea in the world with the image of Ceylon tea enhanced by its unique specialty character.
Meanwhile, Sri Lanka is one of very attractive destinations among the tourists all over the world. Sri Lanka Tourism has boomed to a new milestone of one million arrivals in 2012, which is an all-time high figure in the history of the country (Sri Lanka Tourism Development Authority 2012). Ceylon tea attracted a whole new group of customers who were traditionally non-customers in the industry. Times are fast changing, and the people are no longer looking for the cheapest beverages. They are moving away from low quality tea to a quality product. With this background Ceylon tea is being popular among tourists coming to Sri Lanka.

The local value added tea market is led by multinational players and small holders. All of these brands cater to low and middle income category consumers, who purchase tea for value for money. In addition to these players, there are plenty of small time cottage tea players who sell unbranded/loose tea (Prematunga 2009). Merely a few brands are targeting this consumer segment currently. Such brands also have no idea about tourists buying behavior of Ceylon tea.

Consumer buying behavior has been always of great interest to marketers. The knowledge of consumer behavior helps the marketer to understand how consumers think, feel and select from alternatives like products and brands and how the consumers are influenced by their environment, the reference groups, family, and salespersons and so on. The consumer's buying behavior is influenced by many factors. Most of these factors are uncontrollable and beyond the hands of marketers. An important marketing implication is that there is a growing demand to understand tourists' buying behavior in Sri Lanka. Particularly in the context of Ceylon tea this is sort of significant. Understanding the tourists' buying behavior of Ceylon tea is truly significant to the increment of sales and it functions as an indirect communication tool as well. However, despite its obvious importance, there appears to be a serious lack of formal understanding of tourists' buying behavior by both academics and practitioners. Thus, there is an immediate need of systematic research and scientific understanding of this topic.

## Methodology

Data were collected through a survey by giving a structured questionnaire to 160 tourists who bought Ceylon tea from three tea centers located in Kandy district. Judgment sampling technique was used to select Kandy as the location of the study since it is one of the major tourist destinations in Sri Lanka. Further, Kandy is known as the most famous city among tourist for Ceylon tea. Among all the identified tea outlets in Kandy district, four tea centers were selected using random sample method. Data was collected from consumers on the basis of first come, first served (FCFS).
Primary data was collected through a self-administered questionnaire among the tourist consumers of Ceylon tea. The questionnaire was consisted of three sections. Section 01 was consisted questions

regarding demographic variables such as country, gender, age, education level and number of family members. These questions helped to express a simple overview of the sample.

Section 02 was consisted 23 questions regarding independent variables which assume to be affected for tourists' buying behavior of Ceylon tea. These questions prepared for gathering data about Product factors, Motivational factors, Promotional factors, Legal factors, Travelling factors, Awareness and attitudes of Ceylon tea and past experience with Ceylon tea. All those questions were created based on Five Point Likert Scale in order to identify how these predicted factors affect to Ceylon tea buying behavior. The Likert scale was ranging from strongly agree (SA) to strongly disagree (SD).

Section 03 was consisted only one question regarding the amount spending for Ceylon tea by tourist consumers. This question prepared for gathering data about how much money they had spent for Ceylon tea during the journey.

Data were analyzed using IBM SPSS Statistics 20 software and Microsoft excel 2013 software version. Descriptive statistical techniques were used to discover and summarize the attributes of the sample and it was provided descriptive information such as mean, mode, median and standard deviation of the studied sample. Correlation coefficient and multiple regression analysis revealed that how predicted factors effect on tourists' buying behavior of Ceylon Tea.

**Results and Discussion**

According to the descriptive statistics of the study the "mean" of promotional factor has fallen under the range of $3.5 <= X < 5$.This illustrates that all the participants almost agree with the existing situation of promotional factors in Ceylon tea purchasing. However, participants are moderately agreed with six independent variables. They are Attitudes of Ceylon tea, Awareness of Ceylon tea, Experience with Ceylon tea, Legal factors, Motivational factors and Product factors. The "mean" value of all these input variables have fallen under the range of $2.5< = X < 3.5$. The "mean" value of Travelling factor has fallen under the range of $1 < = X < 2.5$. This mean value implies that tourist customers almost disagree with travelling factors in tea purchasing.

Table 1: Mean and Standard Deviation of Input Variables

| **Variable** | **Mean** | **Std. Deviation** |
|---|---|---|
| Attitudes | 3.3703 | 0.92738 |
| Awareness | 3.0766 | 0.96438 |
| Experience | 3.1625 | 1.08528 |
| Travelling Factors | 2.1219 | 0.70877 |
| Promotional Factors | 3.5073 | 1.05461 |
| Legal Factors | 3.0563 | 0.86691 |
| Motivational Factors | 3.1398 | 0.70507 |
| Product Factors | 3.0438 | 0.92848 |

According to Correlation coefficient analysis, Attitude of Ceylon tea denotes a 0.725 amount of correlation with Amount of money spend which is suggested that there is strong positive relationship between independent variable Attitude of Ceylon tea and dependent variable Amount spend. As well as, Awareness of Ceylon tea (0.542) and Product factors (0.569) show strong positive relationship with dependent variable Amount spend.

Table 2: Correlation between factors and amount spends for Ceylon tea

| **Variable** | **Pearson correlation** | **Relationship** |
|---|---|---|
| Attitudes | 0.725 | Strong positive correlation |
| Awareness | 0.542 | Strong positive correlation |
| Experience | 0.483 | Weak positive correlation |
| Travelling Factors | 0.273 | Weak positive correlation |
| Promotional Factors | 0.261 | Weak positive correlation |
| Legal Factors | 0.391 | Weak positive correlation |
| Motivational Factors | 0.483 | Weak positive correlation |
| Product Factors | 0.569 | Strong positive correlation |

According to the Multiple Regression Analysis of Predicted factors and Amount spends, Promotional factors (0.162), Travelling factors (0.120) and Legal factors (0.090) are P-Value is greater than the 0.05 therefore those elements are not significantly to the model.

Table 3: Multiple Regression Analysis of Predicted factors and Amount spends

| Variables | Unstandardized Coefficients | | Standardized | P- Value |
|---|---|---|---|---|
| | B | Std. Error | Beta | |
| (Constant) | -5176.471 | 824.660 | | **0.000** |
| Attitudes | 1340.104 | 178.748 | 0.425 | **0.000** |
| Awareness | 511.563 | 158.525 | 0.169 | **0.002** |
| Experience | 313.763 | 129.388 | 0.116 | **0.016** |
| Travelling Factors | 301.710 | 192.778 | 0.073 | 0.120 |
| Promotional Factors | 180.796 | 128.525 | 0.065 | 0.162 |
| Legal Factors | 280.579 | 164.291 | 0.083 | 0.090 |
| Motivational Factors | 634.277 | 208.042 | 0.153 | **0.003** |

When consider Attitudes of Ceylon tea, the Beta coefficient of 0.425 indicates that when Attitudes of Ceylon tea was increased by one unit while other variables remain constant, amount of money spend was increased by 0.425 units. It can be seen that Assurance contributed significantly to the model since p-value of 0.000 is less than 0.05 level of significant.

When consider Awareness of Ceylon tea, the Beta coefficient of 0.169 indicates that when Awareness of Ceylon tea was increased by one unit while other variables remain constant, amount of money spend was increased by 0.169 units. It can be seen that Assurance contributed significantly to the model since p-value of 0.002 is less than 0.05 level of significant.

When consider Experience of Ceylon tea, the Beta coefficient of 0.116 indicates that when Experience of Ceylon tea was increased by one unit while other variables remain constant, amount of money spend was increased by 0.116units. It can be seen that Assurance contributed significantly to the model since p-value of 0.016is less than 0.05 level of significant.
When consider Motivational Factors, the Beta coefficient of 0.153 indicates that when Motivational Factors were increased by one unit while other variables remain constant, amount of money spend

was increased by 0.153 units. It can be seen that Assurance contributed significantly to the model since p-value of 0.003 is less than 0.05 level of significant.

When consider Product Factors, the Beta coefficient of 0.200 indicates that when Product Factors were increased by one unit while other variables remain constant, amount of money spend was increased by 0.200units. It can be seen that Assurance contributed significantly to the model since p-value of 0.000 is less than 0.05 level of significant.

By using above information, multiple linear regressions model can be articulated as follows.

$$\mathbf{AS = - 5176.471 + 0.2\ PDF + 0.153\ MF + 0.169\ AW + 0.425\ AT + 0.116\ EX + \delta}$$

**Conclusion**

The first objective of this research was to identify the relationship between factors affecting on tourists' buying behavior of Ceylon tea. Correlation coefficient used to identify the relationship between predicted factors and amount spends for Ceylon tea. According to the results, Attitude on Ceylon tea, Awareness of Ceylon tea and Product factors have a strong positive relationship with Ceylon tea buying behavior but, travelling factors, legal factors, motivational factors, promotional factors and experience have weak positive relationship with Ceylon tea buying behavior of tourists.

The second objective of this research was to identify the impact of factors on Ceylon tea buying behavior. Multiple regressions analysis was used to identify the factors influence on Ceylon tea buying behavior. According to multiple linear regression test, Attitude of Ceylon tea, Awareness of Ceylon tea, experience of Ceylon tea, Product and motivational factors were significant under 95% significant level. All other factors weren't significant.

The third objective was to identify the most and least influencing factors on tourists' buying behavior of Ceylon tea. Among the eight factors, Attitudes of Ceylon tea has high correlation with amount spends for Ceylon tea. Therefore it's most important factor which is having high influence over to the Ceylon tea buying behavior. Further, Promotional factor has a least influence on tourists buying behavior of Ceylon tea.

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# Determinants of Poverty in Tea Estate Workers in Nuwara Eliya District

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## Introduction

As a developing country, poverty is a major issue in Sri Lanka. The poverty or poor is expressed as lack of access to basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education etc. The poverty line specifies the minimum standard of living condition in the society to which everybody should be entitled. However, income level and other facilities available to people in the different sectors may vary. Also, the household living standard has a strong relationship with the poverty of the people. NuwaraEliya district is one of the major tea growing areas in Sri Lanka. Of the total population in NuwaraEliya district (706,588), 53.6 % of the population is belonged to estate sector (Central Bank, 2013). Knowing the socio-economic factors which affect to poverty in estate sector is vital to find the strategies for improving their living conditions. Therefore, this study attempts to identify the determinants of poverty in estate sector. The results of the study will be useful to make policies and suggestions to improve their living conditions of estate workers in NuwaraEliya district.

## Methodology

The present study was conducted in tea growing locations of NuwaraEliya district. There are five District Secretariat (DS) divisions in NuwaraEliya District and of them, NuwaraEliya DS division was purposely selected for the study, since the highest estate population is recorded in this DS division (Central Bank, 2013). Multi stage sampling method was used for the selection of tea estates and systematic sampling technique was used to select the respondents. Out of seventy two GramaNiladari divisions, four GramaNiladari divisions were randomly selected. An estate was randomly selected from each selected GramaNiladhari division. Fifty workers were selected from each estate for the survey and total sample size was 200 estate workers. Primary data relating to various parameters of socio - economic status were gathered through well designed and pre tested questionnaire. The secondary information was collected from various published/unpublished sources. Tabular and regression techniques were employed to analyse the data. Binary Logistic regression model was employed to identify the determinants of poverty.

A poverty level (poor or non - poor) was decided by using the real per capita expenditure as a cut off point corresponding to Sri Lanka Official Poverty Line (OPL) Rs. 3924 in 2014 August (Department of Censes and Statistic, 2014).

The Binary Logistic regression model could be expressed as

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \varepsilon$$

$$P(Y_i = 1) = \frac{exp\ (x_i\beta)}{1 + exp\ (x_i\beta)}$$

Where,

Table 01: Variable description

| Variable | Variable Description |
|---|---|
| Y | Poor / Non poor household<br>1, Poor (if per capita household monthly expenditure < Official poverty line)<br>0, Non poor (if per capita household monthly expenditure > Official poverty line) |
| $X_1$ | Household size (Number) |
| $X_2$ | Gender of the household head<br>1, Male<br>0, Female |
| $X_3$ | Dependency Ratio |
| $X_4$ | Age of household head (Years) |
| $X_5$ | Education level of household head<br>1, if the household head was illiterate<br>2, if household head had studied up to primary (Grade1-5)<br>3, if household head had studied up to middle (Grade 6-10)<br>4, if household head had studied up to secondary (Grade 11-13)<br>5, if household head had studied up to graduate and post graduate |
| $X_6$ | Household Income (Rs. / Month) |
| $X_7$ | Household daily calorie intake (Calories / day) |
| $X_8$ | Number of occupant members in the household (Number) |
| $X_9$ | Monthly household savings (Rs / Month) |

| | |
|---|---|
| $X_{10}$ | Suffering from Chronic illness or disability within the household members<br>0, if yes<br>1, if no |
| $\beta_0$ | Intercept term |
| $\beta_1 - \beta_{10}$ | Coefficients of X1 – $X_{10}$ |
| $\varepsilon$ | Random error term |

**Results and Discussion**

According results of the binary logistic regression (Table 02), gender of household head, education level of household head, household income and household daily calorie intake were the negative significant factors. That indicates these factors are negatively effect on poverty and positively effect on non - poor. However, household size was positive significant factor to the poverty. The negative coefficient of gender of household head (- 1.49) showed that tendency of female headed household to become a poor is high. The negative coefficient value of education level of household head (- 0.39), indicated that when the education level of the household head decreased, probability of becoming their family in to poor has increased. The coefficient associated with household income had a negative effect on poverty (- 0.000042). It indicated that when the household income was reduced they cannot fulfill their basic needs and wants, therefore the family become a poor family. The coefficient of household daily calorie intake was also negative (- 0.000150). It means that when the family members did not get their daily recommended nutrient allowance they are poor. The positive coefficient associated with household size is (0.72). Hence when household size increases, the poverty also increased.

Table 02: Parameter estimates for binary logistic regression

| Variables | Coefficient | P > Z | Exp (β) |
|---|---|---|---|
| Household Size | 0.723360*** | 0.000 | 2.061 |
| Gender of Household Head | -1.497702 | 0.083 | 0.224 |
| Age of household head | -0.035240 | 0.113 | 0.965 |
| Education level of household head | -0.399094*** | 0.009 | 0.671 |
| Dependency ratio | 0.001365 | 0.628 | 1.001 |
| Household income | -0.000042** | 0.016 | 0.999 |

| | | | |
|---|---|---|---|
| Household daily calorie intake | -0.000150*** | 0.005 | 0.999 |
| Household members suffering chronic illness or disability | 0.177778 | 0.619 | 1.195 |
| Constant | 2.507769 | 0.151 | 12.278 |

Note: significant levels denoted as *** P < 0.01 (1%) ** P < 0.05 (5%) * P < 0.1 (10%)

**Conclusion**

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \varepsilon$$

According to the results household size, gender of the household head, education level of the household head, household daily calorie intake and household income are directly influenced to the poverty in estate workers. These results indicate that large families are more tend to be poverty. Awareness creation on family planning will go a long way in reducing the household size of the estate households since there is tendency of being poor with large household size. Most of the estate workers always eat less number of food groups and their diet diversity was less therefore the awareness program should be conducted to increase workers knowledge about food consumption pattern. And also awareness program should be conducted to the parents, about importance of the education. More attention should be given to the above factors when designing poverty alleviation programmes to the estate workers in the NuwaraEliya district. The findings of the study will be useful to the government when make policies for poverty alleviation programmes in the study area.

**Acknowledgement**

All the estate managers and estate workers who have participated in my interviews are acknowledged.

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# Remittance and investment of Tea small holders in Uva region

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## Introduction

Labor shortage is a current problem facing by tea small holding sector. The predominant reason for that is migration of workers from out of farming. These migrants send remittance to their households. Societal perception about labor migration is that it has a negative impact on the sustainability of the tea small holding sector. But, there might be some positive impacts from remittance gained by the migrants especially as investments on tea lands. Hence, it is very much important to understand the ability to compensate the labor shortage by the remittance sent by the migrants. According to Chen (2004), Migrants are defined as those who lived away from their families for migratory work for no less than one month.As well as Migrant familiesspecifically refer to those rural families in which at least one family member is identified as migrant.Money and goods that are transmitted to households back home by people who working away from their origin community (Adams, 1989).

## Methodology

The population of the research was the total tea small holders in Uva region. There are 16 TI ranges under 3 main sub offices in Uva region. (Annual Report 2012, Tea Small Holding Development Authority). Multistage sampling method was used for the selection of the tea small holder's household units. There are three sub offices in Uva region as Haliela, Bandarawela, Welimada. There are six ranges of Haliela sub office, six ranges of Bandarawela sub office and four ranges of Welimada sub office. Three ranges each from Haliela and Bandarawela sub offices and two ranges from Walimada range were randomly selected. 100 Tea small holders were randomly selected from these 8 TI ranges. Primary data were collected from the farmers while they were interviewed at their field or their residences. Productive investment for tea land was the dependent variable of this study. It was measured calculating all the expenses for tea land within past twelve months. The expenditure for, Buying new tea land, Infilling the tea land, Fertilizer application, Soil conservationmeasures, Shade tree management, Pest and disease management , Within last twelve months. Household characteristics, characteristics of household head and socio economics characteristics were used as independent variables. There are thirteen independent variables as Age of house hold head, Education Level of household head, Tea cultivated land extent, Number of children, Income from Tea land, Durable consumption, Non-durable consumption, Other Investment, Migration Dummy, Remittance, Income from Other Cultivation, Income from Job of household head, Number of family members. Data were analyzed by Using Stata software package. Descriptive statistical techniques were used to present the demographic features of the sample. Multiple linear regression analysis was worked out to find out the impact of remittance on productive investment of Tea small holders in Uva region.

$$\mathbf{InvT = \beta_0 + \beta_1 AH + \beta_2 Edu + \beta_3 Land + \beta_4 NOFM + \beta_5 NOC + \beta_6 InT + \beta_7 InOC}$$

**+ β8InJ + β9Dura + β10NDura + β11OIn + β12MigD + β13Rem + εi**

(InvT - productive investment for tea land, $\beta_0$ – Constant, $\beta_0$ to $\beta_{13}$ – Coefficient, εi – Error)

**Results and Discussion**

Regression analysis were used to quantify the relationships between variables to achieve the objectives more precisely.

According to the results of the multiple regressions, coefficient value for each variable has given below.

| **Notation** | **Description** | **Coefficient** |
|---|---|---|
| Land | Tea cultivated land extent | -323.5198 |
| NOFM | Number of family members | 7835.633** |
| AH | Age of household head | -465.2015 |
| Edu | Education Level of household head | 6778.881** |
| NOC | Number of Children | -7102.874*** |
| InT | Income from tea land | 1.6452* |
| InOC | Income from Other Cultivation | 0.423728 |
| InJ | Income from job of household head | 0.3829989 |
| Dura | Durable consumption | -0.0663617** |
| NDura | Non-durable consumtion | -0.2829667 |
| OIn | Other Investment | -0.436204 |
| MigD | Migration Dummy | -18314.91*** |
| Rem | Remittance | 3.706997* |
| Cons | | -6835.742 |

[Note: * p< 0.01(99% confident interval), ** p< 0.05 (95% confident interval), ***p< 0.1 (90% confident interval)]

Independent variables which are giving high P- value less than 0.05 and 0.1, can be included to the regression equation as follows,

**InvT = -6835.742 + 6778.881Edu** + 7835.633NOFM ** + 1.6452InT***

**+ (-.0663617)Dura** + (-18314.91) MigD*** + 3.706997Rem***
**+ (-7102.874) NOC*****

The results of regression analysis shows that education level of household head, number of family members, income from tea land, durable consumption, migration of family members, remittance and number of children were the significant factors affecting on productive investment on tea land. Education Level of household head has a positive effect on productive investment for tea lands. Therefore having a profound sound education standard of household will lead to increase the productive investment. Numbers of family members have positive significant effect on the productive investment on tea land. It reveals that when the numbers of family members are increase, the productive investment on tea land will be increased. Income from tea land has positive significant effect on the productive investment on tea land. It explained that when income of the tea land is increased the productive investment also can be increased. Durable consumption has negative significant effect on the productive investment on tea land. It suggests that when increase durable consumption; productive investment on tea land will be decreased. There is a negative relationship between number of children and productive investment for tea land. Itexplained that when number of children is increased, productive investment on tea land will be decreased. Migration dummy variable has negative significant effect on the productive investment for tea land. It revealed that when labours migrate to another area out of farming, productive investment on tea land will be decreased. Even migration has negative impact on productive investment on tea land, remittance variable has positive significant effect on the productive investment on tea land. It reveals that when the possibility of remittance is increased, the productive investment on tea land will be increased.

## Conclusion

There is a significant impact of remittance gained by migrant on productive investment in tea land In Uva region among tea small holders. With increasing of remittance gained by migrants the productive investment in tea lands also increasing can be identified. My findings also imply that migrant remittances can compensate for the loss of labor in agricultural production from out migration of labours.

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Rozelle S., Taylor J. D. &DeBrauw A. 1999. Migration, Remittances, and Agricultural Productive in China, The American Economic Review, 287- 291.

# Awareness and adoption of recommended technologies and management practices by the Tea small holders

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## Introduction

Tea (*Camellia sinensis*) is the world famous beverage next to the water and having numerous health and socio economic benefits. Tea, the prominent crop of the plantation sector in Sri Lanka, grows in many parts of the country (Mendis, 1992).Tea growers who have lands less than 10 acres in extent are treated as "Tea small holdings" according the Tea Control act. The cultivation of tea is attractive to small farmers because tea provides work and income throughout the year, requires relatively little investment, and the risk of complete crop failure is small (Annual Report, Tea Small Holdings Development Authority, 2012).As well as the Contribution of small holders to the Sri Lankan tea sector is higher than the plantation sector and it is account for 71.4 % of the national tea output (TSHDA, 2012). Therefore, application of scientific agricultural knowledge and technology adaptation in the small holding tea sector is a vital investment to enhance the productivity and overall performance of the tea industry.

## Materials and methodology

Data were collected through a sample survey by giving a structured questionnaire to 8 tea inspector's (TI) ranges at Badulla administrative district and 150 small holders were randomly selected as the respondents. The questionnaire was mainly formulated to identify the awareness, level of adoption, and factors affecting to the level of adoption. The awareness was measured by percentage of aware respondents. The adoption level was measured by using "Adoption index" and "Confident interval method". Adoption index was categorized in to three levels as low adoption, medium adoption and high adoption. To identify the factors affecting to level of adoption, regression analysis was conducted and "Adoption on Technology and recommended practiced" has been taken as the dependent variable and data were collected for dependent variable under five categories as Machinery usage, Planting materials, Field practices, Recommended tests and Extension services. For the independent variables data were collected under nine categorical variables as Gender, Age level, Education Level, Source of Income, Experience with Tea land, Land ownership, Land extent, Time spending with tea land and Yield.

Data were analyzed using SPSS Software package and MS-Excel 2010 package. Descriptive statistics were done to analyze the independent variables and by using regression and correlation analysis factors affecting to the level of adoption was analyze and their strength was measured.

## Results and Discussion

According to the study only 26 % of respondents have the awareness regarding machinery usage in tea plucking and from them, 48.7 % belongs to year 40 – 50 age group. 79.3 % of the respondents have awareness regarding the improved varieties. According to the study 64.7 % of the respondents have an awareness regarding recommended tests like pH test, starch test which use at the field. Extension services have been accounted under two categories as consulting services and E-consulting services and according to the study 100 % of the respondents have an awareness on consulting services while 36 % of the respondents have awareness on E-consulting services. According to the

results of the study it shows that awareness on shade trees, pruning methods and soil conservation methods are respectively 95.3 %, 90.3 % and 93.3 %.

Level of adoption was calculated using Adoption index and confident interval method. Data were collected under five categories and finally overall adoption level for the recommended technology and management practices was calculated.

**Table 1: Level of Adoption on Recommended Technologies and Management Practices**

| **Statement** | **Adoption Level** | | |
|---|---|---|---|
| | **Low Adoption** | **Medium Adoption** | **High Adoption** |
| Machinery Usage | 71.3 % | 0 | 28.7 % |
| Improved Planting Materials | 58.7 % | 0 | 41.3 % |
| Field Practices | 26.7 % | 30 % | 43.3 % |
| Recommended Tests | 44.7 % | 0.7 % | 54.6 % |
| Extension Services | 39.3 % | 18 % | 42.7 % |
| **Overall Adoption on Recommended Technology and Management Practices** | **38 %** | **9 %** | **53 %** |

According to the Table 1, it clearly shows a lack of adoption on machinery usage in tea fields and usage of improved planting materials for the tea fields by small holders. But when we consider about the adoption level on field practices, recommended tests and extension services respectively 43.3 %, 54.6 % and 42.7 % are belong to high adoption level. After analyzing all factors 53 % of tea small holders in Badulla district show high adoption on recommended technologies and management practices while 38 % and 9 % respectively show low adoption and medium adoption.

Regression analysis was conducted to identifying the factors affect to the level of adaptation on recommended technologies and management practices. Mainly there were nine factors have been considered as independent variables. According to the results of the regression analysis Gender (0.000), Age level (0.009), Education level (0.043), Experience with Tea land (0.001) and Land extent (0.001) gave significant effect on level of adoption on recommended technologies and management practices under 0.05 significant level with the 67.9 % of $R^2$value.

After that to identify the relationship between level of adaptation and factors affected on level of adaptation, Correlations analysis was conducted.

**Table 2: Results of the Correlation Analysis with Level of Adoption**

| Independent Variables | Correlation Co-efficient | Status of Correlation |
|---|---|---|
| Gender | -0.661 | Strong Negative Relationship |
| Age | -0.251 | Week Negative Relationship |
| Education Level | 0.304 | Week Positive Relationship |
| Experience | -0.313 | Week Negative Relationship |
| Land Extent | 0.451 | Week Positive Relationship |

Results of the Table 2 show that there is negative relationship of Gender, Age level and Experience with tea land while Education Level and Land extent show positive relationship. The negative relationship of gender is due to male is given "1" and female is given "2" at the analysis. The negative relationship of the age level shows that the youngers have more adopted on recommended technologies and management practices than elders. It may be elders are not willing to shift from their traditional methods. As well as when farmers older their experience is also high. There for the experience with the tea land also have given the negative relationship. Education level has given a positive relationship with the adoption. It may due to high educated people more likely to use new technology than others and they have more access to reach for technologies. Land extent also shows the positive relationship with the technology usage. It may due to people use technology for larger lands than small lands.

## Conclusion

According to the research it is revealed that there is a good awareness on recommended technologies and management practices by the small holders. But there is a lack of awareness regarding usage of plucking machineries as 26 % and the usage of E – Consulting services (36%). When we consider about the adoption level of small holders, majority of small holders (53%) have high adoption level on recommended technologies. For the above adoption levels, Gender, Age level, Education level, Land extent and Experience is affected. Land extent and Education level positively affect while Gender, Age level and Experience affecting negatively.

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# Analysis of factors affecting for Tea buyers' level of trust on Tea brokers

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## Introduction

The tea industry in Sri Lanka has paramount importance to country's economy. In Sri Lanka, out of total quantity of bulk packaged tea, more than 95% is sold through public auction annually. The main participants of auction system are buyers and brokers. The most important concept, to carry out the business relationship between buyers and brokers is TRUST. All the transactions between buyers and brokers will confirm with the trust before complete the transaction by using monetary terms. In economic terms, trust can be defined as "the belief or perception by one party (e.g. a principal) that the other party (e.g. an agent) to a particular transaction will not cheat" (Paul J. Zak and Knack, 2001). In the case of buyer-broker relationship in the tea industry (relevant to buyers), trust can be defined as a belief of the buyer that the broker will efficiently provide good quality teas without any deceptions, while maintaining the goodwill. Therefore this research was carried out to identify major factors affecting for tea buyers' trust on tea brokers.

## Methodology

The selected population for the study was all the tea buyers who are weekly buying tea at the Colombo Tea Auction. The data were collected from a sample of 70 tea buyers selected using Simple Random Sampling technique and ranked according to their export quantity (Sri Lanka Custom Data, 2012).

Data were collected through a questionnaire by individually giving it to the selected sample. The trust was measured by using ten point likertscales. Data were analyzed using Descriptive Statisticsmanner andbased on Ordinal Logistic Regression analysis techniques.Ordinal Logistic Regression is used to predict an ordinal dependent variable given one or more independent variables(ChristensenR.H.B.,2011). The SPSS statistical software, Minitab 16 software and Microsoft Excel were used for both descriptive and ordinal logistic regression analysis.

## Result and Discussion

Following empirical model was developed to determine the factors affecting for buyers' trust on brokers.

$$Y_j=\alpha_j+\beta_1 RC+ \beta_2 RP+ \beta_3 CS+ \beta_4 CON+\beta_5 COM+\beta_6 EX +\beta_7 IR+\beta_8 ES+\varepsilon$$

Where, j = from 1 to the number of trust levels minus 1 = 1 to 9, $\alpha_j$ = Intercept of $j^{th}$threshold level (threshold coefficient), $\beta_1$ to $\beta_8$ = coefficient, RC=Relationship Continuity, RP= Reputation, CS=Conflict Solving, CON=Confrontation, COM=Communication, EX= Experience in the industry as a individual person, IR=Interpersonal Relationship, ES=Efficiency of the service and Ɛ = error.

Table 1: Estimated values of the Parameters in the fitted Regression Model Parameter Estimate Table

| Variable | Estimated coefficient | Significant value |
|---|---|---|
| Threshold | | |
| Trust = 3 | - 8.496 | 0.000 |
| Trust = 4 | -7.653 | 0.000 |
| Trust = 5 | - 6.245 | 0.000 |
| Trust = 6 | - 5.708 | 0.000 |
| Trust = 7 | - 3.417 | 0.008 |
| Trust = 8 | 0.024 | 0.985 |
| Location | | |
| Relationship continuity | 0.070 | 0.548 |
| Reputation 2 | - 1.979 | 0.167 |
| Reputation 3 | 0[a] | - |
| Conflicts solving 0 | 2.196 | 0.007 *** |
| Conflicts solving 1 | 0[a] | - |
| Confrontations | - 0.378 | 0.051 |
| Telephone frequency | 0.098 | 0.001 *** |
| Experience | - 0.212 | 0.078 |
| Interpersonal relationship 0 | - 2.832 | 0.013 *** |
| Interpersonal relationship1 | 0[a] | - |
| Efficiency of services 2 | - 3.606 | 0.012 *** |
| Efficiency of services 3 | 0[a] | |

Source: SPSS output * Significant at 5% significant level

Table 1 contains the estimated coefficients for the model. The estimates labeled thresholds are the $\alpha_j$'s, the intercept equivalent terms. The estimates labeled locations are the coefficients for the predictor variables.According to table 4.5, Reputation (Good), Taking immediate solutions for conflicts (Yes), Having interpersonal relationship (Yes) and Efficiency of the services (Efficient) were dropped to avoid singularity problems in the respond. All these variables were measured relative to the dropped categories. Estimated coefficients are tested by using standard errors and p-values

**Conclusion**

The results of the study revealed that frequency of telephone calls, taking immediate actions to solve problems, interpersonal relationship and efficiency of service providing were significant factors on

the buyers' level of trust on tea brokers at 5% significant level. Brokers should consider much on significant factors, to increase the buyers' trust level towards them by doing adjustments according to the identified factors.Experience of buyer in the tea industry (number of years in the industry as a buyer) is not affect to their trust on tea brokers. Therefore brokers should consider on all buyers without any differences according their working period in the tea industry. Sometimes though a broker is given more respect and consideration to experienced buyer, some new buyers will trust the broker than old buyer. And when having trust, it is not difficult to continue the business relationship with buyers.

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# Development of Green Tea incorporated Ayurvedic toothpaste

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## Introduction

The tea plant *Camellia sinensis* is native to South East Asia and consumed worldwide, although in greatly different amounts. It is generally accepted that, next to water, tea is the most consumed beverage in the world, with per capita consumption of $120mLd^{-1}$. Green tea contains polyphenolic compounds, which include flavanols, flavandiols, flavonoids, and phenolic acids and account for 30% of the dry weight of green tea leaves. Green tea contains compounds that appear to control inflammation and fight bacterial infection. This drink is also rich in antioxidants, which have many oral health properties as Cavity prevention, Gum health, Less tooth loss, Cancer control, Better breath (Lisa, 2011). But the oral health benefit of the green tea is less aware by the people (Narotzki *et al*, 2012). This study is aimed to develop green tea incorporated ayurvedic toothpaste by addition of five different herbs to enhance the natural flavor of the tooth paste while increasing the oral health benefits.

The main objective is to develop ayurvedic toothpaste incorporating green tea and evaluate it for selected quality parameters. Other objectives are to determine the appropriate green tea and herbal oil incorporation quantity, to evaluate taste of the toothpaste (strength, bitterness), liquor color, smell, freshness after washing and the overall acceptability as quality indicators.

## Materials and Methods

The green tea ayurvedic toothpaste consists with chemical mixture, green tea extract and herbal oil. To prepare the toothpaste chemical mixture 325g of powdered Calcium Carbonate ($CaCO_3$), 5g of Carboxy Methyl Cellulose (CMC), 10g of Sodium Lauryl Sulfate (SLS) and 2g of Methyl Paraben were mixed well during 15 minutes. And 110 mL of distilled water, 70 mL of glycerol and 70 mL of sorbitol were mixed in a separate dish and poured in to the solid chemical mixture and mixed together until 30 minutes. It was stored in a sealed container.

To extract the herbal oil 110g of each powdered Clove, Welmee, Munamal and Aralu were ground by adding 100 mL of distilled water until herbal pulp was formed. And the pulp was boiled during 10 minutes at constant temperature while mixing with 500 mL Sesame oil until evaporated the total water amount. Green tea – water extraction was done using reflux extractor (ISO 1574:1980). To prepare the green tea ayurvedic toothpaste all the three ingredients (chemical mixture, green tea and herbal oil) were mixed together at 1% , 2% of green tea extract and herbal oil levels.

Sensory evaluation with 30 untrained panelists was carried out to select the best green tea, and herbal oil incorporation quantity for the formulated toothpaste. Five point hedonic scale was used to evaluate samples for taste (strength, bitterness), color of the paste, smell, freshness after washing and the overall acceptability. Data were statistically analyzed using Freidman test at 5% level of significance using MINITAB statistical software.

The pH value of the developed toothpaste was measured with electronic pH meter. Determination of Moisture and Volatile Matter, Foaming Volume and Stability of the toothpaste were done based on SLS 275:2006 specifications.

Determination of polyphenol content of the toothpaste was done according to the ISO 14502-1 specifications. Prepared green tea ayurvedic toothpaste and control were tested for well diffusion assay using experimental microorganism included *Strephylococcs aureus* and the mean zone inhibition was measured (Awadalla *et al*, 2011). A total plate count test was done to determine the microbial evaluation of the toothpaste. The prepared mouthwash was subjected to a storage study by observing color and the smell at two weeks intervals and the pH of the product also measured.

**Results and Discussion**

Analyzed statistical data of the sensory evaluation of first experiment revealed that, there was a significant difference ($p<0.05$) among five treatments in respect to the all the sensory attributes tested. According to the Figure 1, Second treatment combination (475) which consisted of 1% of green tea extract and 2% of herbal oil amounts were selected as the best treatment to develop the new product since each of the significantly different attribute bears the highest rank mean and median values except colour of the product.

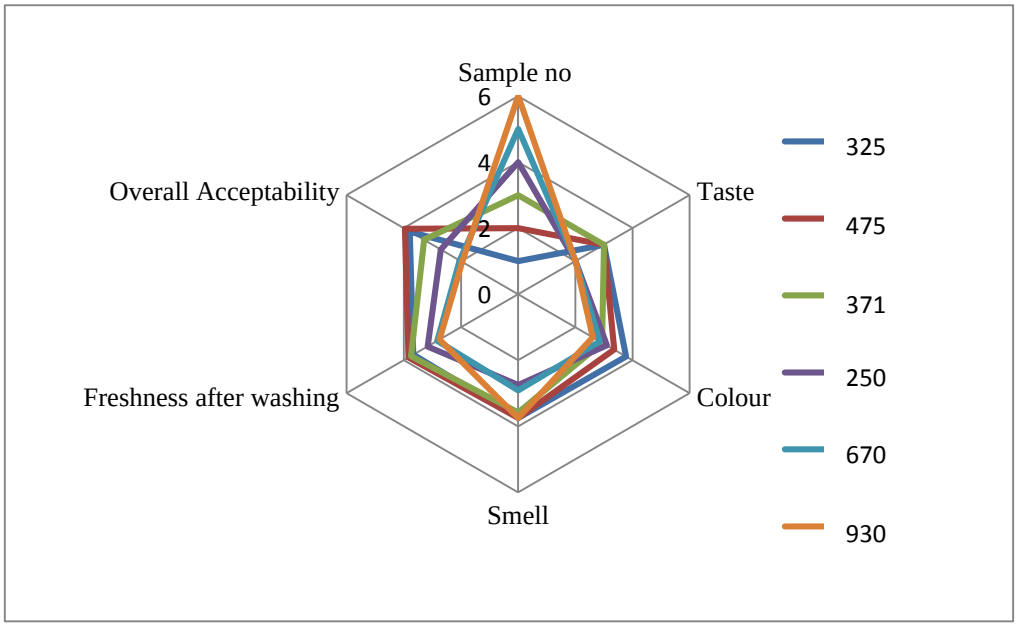


**Figure 1: Sensory profiles of different treatments tested**

The pH value of the toothpaste was 7.12. It was in the favorable pH range 5.8 – 10.5. As well as there was no any variations of the pH values during the storage. The toothpaste was consisted with 52% of moisture and volatile matter. It was in the favorable range 12 to55 percent by mass. Foaming volume of the toothpaste was 51 mL by fulfilling minimum SLS requirement

Toothpaste was having good stability at 0$^{o}$C to 45$^{o}$C temperature range and the total polyphenol content of the toothpaste was 23%. The fluoride concentration of the toothpaste was 4 ppm and it was having good effectiveness against the *Strphylococcus aureus* and free from coliform bacteria based on microbial evaluation (Figure 2), zone of inhibition and coliform test.

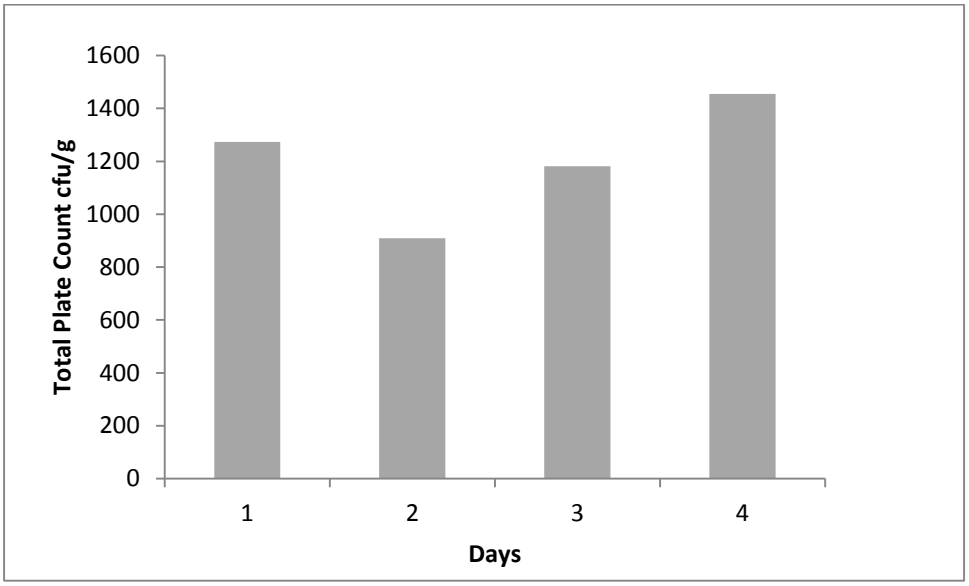


**Figure 2: Variation of Total Plate Count with the Time**

The total colony count was increased during 4 days period.The cost of production of 1g of toothpaste was Rs.1.80 based on cost for all chemical and non-chemical ingredients.

## Conclusion

To develop good quality ayurvedic toothpaste 1% of green tea extract and 2% of herbal oil amount were selected. The new product contains an appropriate polyphenol content, foaming volume, stability, pH value by fulfilling SLS requirement. The new product can store in cool and dry place at $0^{o}$C to $45^{o}$C temperature range. Based on the microbial studies, ayurvedic toothpaste was having good effectiveness against *S.aureus* and coliform bacteria.

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# Effect of Black Tea adulteration on quality parameters of Black Tea

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## Introduction

Black tea is produced by withering, rolling, fermentation and drying from the tender shoots of varieties of the species *Camellia sinensis* (L.) (ISO 3720, 2011). Black tea adulteration is a particularly massive problem because of the universality of its consumption (Kariyawasam, 2014). Since black tea is a pure beverage material, it should be free from extraneous matter, added colouring matter and harmful substances (FSSAI, 2011). But sugar, ferrous sulphate and sodium bicarbonate are added majorly to black tea during manufacturing to improve colour of tea particles and weight of tea (Deshappriya, 2013; Kariyawasam 2014). The current study was carried out at Sri Lanka Tea Board to investigate the effect of major adulterants on quality parameters of black tea.

## Materials and Methods

Black tea manufacturing was carried out in Uva medium black tea manufacturing factory following general requirements and steps (withering, rolling, fermentation and drying). 50% sugar, 10% sodium bicarbonate and 10% ferrous sulphate solutions in mass fraction were treated separately to first dhools as adulterants after rolling and kept it for fermentation. Those adulterated black tea samples and pure black tea samples were analysed for quality parameters such as, total polyphenol content, moisture content, total ash, water soluble ash, alkalinity of water soluble ash, water extract, total plate count, total liquor colour and brightness.

These quality parameters were analysed in accredited analytical laboratory at Sri Lanka Tea Board according to the ISO 14502-1: 2005 for total polyphenol content of black tea, ISO 1573: 1980 for loss in mass at 103 $^{\circ}$C (moisture content), ISO 1575: 1987 for total ash, ISO 1576: 1988 for water soluble ash and water insoluble ash, ISO 1578: 1975 for alkalinity of water soluble ash, ISO 1574: 1980 for water extract, SLS 516-1: 1991/ ISO 4833: 2003 for total plate count, spectrophotometric method described by Roberts, and Smith (1963) for determination of total colour and brightness of black tea. The data were statistically analyzed with ANOVA using Minitab statistical package. Mean comparisons with control level (pure black tea) and multiple mean comparison were performed by Dunnett simultaneous test and Tukey simultaneous test using General Linear model at 5 % significance level.

## Results and Discussion

Externally added sugar, sodium bicarbonate and ferrous sulphate significantly ($p<0.05$) affected on total polyphenol content, total ash, water soluble ash, alkalinity of water soluble ash, water extract, total colour, brightness and total plate count except on moisture content.

According to the Figure 1, the highest total polyphenol content (14.38 %) was recorded by pure black tea while the lowest (8.81 %) was given by ferrous sulphate adulterated black tea. It was lower than the ISO 3720 limit (9 %) which may be due to formation of Fe-Polyphenol complex during

fermentation stage. High concentration of ferrous result in localized formation of iron polyphenols complex in made tea (Venkatesan *et al*., 2006). The total polyphenol content in sodium bicarbonate and ferrous sulphate adulterated black tea samples were significantly lower ($p<0.05$) compared to pure black tea sample whereas mean difference of sugar adulterated black tea sample was not significant ($p>0.05$). Total ash, water soluble ash, water extract values recorded by all three adulterated black teas were within the ISO 3720 limits while alkalinity (3.26 %) of sodium bicarbonate adulterated black tea was beyond the ISO 3720 limit (1-3 %). The alkalinity of sodium bicarbonate adulterated black tea sample was significantly higher ($p<0.05$) than pure black tea. The alkalinity of sugar and ferrous sulphate adulterated black tea samples were significantly lower ($p<0.05$) than pure black tea.

The highest total colour (6.07 %) was observed in ferrous sulphate adulterated black tea while giving the lowest brightness (13.54 %) due to the lowest polyphenol content. Total polyphenol content is positively correlated with brightness which is responsible for tea liquor quality (Kottawa-Arachchi *et al.*, 2011). Total colour for sugar and ferrous sulphate adulterated black tea samples were significantly higher ($p<0.05$) compared to pure black tea while the total colour for sodium bicarbonate adulterated black tea sample was significantly lower ($p<0.05$) than pure black tea. Brightness values for all adulterated black tea samples were significantly lower ($p<0.05$) than pure black tea. TPP - total polyphenol content, MO - moisture content, TA - total ash, WSA - water soluble ash, ALK - alkalinity, WE - water extract, TC - total colour, BRI - brightness.

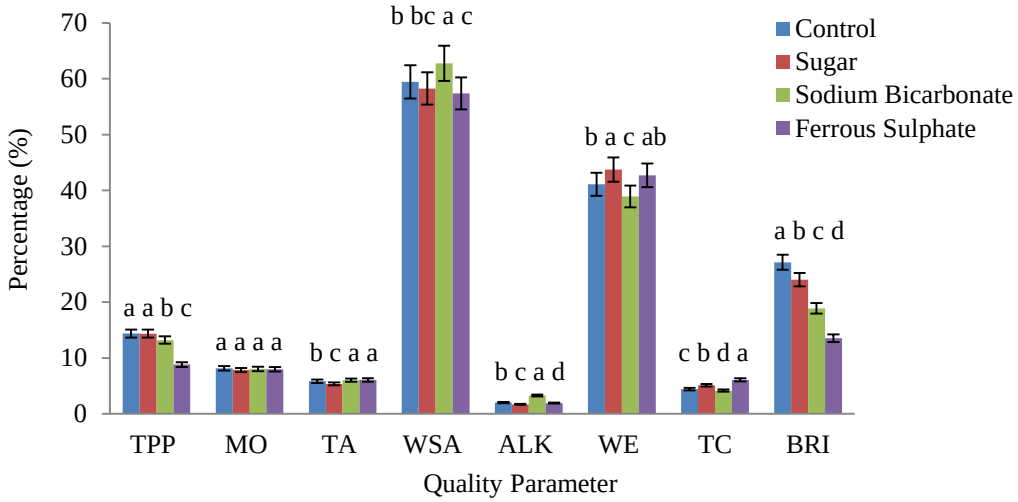


Figure 1: Effect of adulterant on ISO 3720 parameters, total colour and brightness of black tea

The variation of total plate count with respect to adulterated black tea samples at 78 % RH and 30 $^{\circ}$C during storage are given in Figure 2. Sugar adulterated black tea exhibited the highest total plate count (1317 cfu/g). It may be due to, sugary outer layer of tea particles helps microorganisms to grow rapidly. However, it was within the SLS 516-1 limit (10000 cfu/g) for black tea. According to the present findings, addition of ferrous sulphate led to lower the total plate count (365 cfu/g) in black tea compared to pure black tea. Fe (II) acts synergistically to delay the growth of diverse bacteria, at environmentally relevant metal concentrations (Bird *et al*., 2013). Effect of interaction between adulterants and time was significant ($p<0.05$) on total plate count. Effect of adulterant factor and time factor individually were also significant ($p<0.05$). The total plate count value for sugar added black tea sample was significantly higher ($p<0.05$) compared to pure black tea sample while ferrous sulphate added sample was significantly lower ($p<0.05$) than pure black tea.

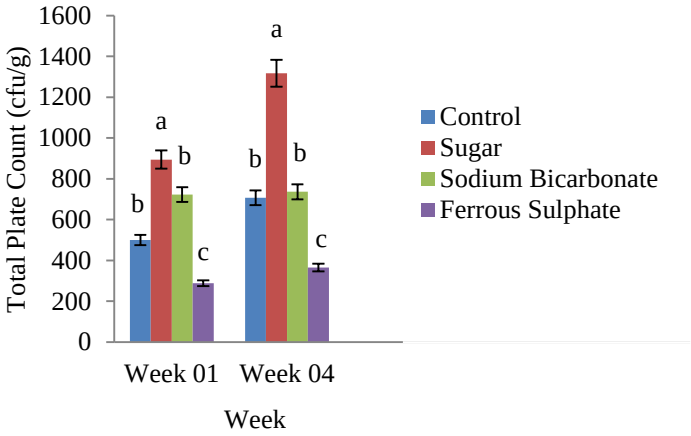


Figure 2: Effect of adulterant on total plate count of black tea over one month storage

**Conclusion**

The present study reveals that addition of sugar, sodium bicarbonate and ferrous sulphate to black tea significantly affect on total polyphenol content, total colour, brightness, total ash, water soluble ash, alkalinity of water soluble ash, water extract and total plate count of black tea except for moisture content. Usage of sodium bicarbonate as an adulterant for black tea lead to increase alkalinity percentage of water soluble ash beyond the limit which is given in ISO 3720 standard for black tea. Ferrous sulphate adulteration leads to drastically reduction of the total polyphenol content beyond the ISO 3720 requirement. Sugar adulteration results rapid growth of microbial colonies in black tea. Thus the study clearly highlights that adulteration of black tea by sugar, sodium bicarbonate and ferrous sulphate result poor quality black teas which have blackish appearance of tea particles with dull liquor colour and lower brightness.

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# Effect of thermal time on shoot growth and development of low grown Tea [*Camellia sinensis* (L.) O. Kuntze] in Sri Lanka

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## Introduction

Tea [*Camellia sinensis* (L.) O. Kuntze] is an important beverage crop in Sri Lanka and it is a sector where the country can take a lot of pride. The young, light green leaves, usually, the bud and the first two to three leaves are harvested for tea production. Study the shoot growth pattern of tea is an important element in tea physiology. It is difficult to predict leaf expansion and growth, based on calendar days, because leaf initiation and expansion are highly temperature dependent (Ritchie and Ne Smith, 1991). Because of the dependency on temperature, rate of shoot growth varies with elevation. Therefore, growing degree days based on actual temperature is a simple and accurate method to predict the occurrence of a certain developmental stage. Thus, thermal time can be used to predict the developmental stage of a leaf, extension of a tea shoot and Leaf Area (LA) expansion of shoot accurately.

This study was aimed to assess the variation in number of shoots at different developmental stages in the bush with thermal time, estimate shoot extension of a developing and harvestable tea shoot as a function of thermal time, estimate the Leaf Area (LA) of a developing and harvestable tea shoot as a function of thermal time and estimate the number of days taken to reach different leaf developmental stages of cultivar TRI 2025. This will provide an opportunity to estimate the shoot extension and Leaf Area (LA) expansion of harvestable tea shoot and it will help to adjust field management practices and to determine correct harvesting policies.

## Materials and Methods

The field experiments were carried out at Field No 01, St. Joachim Estate, Tea Research Institute, Ratnapura, Sri Lanka (latitude : 6º 40' N; longitude : 80º 25' E ) during mid of May to July 2014. Elevation of the study location is 29 m amsl and belongs to Agro ecological region of WL2. The soil group of the site belongs to Red Yellow Podzolic (Panabokke, 1996). The total rainfall was about 711 mm with a mean temperature of 28.5 ºC during the experimental period. TRI 2025 was used as the planting material. Daily sunshine hours, rainfall, minimum maximum temperature was obtained from the meteorological station at St. Joachim Estate, Ratnapura. In addition, soil moisture was measured during the experimental period at weekly. Data analysis was done using MS-Excel and Minitab 16 software.

In the first experiment, field observations were made for TRI 2025 using $1m^2$ sample size of plucking table with ten bushes at homogeneous location. The numbers of shoots at different shoot developmental stages in the bush (i.e. buds, bud with fish leaf, bud with one normal leaf, bud with two normal leaves, bud with three normal leaves and banjies) were counted at seven days interval. The accumulation of Thermal Time (TT) over the growing period was calculated using equations developed by Robertson *et al*., 2002. It was considered that $T_{base}$ of 12.5 ºC (Carr and Stephens, 1992), $T_{Opt}$ 22 ºC (Amarathunga *et al*., 1999) and $T_{ce}$ 40 ºC (Carr, 1972) for TRI 2025.

In the second experiment, with the appearance of each leaf, length of the shoot was measured at seven day intervals from randomly selected five axillary buds per bush that tagged immediately after plucking. The length of the new shoot was measured from the base of the shoot to the base of the bud. All measurements were taken until individual shoots reached their acceptable harvesting stage (bud with three normal leaves). Weather records obtained at experiment 01 were used in experiment 02.

In third experiment, Length (L) and width (W) of the individual leaves in a tea shoot (i.e. fish leaf, first, second, third normal leaf and bud) were measured at seven day intervals. Leaf length (L) was measured from lamina tip to the point of intersection of the lamina along the mid-rib, while leaf width (W) was measured from end to end between the widest lobes of the lamina perpendicular to the lamina mid-rib. The equation for TRI 2025 developed by (Jayasinghe *et al*., 2013) was used in estimating the Leaf Area (LA) at each day. In addition to that, record the number of days it was taken to unfolding of each appendage from the date of tagging and time it was taken to reach a acceptable harvesting stage having bud with a three leaf stage.

**Results and Discussion**

**Experiment 01**

Distribution of shoot generations in plucking table with cumulative thermal time from May to July 2014 is shown in figure 01.

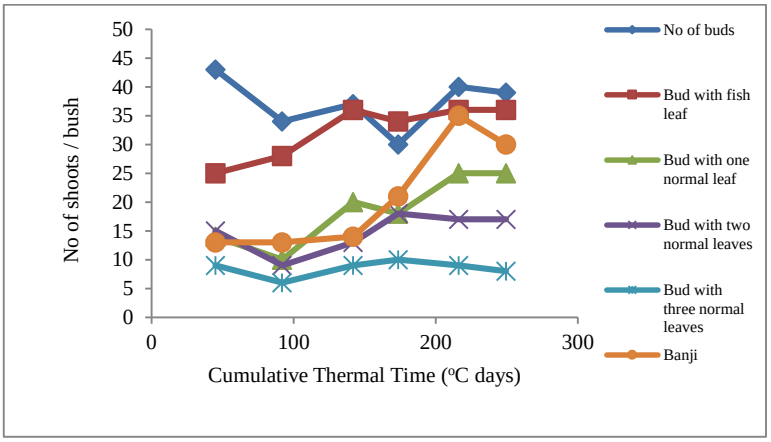


Figure 01: Distribution of shoot generations in plucking table with cumulative thermal time (ºC days) from May to July 2014.

According to the Pearson's correlation coefficient (r), there was a positive correlation between the number of shoots having bud with fish leaf (r = 0.912), bud with one normal leaf (r = 0.820), bud with two normal leaves (r = 0.688), bud with three normal leaves (r = 0.502), number of shoots having banji (r = 0.799) and total number of shoots (r = 0.848) per bush and the cumulative thermal time at 5 % probability level. According to the results average temperature, rainfall, daily sunshine hours and soil moisture were not significantly affect to the numbers of shoots at different developmental stages on the bush during the period at 5 % probability level.

**Experiment 02**

Mean shoot length of the tea shoot in relation to cumulative thermal time from May to July 2014 is shown in figure 02.

According to the Pearson's correlation coefficient (r), there was a positive correlation between the mean shoot length (r = 0.842) and the cumulative thermal time at 5 % probability level. According to the results, average temperature (P = 0.549), rainfall (P = 0.532), daily sunshine hours (P = 0.128) and soil moisture (P = 0.599) were not significantly affect to the length of the developing and harvestable tea shoot during the period at 5 % probability level.

According to the regression analysis, there was a very close relationship between the shoot length and the cumulative thermal time ($R^2$ = 0.956). Figure 02 showed that, growing bud needs to accumulate 249.56 $^oC$ days to attain to the harvestable size having length of 112.34 mm.

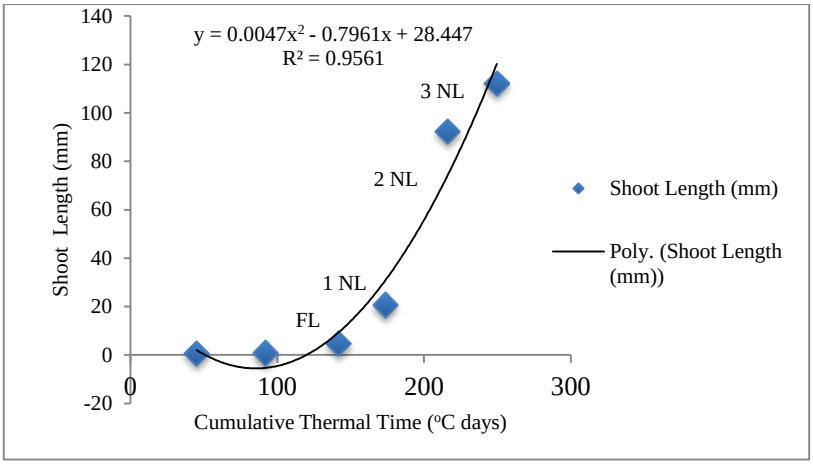


Figure 02: Mean shoot length (mm) of the tea shoot with cumulative thermal time from May to July 2014, note: FL – Fish Leaf 1NL – First Normal Leaf 2NL – Second Normal Leaf 3NL – Third Normal Leaf

**Experiment 03**

Total Leaf Area (LA) expansion of a tea shoot in relation to cumulative thermal time from May to July 2014 is shown in figure 03.

According to the Pearson's correlation coefficient (r), there was a positive correlation (r = 0.810) between the total leaf expansion of a harvestable tea shoot and the cumulative thermal time at 5% probability level. According to the results, average temperature (P = 0.463), rainfall (P = 0.553), daily sunshine hours (P = 0.074), soil moisture (P = 0.652) were not significantly affect to the Total Leaf Area (LA) expansion of the developing and harvestable tea shoot during the period at 5 % probability level.

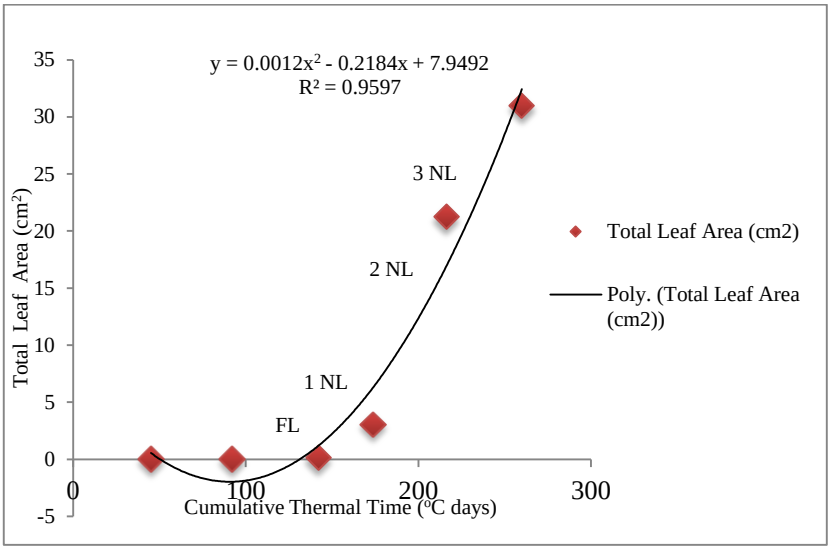


Figure 03: Total Leaf Area (LA) expansion of a tea shoot in relation to cumulative thermal time from May to July 2014, note: FL – Fish Leaf 1NL – First Normal Leaf 2NL – Second Normal Leaf 3NL – Third Normal Leaf

According to the regression analysis, there was a very close relationship between the Total Leaf Area expansion of developing and harvestable tea shoot with cumulative thermal time ($R^2 = 0.959$).

**Conclusions**

Leaf initiation, shoot extension and leaf expansion can be predicted using calendar days but it varies with the temperature and other environmental factors. Growing degree days based on actual temperature is a simple and accurate method to predict the occurrence of a certain developmental stage. After the bud break, growing tea bud required 24, 28, 32 and 35 days to produce fish leaf, the first normal leaf, second normal leaf and third normal leaf, respectively and bud break was occurred after 18 days from the date of tagging. In terms of degree days 153.82, 173.69, 197.28 and 216.17 °C days were required to initiate, fish leaf, the first, second and the third normal leaf respectively, after the removal of apical dominance by plucking. To attain a harvestable tea shoot (bud with three normal leaves) of cultivar TRI 2025 required with accumulation of 249.56 °C days (at mean temperature 28.5 °C and base temperature 12.5 °C. Length of the tea shoot having almost 112 mm in 41 days required to become pluckable size in low country region.

**Acknowledgement**

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# Investigating the causes for poor control of *Crassocephalum crepidioides* (Thandam pillu) weed by Glyphosate in the Uva region

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## Introduction

Weed management in tea field is great importance among other agronomic practices as weeds are the number one pest and they can lower the productivity of tea by 10 to 50 percent due to their competition for light, space, water and nutrients. Various weed management practices are used in tea cultivation such as manual, mechanical, cultural, chemical, and biological methods. Chemical weed control is the most convenient and effective methods among the various weed management techniques available. Unlike manual weeding, chemical weed control minimizes soil erosion and largely eliminates the loss of plant nutrients, which were carried away in the weeds removed from the field and less labour required. Other than normal classifications, weeds can be grouped as common weeds, hard-to-kill weeds and favorable herbs. Among the weeds Thandam pillu was considered as a common weed, but it is becoming a hard-to-kill weed. It was already become resistant to Paraquat herbicide and now there are complaints that it is difficult to control even by Glyphosate herbicide. Recent investigations under up country conditions have shown that such poor control is attributed to the dosage of Glyphosate applied and the age or growth phase of weeds, (Prematilake and Nawarathne, unpublished). Therefore, the objective of the present study was to elucidate the possible causes of poor control of Thandam pillu weed under Uva region.

## Materials and methods

An experiment was carried out at the Uva Wellassa University during July-August 2014. C.crepidioides weed plants at five different growth phases such as 3-4, 5-6, 7-8, 9-10 and > 10 leaf phase, were collated from Ury Estate and they were planted randomly on raised beds, (30 plants per each growth phase) and left for 2 weeks to established. Two Glyphosate (36%) dosages (5 ml/L and 3 ml/L) were sprayed on plants by isolating the plant to prevent contaminations with other plants. An untreated Control was also maintained. Herbicide application was done as drenching application, by using hand sprayer during morning. The degree of chlorosis, wilting of leaves, scorching and drying of leaves and leaf fall occurred at 7, 14 and 21 days after application (DAA) of Glyphosate. Thandam pillu weed was observed and rated. Dead plant percentage, dry weight of viable plants and recovery of plants were recorded at 21 DAA.

## Results and Discussion

Chlorosis was more prominent at 7 DAA and it occurred at significantly higher rate with Glyphosate at 5 ml/L than at 3 ml/L at 3-4 and 5-6 leaf growth phases. Leaf wilting was more prominent at 14 and 21 DAA and it occurred at significantly higher rate with Glyphosate at 5 ml/L at all five growth phases. Scorching and drying of leaves took place at the same rate with both Glyphosate at 5 ml/L and at 3 ml/L at 3-4, 5-6 and 9-10 leaf growth phases. However, symptoms were more severe with

Glyphosate at 5 ml/L than at 3 ml/L at 7-8 and >10 leaf phases. Leaf fall also occurred more severely with Glyphosate at 5 ml/L than at 3 ml/L at 7-8 leaf phase. Mean percentage of dead plants of C.crepidioides was significantly higher with Glyphosate at 5ml/L than that of 3ml/L at all growth phases. There was no death of the weed after phase 3 onwards with Glyphosate at 3ml/L and at phase 4 and 5 with Glyphosate at 5ml/L.

Table 01: Mean percentage of dead plants of C.crepidioides at different growth phases as affected by two dosages of Glyphosate

| Treatments | Stage 1 (3-4 leaf) | Stage 2 (4-5 leaf) | Stage 3 (6-7 leaf) | Stage 4 (8-9 leaf) | Stage 5 (>10 leaf) |
|---|---|---|---|---|---|
| T1 (Gly: at 5 ml/L) | 90 a | 50 b | 10 c | 0 | 0 |
| T2 (Gly: at 3 ml/L) | 70 b | 30 c | 0 | 0 | 0 |
| T3 (Control) | 2 c | 0 | 4 c | 0 | 0 |

(Means followed by the same letter are not significantly different at P<0.05)

Mean dry weight per plant was not recorded at 3-4 and 5-6 leaf phases, but a lower weight was recorded at mature phases above 6-8 leaf phase. There was no significant different in weight between herbicide treatments and the Control. Poor response to Glyphosate at the maturity stages may be due to the hairiness of the leaves and stems and leaf angel (erect) act as barrier to absorb herbicide in to the plant.There was high recovery rate at latter phases in 3 ml/L Glyphosate treated plants than Glyphosate at 5 ml/L treated weed plants.

Table 02: Mean recovery of *C. crepidioides* at different phases with two Glyphosate dosages

| Treatments | Stage 1 (3-4 leaf) | Stage 2 (4-5 leaf) | Stage 3 (6-7 leaf) | Stage 4 (8-9 leaf) | Stage 5 (>10 leaf) |
|---|---|---|---|---|---|
| T1 (Gly: at 5 ml/L) | 0 c | 0 c | 0.2 b | 0.3 b | 0.3 b |
| T2 (Gly: at 3 ml/L) | 0 c | 0 c | 0.2 b | 0.2 b | 0.5 a |
| T3 (Control) | 0 c | 0 c | 0 c | 0 c | 0 c |

(Means followed by the same letter are not significantly different at P<0.05)

Finally, *C.crepidioides* at early growth phases with 3-6 leaf is more susceptible to Glyphosate herbicides and with higher dosage it is more susceptible for Glyphosate.

## Conclusions

The degree of control of C. crepidioides weed is dependent upon the dosage of Glyphosate. The higher the dosage the greater the controlling efficacy.The growth phase or maturity level of C.crepidioides also a factor that cause to tolerate the control of Thandam pillu weed by Glyphosate (36 %). The initial growth phase of C.crepidioides up to 6 leaf per plant phase is more susceptible for Glyphosate.

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# Development of Tea incorporated Jackfruit *( Artocarpus heterophyllus Lam )* cordial

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**Introduction**

Since few decades tea has become one of the most famous and commonly consumed beverage which only second to the water in the world. There is evidence that the bio active compound like polyphenols, flavonoids, catechins, caffeine which comprise in tea are responsible for the human health ( Puneet, 2013 ) by helping to reduce the risk of cardiovascular diseases and some forms of cancer, promoting oral health, reduce blood pressure, helping for weight control, improving antibacterial and antiviral activity etc. Jackfruit is an excellent source of phytonutrients including lingans, isoflavones and saponins which all have anti-cancer properties due to their capacity to protect the body from the effects of free-radicals, slowing the degeneration of cells that can lead to degenerative diseases. Jackfruit also provides small amounts of essential fatty acids with an ideal omega 3 to omega 6 ratio of roughly 1:2. We now know that the ratio at which we consume these essential fatty acids is just as important, if not more important than how much we consume of them (Baslingappa, 2012). The ripened jackfruits have appealing flavor, color, and a taste that can be used to prepare a delicious fruit drink enriched with vitamins. Therefore, this research was carried out to develop a tea incorporating jackfruit cordial which enrich with nutritional and stimulant effect with the endurable cost of production and maximizing the consumer satisfaction.

**Methodology**

There were two treatments conducted by changing tea type as green tea and black tea and amount of tea. Jackfruit to tea combination was evaluated and trial was done in order to find the best overall acceptability and finally three treatments were prepared and evaluated on sensory, chemical and microbiological basis. The sensory evaluation was done using 30 untrained panelists. In chemical analysis, proximate composition was determined for moisture content, crude fat, crude protein, ash and carbohydrate for content. pH value, brix value and microbiological analysis were done for *Escherichia coli*, Total Plate Count (TPC) and Yeast and mold in weekly for 1 month and analyzed by using Friedman nonparametric statistical method.

Table 1: Six recipes developed in preparation of tea incorporated jackfruit cordial

| Ingredients | Sample Codes | | | | | |
|---|---|---|---|---|---|---|
| | 443 | 521 | 352 | 289 | 450 | 365 |
| Jack fruit pulp (g) | 500 | 500 | 500 | 500 | 500 | 500 |
| Water (ml) | 500 | 500 | 500 | 500 | 500 | 500 |
| Sugar (g) | 450 | 450 | 450 | 450 | 450 | 450 |
| Black Tea (g) | 40 | 30 | 20 | | | |
| Green Tea (g) | | | | 40 | 30 | 20 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Citric Acid (CMS) (g) | 5 | 5 | 5 | 5 | 5 | 5 |
| Sodium Meta bi-sulfite (SMS) (mg) | 610 | 610 | 610 | 610 | 610 | 610 |

**Results and Discussion**

According to the sensory evaluation, two best recipes were selected from green tea and black tea incorporated recipes. With 20 g of tea added cordial recipe has given a desirable sensory attributes in sensory evaluation.

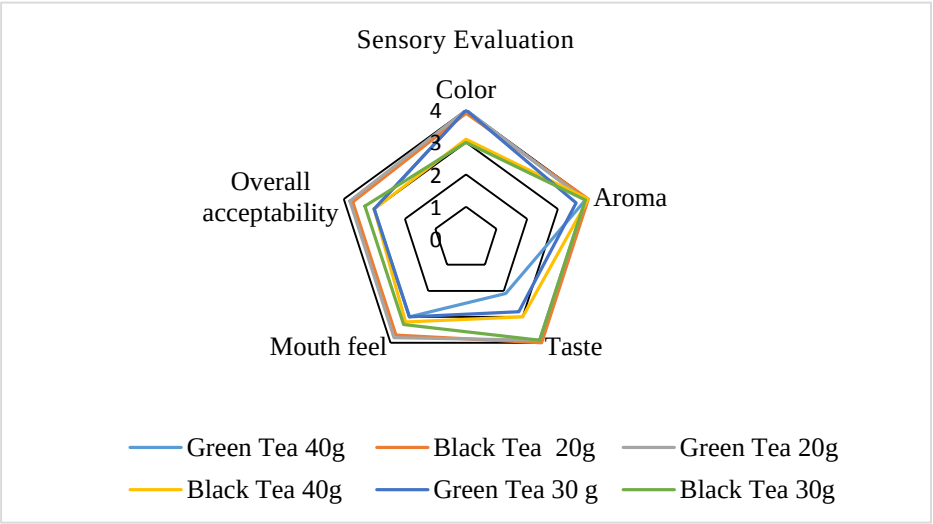


**Figure 1: Web diagram for the sensory evaluation**

There was a significant difference ($P<0.05$) among six samples regarding color, taste, mouth feel and overall acceptability.

Table 2: Proximate analysis for 30 ml sample of final products

| Parameter | Black tea incorporated | Green tea incorporated |
|---|---|---|
| Moisture % | 41.1 | 47.5 |
| Ash % | 0.5 | 0.3 |
| Crude Protein % | 1.0 | 0.7 |
| Fat % | 00 | 0.1 |
| Carbohydrate % | 57.4 | 51.4 |

As indicated by the Table 2, the highest moisture content and no fat was observed in green tea incorporated cordial followed black tea incorporated cordial. Highest crude protein and ash content was observed in black tea incorporated cordial.

The pH values of final products showed a slight elevation and it was between 4 to 5 pH levels. Total soluble solids (Brix) value for black tea incorporated cordial and green tea incorporated cordial were respectively $54^{\circ}$ and $48^{\circ}$.

Total plate count in the samples complied with the requirement of Sri Lankan Standard (SLS). TPC value of both green tea and black tea added cordial has increased in increasing rate during first week. Then it has increased in decreasing rate with the time period. Yeast and mold and *Escherichia coli* were absent in both samples for four week time period.

Green tea incorporated cordial was contained 0.94 mg/mL polyphenol and black tea incorporated cordial was contained 0.72 mg/mL.

**Conclusion**

Tea incorporated jackfruit cordial can be produced from ripened jackfruit pulp and tea syrup, as a value added product having $54^{\circ}$ brix for black tea incorporated cordial and $48^{\circ}$ brix for green tea incorporated cordial. Black tea incorporated cordial consists with high nutritional value and zero fat. There is no significant undesirable changes in final products within storage period. Microbiological and chemical parameters in the recommended level.

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# Factors affecting the level of effectiveness of dryers used in Sri Lankan tea manufacturing

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**Introduction**

Tea production is basically a drying process of freshly harvested green tea leaves, reducing its moisture content from about 75-83% down to 3%. In black tea manufacturing tea undergoes mainly withering, rolling, fermenting, drying, grading and packaging processing steps. Sri Lanka mainly produces tea by the Orthodox technology. Drying is the most expensive process in the manufacture of tea (http://www.biriz.biz/cay/TeaSector2002). The capital investment on dryers is also the highest among the different processing machines. There are three different types of tea dryers up to now namely ECP (Endless Chain Pressure), FBD (Fluidized Bed Dryer) and combination dryers. ECP dryer has been used in tea industry since 1907 and fluidized bed dryer was first developed for tea in Sri Lanka in 1974 (Temple S.J., 2000). Tea dryers have its defined output as rated output. But normally dryer machines give lower output (actual output) than rated output. There may be several reasons affecting for dryer output deviation from rated output. Ultimately this would lead to poor production and high cost of production to the tea factories.

Main objective is to find out the factors affecting for deviation of actual dryer output from rated dryer output in different types of tea dryers.

**Materials and Methodology**

Effectiveness of three types of tea dryers was taken as dependent variable. Effectiveness of tea dryers can be measured as the ratio between actual output and rated output. It will be finally taken as a percentage value.

As independent variables four factors have been selected as moisture content of withered leaves (wither percentage %), age of three types of dryers (Years), moisture of firewood used for drying (firewood moisture) and dhool percentage taken after roll breaking process (first, second and third dhool percentage).

The sampling frame was 37 tea dryers representing three manufacturing regions in Sri Lanka (Up country, Mid country and Low country). There were 17 ECP dryers, 15 FBD dryers and 5 combination dryers in the sample. The data were collected for recent three months time period and average values were taken finally. For the analysis descriptive, correlation and simple linear regression was used.

**Results and Discussion**

According to descriptive statistics mean effectiveness of ECP, FBD and combination dryers were 85.88%, 89.83%, 91.53% respectively.

Table 1: Descriptive statistics Results of Effectiveness of Tea Dryers

| **Dimension** | **Dryer Type** | **Mean** | **Minimum** | **Maximum** |
|---|---|---|---|---|
| **Effectiveness** | ECP | 85.88 | 72.73 | 93.33 |
| | FBD | 89.83 | 83.64 | 97.22 |
| | Combination | 91.53 | 83.33 | 96.15 |

Table 2: Pearson Correlation Results

| Dryer Type | Factors | Correlation Coefficient | Status of Correlation |
|---|---|---|---|
| ECP Dryer | Wither Percentage | -0.957 | Strong Negative |
| | Age of the Dryer | -0.992 | Strong Negative |
| | Firewood Moisture | -0.967 | Strong Negative |
| | Dhool Percentage | 0.955 | Strong Positive |
| FBD Dryer | Wither Percentage | -0.862 | Strong Negative |
| | Age of the Dryer | -0.977 | Strong Negative |
| | Firewood Moisture | -0.957 | Strong Negative |
| | Dhool Percentage | 0.912 | Strong Positive |
| Combination Dryer | Wither Percentage | -0.946 | Strong Negative |
| | Age of the Dryer | -0.969 | Strong Negative |
| | Firewood Moisture | -0.971 | Strong Negative |
| | Dhool Percentage | 0.960 | Strong Positive |

Correlation results showed that wither percentage, Age of the dryer and Firewood moisture has strong negative relationship while dhool percentage has strong positive relationship for the level of effectiveness of three different types of dryers. The correlation results further support to run the regression.

Simple Linear Regression Model resulted following results.

| Dryer Type | Factors | R-sq value | P-value |
|---|---|---|---|
| ECP Dryer | Wither Percentage | 91.6% | 0.000** |
| | Age of the Dryer | 98.3% | 0.000** |
| | Firewood Moisture | 93.6% | 0.000** |
| | Dhool Percentage | 91.3% | 0.000** |
| FBD Dryer | Wither Percentage | 74.3% | 0.000** |
| | Age of the Dryer | 95.4% | 0.000** |
| | Firewood Moisture | 91.6% | 0.000** |
| | Dhool Percentage | 83.1% | 0.000** |
| Combination Dryer | Wither Percentage | 89.6% | 0.015** |
| | Age of the Dryer | 93.8% | 0.007** |
| | Firewood Moisture | 94.3% | 0.006** |
| | Dhool Percentage | 92.2% | 0.009** |
| **significant at 0.05 | | | |

All the four factors has been affected for the level of effectiveness of three dryers because of simple linear regression model significant at 0.05.

**Conclusion**

Level of effectiveness of three different types of tea dryers were affected by wither percentage of tea leaves used for drying, age of the dryers, firewood moisture and dhool percentage. Effectiveness of dryers were decreased with increasing of wither percentage, age of the dryers and firewood moisture while increased with increasing dhool percentage. Further research could be done by increasing sample size to overall Sri Lanka and finding more factors which will affect for deviation of dryer output than rated output.

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# Effect of Tea bag materials on physical and chemical quality parameters of Black Tea during storage

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## Introduction

The tea (*Camellia sinensis*) produced in Sri Lanka is popular as "Ceylon tea" and has a higher demand as 'best quality tea' in the international trade. Packing tea into bags in many forms has become very popular because of convenience and it can be considered as an effective form of value addition. Though tea bags are used as packaging strategy in order to protect the quality parameters of tea during storage, while extending the shelf life, there are many quality claims against tea bag materials. The other bad news is that paper tea bags may be just as bad, or worse, than the plastic ones because many of them are treated with epichlorohydrin, a compound mainly used in the production of epoxy resins. The purpose of this research was to evaluate effect of different types of tea bag packaging materials on physical and chemical parameters of tea and selecting best tea bag packaging material.

### Methodology

There are three types of tea bag materials as Paper, Soilon and Nylon that used to export tea in Sri Lanka, were used for this research. Those tea bags contained black tea with same manufacturing date, and also they were received from same tea exporting company. Each tea bag was consisting with Broken Orange Pekoe Fannings (BOPF) grade of black tea and tea bags were in same shape, size and same weight (2.5g) of tea. Each type of tea bag was packed in same size of sealed cardboard boxes and they were stored in normal room temperature. Each box was consisted with 25 tea bags.

Tea bags were stored for three months duration. Every experiment was conducted three times at same time intervals in each month of during storage period and data was collected in each month. Experiments were conducted using selected physical and chemical quality parameters of black tea. Moisture content, dry matter, brightness, total colour were measure as physical quality parameters and total polyphenols, caffeine, thearubigin, theaflavin and thearubigin to theaflavin ratio was measured as chemical quality parameters. Three replicates were carried out for each type of materials in each experiment. Every experiment was conducted according to ISO procedures recommended for black tea.

All data were expressed using descriptive statistics as means, standard deviations and coefficient of variations of triplicate measurements and analysed by using Minitab 16 software. Significant effects were tested by conducting two sample t-tests for each packaging materials by comparing with the initial data set of each material separately. Values of $P<0.05$ were considered as significantly different ($\alpha=0.05$).

**Results and Discussion**

Table 1: Means, SD, SE, and Coef.Var. of Chemical Components of Tea Samples with Different Tea Bag Materials

| Quality Parameter | Material | Mean | St. Dev. | SE Mean | Coef. Var. |
|---|---|---|---|---|---|
| Moisture | 1 | 7.917 | 0.483 | 0.837 | 10.58 |
| | 2 | 7.760 | 0.556 | 7.24 | 7.24 |
| | 3 | 7.627 | 0.732 | 9.60 | 9.60 |
| Dry matter | 1 | 89.767 | 0.527 | 0.914 | 1.02 |
| | 2 | 90.210 | 0.320 | 0.555 | 0.62 |
| | 3 | 90.000 | 0.381 | 0.660 | 0.73 |
| Theaflavin | 1 | 0.328 | 0.028 | 0.048 | 14.72 |
| | 2 | 0.375 | 0.009 | 0.016 | 4.38 |
| | 3 | 0.356 | 0.018 | 0.031 | 8.61 |
| Thearubigin | 1 | 16.320 | 0.769 | 1.333 | 8.17 |
| | 2 | 16.607 | 0.299 | 1.517 | 3.11 |
| | 3 | 17.063 | 0.407 | 0.704 | 4.13 |
| TF/TR | 1 | 0.0197 | 0.0029 | 0.0051 | 26.09 |
| | 2 | 0.0223 | 0.0009 | 0.0015 | 6.84 |
| | 3 | 0.0203 | 0.0007 | 0.0012 | 5.68 |
| Brightness | 1 | 16.68 | 1.10 | 1.91 | 11.47 |
| | 2 | 17.52 | 1.26 | 2.18 | 12.41 |
| | 3 | 14.858 | 0.368 | 0.638 | 4.30 |
| Total Colour | 1 | 5.503 | 0.085 | 0.147 | 2.67 |
| | 2 | 5.203 | 0.379 | 0.656 | 12.61 |
| | 3 | 5.466 | 0.404 | 0.700 | 12.80 |

| | | | | | |
|---|---|---|---|---|---|
| Total Polyphenol | 1 | 12.262 | 0.051 | 0.087 | 0.71 |
| | 2 | 13.239 | 0.039 | 0.067 | 0.51 |
| | 3 | 12.813 | 0.087 | 0.151 | 1.18 |
| Caffeine | 1 | 1.977 | 0.059 | 0.1027 | 5.19 |
| | 2 | 2.007 | 0.022 | 0.0371 | 1.85 |
| | 3 | 2.047 | 0.057 | 0.0982 | 4.80 |

Material 1-Paper Material 2-Soilon Material 3-Nylon

The highest mean value of moisture content of black tea contained in paper tea bags were 7.917 %, ranged from 06.97 - 8.56 % with soilon and nylon tea bags which are having the lower change of moisture 7.04 - 8.09 % and 6.79 - 8.15 % respectively and coefficient of variation 10.58 %. Soilon tea bags having lowest moisture change range from 6.79 – 8.15 % and coefficient of variation 7.24 %. High moisture content aids microbial activities, oxidation – reduction processes and fungal growth. The variation in the moisture may be attributed to the degree of drying type and nature of tea involved (Kumar *et al*., 2005).According to this study it is because of the different textures of these three materials affect for the absorption of the moisture during the storage. Another important factor is use of packaging material to maintain a constant moisture level during storage of commercial tea samples, so moisture content in commercial tea is an essential parameter of quality (Yao *et al*., 2006).

The results of the dry matter analysis are as shown in Table 1, lowest changes of dry matter content was resulted from soilon tea bags which having lowest coefficient of variation 0.62 %.

The theaflavin (TF) content analysis results are shown in Table 1, which follows the order Soilon > Nylon> Paper with a means of 0.375 %, ranging from 0.394 -0.363 % and coefficient of variation 4.38 %.

The results of TF/TR content in Table 1, showed that soilon tea bag had the least change of value of TF/TR ratio of mean 0.0223, ranged from 0.024 - 0.021 with lowest mean 0.0197 of the paper tea bags ranging from 0.024 - 0.014 while nylon tea bag having the mean distribution value of 0.0203 TF/TR content ranged from 0.024 - 0.019 with coefficient of variation 5.68 %, which is low when compared with the paper and soilon, 26.09 % and 6.84% respectively.

Least change of brightness during storage was obtained from nylon tea bags having lowest coefficient of variation 4.3%.

According to Table 1, lowest change of the total colour was obtained from nylon tea bags, mean 5.503, ranged from 5.53 – 5.643 having coefficient of variation 2.67 % compared to soilon and nylon tea bags means 5.203 and 5.466 are ranged from 5.36 - 4.483 and 5.023 – 6.273 with coefficient of variations 12.61 % and 12.80 %.The TR content gives the tea liquor its depth of colour and more TR content means very strong and coloured liquor with less briskness as caffeine along with TF contribute towards briskness. This method also includes the measurement of total colour, which is the combined contribution of colour from TF and TR present in the tea liquor (Borah and Bhuyan).

The results of the Total polyphenol analysis as shown in Table 1 with mean distribution of paper tea bags 12.34 %, ranged from 12.34 – 12.167 % and coefficient of variation 0.7 %, soilon and nylon tea bags having lower total polyphenol changes, ranged from 13.313 – 13.181% and 12.940 – 12.646 % with their means and coefficient of variances 13.239 %, 12.813 % and 0.5 % and 1.18 % respectively and least changes of total polyphenol was obtained from soilon tea bags.

The results of the caffeine analysis as shown in Table 1 with mean distribution of paper tea bags 1.977 %, ranged from 2.053 – 1.86 % and coefficient of variation 5.19 %, soilon and nylon tea bags having lower caffeine changes, ranged from 2.046 – 1.973 % and 2.133 – 1.940 % with their means and coefficient of variances 2.007 %, 2.047 % and 1.85 % and 4.80 % respectively and least changes of caffeine were obtained from soilon tea bags.

Table 2: Significant Effects of the Tea Bag Materials

| **Material** | **P Values** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Time** | **MC** | **DM** | **TF** | **TR** | **TF/TR** | **TC** | **Br.** | **TPP** | **Caff.** |
| Paper | 2 | 0.049 | 0.000 | 0.448 | 0.305 | 0.212 | 0.971 | 0.665 | 0.139 | 0.020 |
| Paper | 3 | 0.017 | 0.041 | 0.117 | 0.019 | 0.025 | 0.431 | 0.499 | 0.023 | 0.000 |
| Soilon | 2 | 0.017 | 0.088 | 0.716 | 0.421 | 0.571 | 0.719 | 0.603 | 0.000 | 0.048 |
| Soilon | 3 | 0.007 | 0.080 | 0.633 | 0.114 | 0.377 | 0.813 | 0.307 | 0.003 | 0.015 |
| Nylon | 2 | 0.077 | 0.190 | 0.335 | 0.181 | 0.248 | 0.211 | 0.874 | 0.073 | 0.035 |
| Nylon | 3 | 0.050 | 0.161 | 0.118 | 0.048 | 0.076 | 0.571 | 0.097 | 0.004 | 0.002 |

**2**- 60 days (2nd month) **3**-60 days (3rd month)

According to two sample t-test, effects are significant ($P<0.05$) for the quality parameters such as moisture content, dry matter content, thearubigin, total polyphenol and caffeine in paper tea bags. Nylon tea bags showed significant effects for the thearubigin, total polyphenol and caffeine. Soilon tea bags showed significant effects for the moisture, total polyphenol and caffeine.

Highest numbers of significant effects for the quality parameters are detected from paper tea bags and minimum numbers of significant effects were detected from soilon tea bags.Descriptive analysis showed highest changes of quality parameters in paper bags and least changes of quality parameters in soilon tea bags.

According to descriptive analysis, t-test effects of changes of quality parameters were vary as Paper> Nylon> Soilon respectively.

## Conclusion

The effects of packaging materials on each quality parameters are varied with the type of material. These variations are mainly due to nature and permeability of the material. Permeable materials allow moisture absorption with time if the moisture levels of the storage environment are not properly controlled. Moisture absorption is high in nylon and paper materials compared to soilon. Changes in Quality parameters of paper and nylon materials are comparatively higher than soilon. Compared to nylon and paper materials, soilon showed minimum significant changes of the quality parameters with minimum significant effects ($P<0.05$). According to descriptive and t-tests, can conclude 'Soilon' is the 'best' material for tea bags for these three months studying period.

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# Development of a biscuit enriched with Tea polyphenols

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## Introduction

Tea is receiving increased interest from food scientists due to its purported antioxidant properties and health benefits.Polyphenols in tea are believed as excellent chemical compounds. Several clinical studies have proved polyphenols to be active in disease prevention in several ways. Polyphenols have also been recently recognized as functionally active molecules, possessing antioxidant, anticancer, anti-mutagenic properties, as well as exerting protective effects against cardiovascular and other diseases.

## Methodology

The current study was carried out at Eswaran Brothers Export (Pvt) Ltd, 104/11 GrandpassRoad, Colombo 14. Laboratory analysis was done at UvaWellassa University laboratories. Indore to find better extraction method for tea polyphenol, preliminary study was conducted by using ethanol and water. Extraction efficiencies of water and ethanol were tested in different time and temperature combination. The total polyphenol content in the tea extract was determined by measuring the color development with Folin-Ciocalteu phenol reagent in alkaline medium (ISO 14502-1), at absorbance of 765 nm using UV-VIS spectrophotometer. Gallic acid was used as a standard and the total polyphenol were expressed as mg / g Gallic acid equivalents (GAE). For this purpose, the calibration curve of Gallic acid was drawn. Through preliminary study of the polyphenol extraction, as a polyphenol source 40 g BOPF black tea concentered extracts were used for final product development. Three kind of final products were developed such as without extract, with water extract and ethanol extract. Organoleptic properties of the biscuits were evaluated using sensory analysis. Total polyphenol content of the final consumer accepted product also test with Folin-Ciocalteu phenol reagent in alkaline medium method.

## Results and Discussion

Through preliminary study high polyphenol content was obtained water at 80$^{o}$C with 30 min extraction and 40 % ethanol solution at 40$^{o}$C with 2 hr. extraction.

Table 1: Detail of total polyphenol content in water and ethanol extracts

| Solvent at 40$^{o}$C | Solvent type | Time (hr.) | Yield mg GAE/g | Solvent | Temperature ($^{o}$C) | Time (min) | Yield mg GAE/g |
|---|---|---|---|---|---|---|---|
| Ethanol | 100 % | 4 | 507.38 ± 1.33 | Water | 100 | 60 | 84.71 ± 7.96 |
| | 100 % | 2 | 618.98 ± 0.48 | | 100 | 30 | 234.56 ± 20. 21 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 80 % | 4 | 606.59 ± 1.26 | | 80 | 60 | 275.78 ± 6.16 |
| | 80 % | 2 | 529.13 ± 6.34 | | 80 | 30 | 320.50 ± 7.29 |
| | 40 % | 4 | 396.08 ± 1.06 | | 60 | 60 | 274.73 ± 14.56 |
| | 40 % | 2 | 671.28 ± 2.18 | | 60 | 30 | 241.65 ± 0.98 |

Through the sensory analysis higher acceptance for overall acceptability ($p<0.05$) was observed for ethanol extract incorporated biscuit.

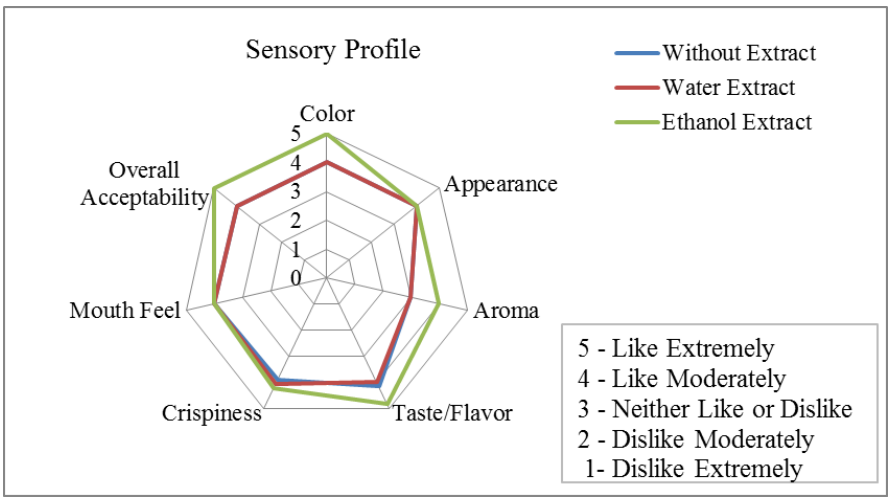


Figure 1: Overall sensory profile for developed product

On the basis of the United States Department of Agriculture "Serving Sizes" (for tea 240 ml), Balentine (2001) showed that black tea having 120 – 300 mg flavonoids / serving. (USAD Serving Sizes Hand Book).Total polyphenol content in consumer accepted biscuit ranged between 551.25 – 521.07 mg/10g (one biscuit), that mean one biscuit is equal to two cup of tea according to USAD Serving Sizes. If one person consume one cup of tea with developed biscuits that will give equal benefits (Tea Polyphenol) of consuming three cups of tea.

**Polyphenols rich biscuit**

Plate 1: Cup of tea with made biscuit

**Conclusion**

The results from this study show that variations in the polyphenol content of various extracts depending on type of solvent used and that aqueous solvents were more efficient in extracting total polyphenol, compared to their corresponding absolute ones and using water.

Present study indicated that ethanol extracts were accepted by consumers as a polyphenol rich source in food product constituents, and might be an interest of wider usage as food components.

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# Development of Black Tea incorporated tomato sauce

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## Introduction

Tea has a lot of health beneficial components and also considered an energy active booster. Current trend is moving to the health benefits concepts and green production. Under this condition, there is a huge demand for black tea sauce like products. There is a high demand for Sri Lankan black tea in Global market due to some specific characteristics. But, still we are failing on tea value addition. Therefore, improving value addition practices and new product development are more essential to Sri Lanka to survive in the Global market.

Recently, research has focused on green tea. Green tea is loaded with the compound epigallocatechin gallate (EGCg), a powerful anti-oxidant. Since the fermentation process used to make black tea converts EGCg into other compounds, researchers assumed black tea had less health benefits than green tea. However, recent studies indicate the compounds contained in black tea which are theaflavins and thearubigens, do more than contribute to its dark color and distinctive flavor. They also provide health benefits originally attributed solely to green tea (Herath, H.M.U.N., and De Silva, D., (2006).

## Objectives

The main objective in the present study was to black tea incorporated tomato sauce while the specific objectives were to determine appropriate amount of ingredients to be added to the product and to extend shelf life, in order to obtain the desired product quality.

## Method

Small pieces of tomatoes and green chilies were mixed using a grinder and salt, chili, black tea brew, honey, garlic and tamarind extraction were added into the mixture until it becomes a cream. The cream was heated until it becomes tick. Then filled into the sterilized glass bottles by using hot filling method. All microbial analysis and proximate analysis were conducted according to the SLSI standard (260: 2008). Statistical analysis was undertaken according to the Friedman test under 5% significance level, by using MINITAB – 16 software package and Microsoft – Excel package.

## Results and Discussions

Table 1 given the Physico-chemical properties and proximate analysis of black tea incorporated tomato sauce. According to proximate analysis, moisture content was 14 % and protein content was 0.5 %. Total soluble solid content of the product was 38. pH of the product was 4.42 and tritratable acidity was 3.69 %. Total poly phenol content was 350 mg GAE/g. By doing sensory evaluation from Friedman test from Minitab 16 software the product contained the best characters of sauce.

Table 1. Physico-chemical properties and Proximate Analysis of Black Tea Incorporated Tomato Sauce

| Constituents | Amounts | Method of Test |
|---|---|---|
| Total Soluble solid Content (brix value) | 38 | SLS 1332 |
| Total Acidity | 3.69 % | SLS 347 |
| pH Value | 4.42 | - |
| Total Poly Phenol Content | 350 mg GAE/g | Gallic Acid |
| Moisture Content | 14 % | SLS 348 |
| Protein Content | 0.5 % | SLS 348 |

According to the microbial analysis there were not yeast, moulds and *Escherichia coli* growth in the product. Total plate count was increased during 1 month period.

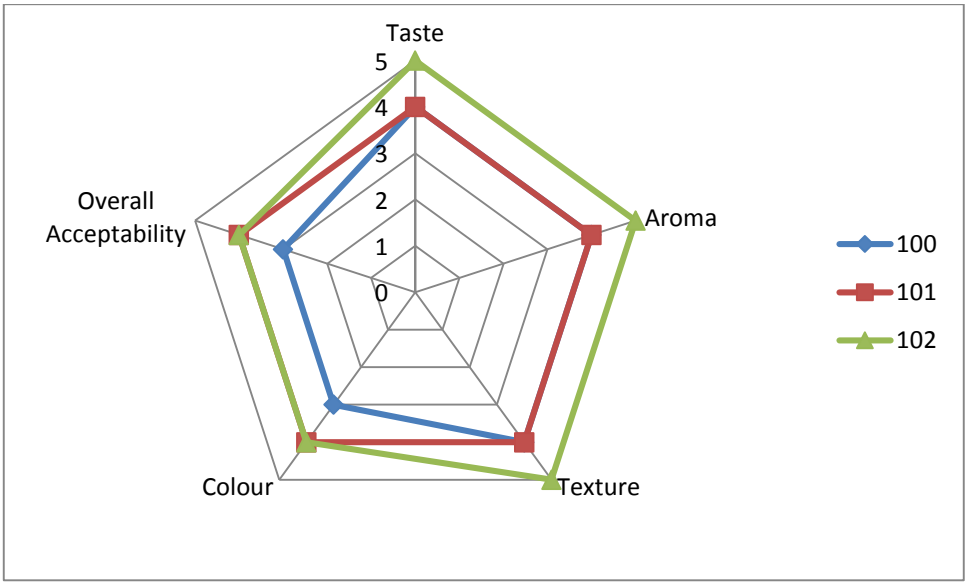


Figure 1. Web diagram for treatments 100, 101, 102 in sensory evaluation

Figure 1 shows that Taste, Aroma, Texture, Colour and overall Acceptability is higher in Treatment 102 than the other treatments.

## Conclusion and Suggestions

As a new value added product if it will reach to customers, it may contribute to more Sri Lankan exports as well. Attraction from the child to the adult one to increase food appetite, low cost of production, low purchasing cost and high market demand are the key benefits of the product. By doing sensory evaluation from Friedman test from Minitab 16 software the product was include the best characters of sauce.

Treatment 102 has been selected as best products through sensory evaluation, proximate analysis and shelf life analysis. With reference to the microbial analysis, it can be concluded that the product have more than two months of shelf life.

According to the statistical analysis, nutritional analysis and microbial analysis the product remains under acceptable level of human consumption.

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Herath, H.M.U.N., and De Silva, D., (2006). Strategies for Competitive Advantage in Value Added Tea Marketing, Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka.

# Development of Green Tea incorporated instant herbal porridge mixture

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## Introduction

As the second largest tea exporter in the world, the greater portion of tea is exported as bulk tea. Average price of bulk tea is lower than that of value added products (Ganewatta et al., 2005). There are several types of teas which are producing with different processing methods such as, Black tea, Green tea, Oolong tea and White tea. Among them, green tea is considered as the healthiest beverage in the world. It is loaded with antioxidants and nutrients have powerful effects on the body. (Gunnars, 2014). Because of the bitter taste of green tea, most of the consumers do not prefer to consume green tea alone. Herbal porridge which is considered indigenous to Sri Lanka, comprises with therapeutic values and nutritious. In Ayurvedic medicine Osbekicaoctandera (heenbovitiya), Murrayakoenigi (curry leaves) are highly recommended for the preparation of Herbal Porridge for Diabetes& heart patients in traditional ayurvedic medicine. O. octandra is a very valuable and widely utilized plant species in indigenous Ayurvedic medicine in Sri Lanka (Peiris et al., 2006).A study published in the (Journal of Plant food for Nutrition), found that curry leaves have a great impact on the blood sugar levels of diabetics (Sampath, 2014). It can be medicinally and economically more valuable to develop green tea incorporated instant herbal porridge mixture by using natural resources. The objectives of this research were:

- Develop a green tea incorporated instant herbal porridge mixture
- Find out the best ratio of dehydrated green leaf powder and green tea powder for herbal porridge mixture
- Determine the Shelf life of the developed product

## Materials and Methods

*Heenbovitiya* (*Osbeckiaoctandra*) leaves and curry leaves (*Murrayakoenigi*) were steam blanched for two minutes separately and few minutes were allowed to drain excess water. Then leaves were oven dried at 60°C. Finally, well dried leaves were grinded and sieved well to obtain fine leaf powder for instant herbal porridge mixture. For the preparation of red rice for the instant herbal porridge mixture, cleaned red rice was presoaked for 4 hours and oven dried at 80°C. Cleaned soya beans were boiled for 25 minutes and oven dried at 80°C. Well dried soya beans were grinded to obtain fine powder for the porridge mixture. All the prepared ingredients were blended with three different levels of green tea powder (2.6, 3.6, 4.6g per cup) according to an Ayurvedic formula; the formula to prepare 25 cups of *Kolakanda* was rice 500g, fresh leaves 275g, soya bean 10g, raw garlic 10g, raw ginger 25g, salt 15g and water 5l (Gamlath et al., 2002).

The developed instant herbal porridge mixtures were evaluated for color, taste, aroma, texture and overall acceptability using 30 untrained panelists. The responses were recorded according to 5 point hedonic scale (5- extremely like to 1- extremely dislike). The sensory attributes were analyzed by Friedman test in MINITAB 14 statistical package and samples were compared by using 5% significant level.

Proximate analysis was carried out to determine the nutrient content of the selected best product through sensory evaluation. Total polyphenol content was determined according to the method based on ISO 14502 -1.

Detection of total plate count and yeast and mould were done during six weeks storage period. A sample of 31.4g of developed product was reconstituted for 5 minutes with 200ml of distilled water and 1ml of reconstituted sample was mixed with 9 ml of 0.1% peptone water in to test tube. After

completing appropriate dilution ($10^{-2}$) 1ml of the sample was introduce in to plates and it was allowed to be incubated at 25°C for two days. To determine the yeast and mould count potato dextrose agar (PDA) medium was used and to determine the total plate count plate count agar medium was used.

**Results and Discussion**

Table: 1 Results of Sensory Evaluation

| **Sensory attributes** | **Treatments** | | | |
|---|---|---|---|---|
| | **Treatment 1** | **Treatment 2** | **Treatment 3** | **P- value** |
| Color | 4.833 | 3.500 | 4.167 | 0.000 |
| Taste | 4.833 | 4.167 | 2.167 | 0.000 |
| Aroma | 4.667 | 4.000 | 3.333 | 0.000 |
| Texture | 4.333 | 4.167 | 4.000 | 0.103 |
| Overall acceptability | 5.000 | 4.000 | 3.000 | 0.000 |

*All the data are given as estimated median values
Given from p-value > 0.05 significant difference

- 3.6g of green tea powder mixed sample (treatment number 2) was selected as the best treatment.

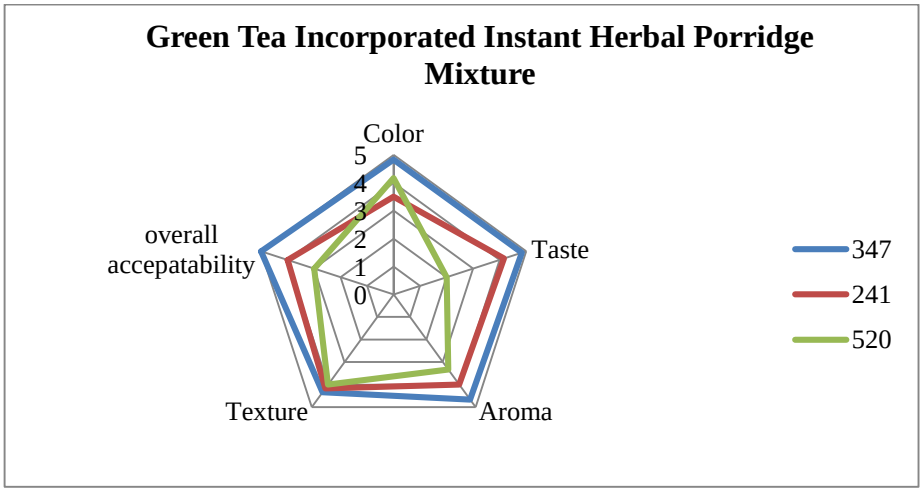


**Figure 1: Results of Sensory Evaluation**

Results of Proximate analysis were included in the table:2 is given below:

Table 2: Results of Proximate Analysis

| Mositure | Protein | Crude Fat | Crude Fiber | Ash | Total Polyphenol |
|---|---|---|---|---|---|
| 5.1% | 2.1% | 10% | 0.6% | 0.4% | 573mg |

Figure: 2 shows that the total plate and yeast and mould count of the product With the increasing time period of the storage. Total plate count were increased slightly but there were no colonies obtained for yeast and mould throughout the six weeks storage period.

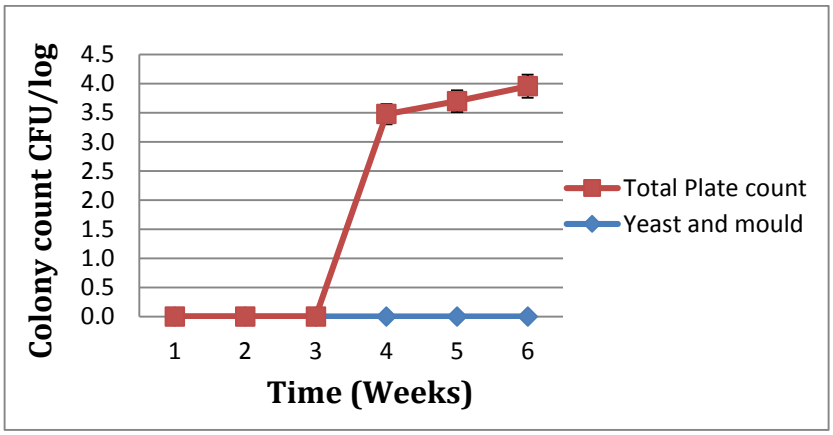


**Figure 2: Microbial count of the Product**

**Conclusion**

It can be concluded that, properly processed (according to above given procedures) green leaves, red rice and soya bean mixture has the ability to prepare porridge for consumption within 5 minutes. 3.6g from *heenbovitiya* power, 3.6g from curry leaf powder and 3.6g from green tea powder are the best green leaf powder ratio for the porridge mixture.Also product is stable under room temperature for more than one month under proper storageconditions(sealed Aluminum foil pouch under room temperature) with the moisture content of 5.1%).

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# Effect of dolomite application on available phosphorus status in Tea soils

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## Introduction

Tea (*Camellia sinensis* L.) is an important economic crop grown on highly weathered Oxisols and Ultisols in Sri Lanka. Phosphorus (P) is one of the most important macro nutrient that influencing growth, yield and quality of tea **(**Zoysa, 1997). Phosphorus deficiency is a concern, and a problem, in most tea soils. Research shows that over 70% of tea soils are P deficient (Lin *et al*., 1991). The availability declines rapidly as the soil pH falls below 5.5 or rises above 7. Therefore, measuring the soil pH helps the tea grower to adjust soil chemical condition suitable for nutrient uptake and plant growth (Zoysa, 2008). Dolomite is recommended for amelioration of acidity in tea soils. Present investigation was carried out to identify the effect of application of Dolomite on soil available phosphorus status in Tea Growing Soils.

## Methodology

**Site Description:** This field experiment was carried out at field No 17, Midland's Lower Division, Ratota. Midlands is an estate(s) and is located in Central Province Matale District of Sri Lanka. Long term experiment was initiated in 2009. The experiment was carried out by using tea cultivar TRI 2023.

**Experimental Design:** Field experiment was laid out in Randomized Complete Block Design consisting of five treatments in different rate of Dolomite (tons/ha/pruning cycle) namely T1 (Absolutely control), T2 (1), T3 (2), T4 (3), T5 (4). Each treatment replicated thrice.

**Soil sampling and Analysis:** Soil samples of two depths 0-15 cm and 15-30 cm were collected from the randomly selected places in each plot as a bulk and sub sample was taken from the bulk after the mixing. pH of soil suspension was determined by using pH meter(ORION 510A model, USA) with Ag/AgCl combined electrode. Soil available phosphorou**s** was extracted by Borax solution ( pH 1.5) and phosphoru**s** was determined by vanadomolybdate blue method (Beater,1949).

**Statistical Analysis**
The data generated from the study was subjected to Analysis of Variance (ANOVA) and treatment means were compared least significance difference at probability $p< 0.05$ using SAS statistical package version 9.1(SAS Institute, 1999).

## Result and Discussion

### Effect of application of different rate of Dolomite on soil pH

The effect of different rate of dolomite on pH in soils of 0-15 cm and 15-30 cm depths are presented in Table 1.Increasing trend in pH was observed with increasing dolomite rates at 0-15cm depth but it was not significant among treatment means. The highest value of pH was observed in T5 and it

significantly varied from other treatments at 15-30 cm depth. The optimum range of pH for tea is 4.5 to 5.5 (Anon, 2000). Application of different rates of dolomite did not exceed that level. It may be due to the high buffering capacity of Ukuwela soil series (Liyanage, 2012). Some mechanisms which affect the soil pH could not be controlled under field trial such as oxidation of applied N fertilizers, exchangeable acidity, washing out of dissolved cations, leaching of Ca and Mg due to the nature of the trial in field level. Due to plant uptake of these cations can alter the pH and those affect the equilibrium of soil pH. When nitrogenous fertilizer of ammonical nature added to soil they are nitrified and nitric acid is liberated.

Table.1: Effect of application of different rate of dolomite on soil pH at 0-15 cm and 15-30 cm depths

| **Level of Dolomite (tons/ha/pruning cycle)** | **pH (Water)** | |
|---|---|---|
| | **0-15cm** | **15-30cm** |
| T1-(0) | 4.43[a] | 4.33[b] |
| T2-(1) | 4.42[a] | 4.42[b] |
| T3 –(2) | 4.47[a] | 4.25[b] |
| T4-(3) | 4.59[a] | 4.48[b] |
| T5-(4) | 4.63[a] | 4.90[a] |
| LSD Value (<0.05% P) | 0.25 | 0.408 |
| CV % | 2.97 | 4.84 |
| P value | 0.289 | 0.041 |

*Means followed by the same letter in each column are not significantly different to LSD at 5% level.*

**Effect of application of different rate of dolomite on soil available phosphorus**

Soil available P was significantly varied at 0-15 cm with the different rate of dolomite application (Table 2). Significant increase of plant available P (13.67mg/Kg) at 0-15cm was recorded in T4 while T5 had shown the highest available P in soil at 15-30cm depth. It is generally known that reduction of soil acidity leads to increased phosphorus availability (Gaume *et al*., 2001). Iljkic.,*et al* (2008) reported that the increasing rate of dolomite increase the pH as well as the availability of phosphorus on acid soils. Most acid soils contain low P in soil pool because that is greatly influenced by soil. Tea plants are well adapted to acid soils with high Al availability. Under this condition P availability is rapidly declined. The sufficiency range of P for tea is 15-20ppm (Zoysa and Ananthacoomaraswamy, 1995). But, the results of this study showed the highest mean value of available P as 13.63 ppm at 0-15 cm depth and 17 ppm at 15-30 cm depth . ERP is only source applied evenly to all plots to satisfy P requirement. Availability of P may be influenced by dissolution of ERP. ERP dissolution is high at optimum moisture and pH (< 5.5) level (Zoysa *et al.* 1998). Low moisture content in soil due to insufficient rainfall during experimental period to dissolve the ERP and plant uptake could be the possible reason for these declines.

**Table 2:** Effect of application of different rate of dolomite on soil available phosphorus

| **Level of Dolomite (tons/ha pruning cycle)** | **P (mg/Kg)** | |
|---|---|---|
| | **0-15cm** | **15-30cm** |
| T1-(0) | 6.00[b] | 3.33[b] |
| T2-(1) | 3.67[b] | 3.33[b] |
| T3-(2) | 3.67[b] | 3.33[b] |
| T4-(3) | 13.67[a] | 4.00[b] |

| | | |
|---|---|---|
| T5-(4) | 7.67[a] | 17.00[a] |
| LSD Value (<0.05% P) | 6.163 | 3.47 |
| CV % | 47.21 | 29.74 |
| P value | 0.029 | 0.0001 |

*Means followed by the same letter in each column are not significantly different to LSD at 5% level.*

**Conclusions**

This study revealed that there was no significant difference in soil pH among different rate of dolomite applied at 0-15cm depth. Significant effect on pH with the different rate of Dolomite was found at 15-30 cm and highest soil pH was noticed with the highest dolomite applied plot. The P availability greatly influenced by soil pH. Application of 3tons dolomite/ha/pruning cycle had shown highest available P at 0-15 cm depth while application of 4tons dolomite/ha/pruning cycle had shown the highest available P in soil at 15-30 cm depth.

**Acknowledgement**

Laboratory facilities provided by the Tea Research Institute Talawakella, Sri Lanka are acknowledged.

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# Determinants of absenteeism in tea plantation workers (Case study in selected tea estate in Badulla)

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## Introduction

Absenteeism is a common problem in many industrial units, small or big, private or Government. It can be defined as a single day of missed work (Martocchio&Jimeno 2003), an individual's lack of physical presence at a given location and time when there is a social expectation for him or her to be there (Martocchio& Harrison, 1993) or non-attendance of employee for scheduled work (Gibson 1966, john 1978). Concerning tea sector in Sri Lanka, chronic absenteeism is one of the major problems which may lead to out-migration in the long run (Institute of Social Development, 2008). The labour situation on plantations has gone from one of surplus to deficit, with an annual decline at the rate of 10% – 20% of the workforce (Institute of Social Development, 2008). This has caused the privatized large-scale plantation or estate to afflict with low productivity and high cost of production which resulted for continuous low profit margins (Institute of Social Development, 2008). Sri Lankan tea production is mainly concentrated into seven regions and Uva region is having nine sub regions. Among these, Telbadde estate is the largest entity in Badulla/Demodera/Hali-Ela sub region (Sri Lanka Tea Board). According to the estate reports, Telbadde estate has one of the largest working populations in this region as well as high rate of absenteeism. As the absenteeism has become problematic to the estate in the short run as well as long run, this study attempts primarily to identify the factors affecting the short run absenteeism.

## Methodology

There are 161 holdings in estate sector all over the Badulla district (Statistical Information on Plantation Crops, 2012). Among them one of the largest entities is Telbadde estate employing 1346 workers with 464.50 ha of land extent. This estate manly consists with six divisions. COBO and Lower divisions are the farthest while Upper and West-Morland are the nearest divisions to the estate office.

Table 01: Worker population in the divisions

| **Division** | **Number of workers** |
|---|---|
| Upper Division | 293 |
| Lower Division | 163 |
| Kendagolla Division | 141 |
| West-Morland Division | 250 |
| Malangamuwa Division | 259 |
| Cobo Division | 149 |
| Factory | 91 |

Source: Progress Report – Telbedda estate, 2012

To find the determinants, primary data of 455 absentees for three months period were collected using a questionnaire survey covering all six divisions. A multiple regression model was used to find the determinants.

$$\boldsymbol{Y = \alpha + \beta_1 X_1 + \beta_2 D_1 + \beta_3 D_2 + \beta_4 X_2 + \beta_5 X_3 + \beta_6 D_3 + \beta_7 D_4 + \beta_8 D_5 + \beta_9 D_6 + \beta_{10} D_7 + \beta_{11} D_8 + \beta_{12} D_9 + + \beta_{13} D_{10} + \beta_{13} D_{11} + \varepsilon}$$

Y= Number of absent days (Number), $X_{1=}$ Age, $D_{1=}$ Gender (Dummy), $D_{2=}$ Marital Status (Dummy), $X_{2=}$ Number of family members (Number), $X_{3=}$ Number of dependent children (Number), $D_3$= COBO Division (Dummy), $D_4$= Upper Division (Dummy), $D_5$= Lower Division (Dummy), $D_6$= Malangamuwa Division (Dummy),$D_7$= Kendagolla Division (Dummy), $D_8$= West Morland Division (Dummy), $D_9$= Worker category (Dummy), $D_{10}$= 15 May - 15 Jun (Dummy), $D_{11}$= 15th Jun - 15th Jul (Dummy), $\alpha$ & $\beta$ = Coefficients, $\varepsilon$ = Random Error

**Result and Discussion**

Results of the regression analysis show that age of the absentee and dummy variables for COBO Division, Upper Division, Lower Division, West Morland Division and Worker category are significant at 95% confidence while the number of family members is significant at 90% confidence.

Table 02: Determinants of Absenteeism

| Explanatory variables | Coefficients | SE Coef | T |
|---|---|---|---|
| Constant | 5.5384** | 0.8076 | 6.86 |
| X1 | -0.02505** | 0.01105 | -2.27 |
| D1 | 0.0611 | 0.1919 | 0.32 |
| D2 | 0.4735 | 0.367 | 1.29 |
| X2 | -0.2396* | 0.1278 | -1.87 |
| X3 | 0.1566 | 0.122 | 1.28 |
| D3 | -0.7269** | 0.3569 | -2.04 |
| D4 | 1.7014** | 0.3994 | 4.26 |
| D5 | -0.898** | 0.3646 | -2.46 |
| D6 | 0.4735 | 0.3799 | 1.25 |
| D7 | 0.2593 | 0.4224 | 0.61 |
| D8 | 3.1469** | 0.3846 | 8.18 |
| D9 | -0.7727** | 0.3542 | -2.18 |
| D10 | -0.0072 | 0.2713 | -0.03 |
| D11 | 0.0381 | 0.2453 | 0.16 |

*and ** indicate significance at a 10% and 5% level, respectively.

The regression equation is

No of absent days = $5.54 - 0.0251\ X_1 - 0.2396X_2 - 0.7269D_3 + 1.7014D_4 - 0.898D_5 + 3.1469D_8 - 0.7727D_9$

More specifically, the results indicate that the absenteeism is decreased with the age of the worker. In plantation sector most of the youngsters prefer to find work out of the estate as their interest in working in estates has lost due to several reasons such as low profile stigma, unavailability of suitable opportunities for educate youth etc. On the other hand this is an indication that more workers are old workers and their main occupation is estate employment in comparison to youth. It is a fact that the younger generation work on and off in estates until they get a better opportunity outside the estate. Family size is a major determinant and it negatively associates with absenteeism. When the Number of family members increases the workers have to earn more for their day –to –day expenses. Since the workers are paid on daily basis they try to earn more via attending frequently to work.

Upper division and West Morland division have the largest worker population in the estate as 293 and 250 respectively. Therefore, naturally the absenteeism is fairly high in those two divisions as it explains by the coefficients of the variables. Also these divisions are the closest to the estate office.

But COBO and Lower division shows a negative relationship with the absent days. These divisions are located in the ends of the estate which are farthest to the office. Therefore the absenteeism in divisions where it has more access to city and the facilities is higher than that of in farthest divisions with less access to the urban area.

Worker category variable consist of residents and non-residents. 91% from the working population in this estate are residents who live inside the estate. Therefore they have to attend for work in the estate as it is the main source of their living. Therefore the variable, worker category, shows negative relationship with number of absent days.

**Conclusions**

According to the results of the study the age, number of family members, divisions with largest worker population locating nearest to the office (Upper and West Morland) and divisions farthest to the office (Lower and COBO) and worker category are the determinants of absenteeism for the workers in the selected tea estate.

**Acknowledgement**

All the staff members and workers in the estate are acknowledged.

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# Determinants of income diversification in Tea estates households in Badulla district

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## Introduction

Tea is the main foreign exchange owner in Sri Lanka. It shows that Tea industry is playing major role in national economy. Estate laborers are one of the major players in tea industry. Tea industry economically depends on sweat and blood of estate workers (Muthulingam, 2010). In initial stage of tea industry, laborers who were working in tea industry had estate income as sole income source. If it was sole way of income, the labor wage was very low. They had not enough facilities to engage with other agricultural and non-agricultural like income activities. Also management of tea estates was provided facilities to estate households to work only in estates. To improve the estate workers living condition, there is an alternative way called as an income diversification. Income diversification has talked world widely with various sectors. But, no any research has carried out on income diversification in tea estate households. Therefore, study of this matter is most important to the tea estate sector. In this study the income diversification and pattern of income diversification of tea estates households are considered in Badulla district.

## Materials and Methodology

The Survey was conducted in Badulla district by using 298 tea estates households. Censored Tobit regression analysis method was used to examine the determinants of income diversification. In many research on income diversification have used censored Tobit model to find out determinants of the income diversification. In this research dependent variables are including value zero to high amount of value. Therefore for Tobit model is used for data analying. (Schwarz and Zeller, 2005). In this study three dependent variables are taken as estate income, other agricultural income and non-agricultural Income. Nine variables are used as explanatory variable. Those are age of household head, gender of household head, number of dependents in a family, number of male, number of female, monthly expenditure, distance to the city, years of schooling household head and loan receipt.

## Results and Discussion

Table 03: Determinants of income diversification

| Explanatory variables | Estate income | Other agricultural income | Non-agricultural income |
|---|---|---|---|
| | Coefficient | Coefficient | Coefficient |
| Number of dependent | -7871.379*** | -2256.287** | -4596.131*** |
| Number of male | 5566*** | 87.8478 | 8231.956*** |
| Number of Female | 7416.034*** | 686.482 | 6434.544*** |

| | | | |
|---|---|---|---|
| Monthly Expenditure | .2750591** | .2519957** | .1913611 |
| Distance to City | 133.5043 | 191.6546 | -540.0511 |
| Age of Household Head | -225.4097*** | 52.19788 | 279.7119*** |
| Gender of Household Head | 1307.716 | 1898.897 | 4320.42 |
| Years of Schooling Household Head | -557.2577* | 767.5238 | 629.9214* |
| Received of Loan | 9767.181*** | 1926.039 | -13556.9*** |

[Note: *** p< 0.01(99% confident interval), ** p< 0.05 (95% confident interval), *p< 0.1 (90% confident interval)]

The results in the table 01 shows that number of dependents of the family, number of males, number of females, monthly expenditure, age of household head, and household head year of schooling and received of loan were the significant factors affecting on estate income share in total income of estate households. Number of dependents has negative significant effect on the income generate from estate activities. Number of males and number of females have positive significant effect on income share from the estate activities. Monthly expenditure has positive significant effect on share of income received from the estate income. Age of household head has negative significant effect on the income share from the estate activities. Household head year of schooling has negative significant effect on the income share from the estate activities. Loan receipt has positive significant effect on the income share from the estate working. Above Tobit results further revealed that monthly expenditure, number of dependents and household head year of schooling were the significant factors that affecting on other agricultural income share in total income of estate households. Monthly expenditure has positive significant effect on income share from the other agricultural activities. Total dependents in a family have negative significant effect on the other agricultural income. Household head year of schooling has positive significant impact on the other agricultural income. According to the findings of Barratt et al. (2001), years of schooling household head has negative significant impact on other agricultural employment.

According to the table 01 number of dependent in a family, Number of males, number of females, age of household head, household head year of schooling and received of loan were the significant factors affecting nonagricultural income share in total income of estate households. Number of dependents has negative significant effect on the income share from the nonagricultural activities. Number of males and number of females has positive significant effect on income share from the nonagricultural activities. There is a positive significant effect on the income share from the nonagricultural activities by age of household head. In many literature findings shows that age of household head has positive significant impact on non-agricultural income. (Mishra et al., 2010; Olay, 2010; Abdulai and Delgado, 1999). Years of schooling of household head has positive significant effect on the income share from nonagricultural activities. Barratt et al. (2001) and Minot et al. (2003) also have found that years of schooling household head has strong positive relationship with the non-agricultural income. Receipt of loan has negative significant impact on the income share from the non-farming activities. It suggested households that share their income from the nonagricultural activities are not going to receipt of loans.

Number of dependent is the only one factor which influenced on the both estate income, other agricultural income and non-agricultural income.

## Conclusion

Through this research we are mainly focused on the analyzing the determinants of tea estates households income diversification. This study showed that tea estates households in Badulla district had involved mainly in three income generating activities. Those are estate income, other agricultural income and non-agricultural income. The regression analysis revealed that diversification of income is determined by some socio economic factors. From those factors number dependents, number of males and females, monthly expenditure, access of loan, age of household head, years of schooling household heads are influenced on estate income. Other agricultural income activities are determined by monthly expenditure and years of schooling household head. Number of males and females, age of household head, years of schooling household head, number of children's, number of dependents and received of loan are determined the non-agricultural income. Only the Number of dependents is influenced on both estates, other agricultural and non-agricultural income activities.

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# Investigating the Causes for Poor Control of *Erigeron sumatrensis* (Alawangupillu) by Glyphosate in the Uva Region

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## Introduction

*Erigeron sumatrensis* (Alawangupillu) could be considered as a hard-to-kill weed in tea plantations because it has become totally resistant to Paraquat (Marambe et al, 2002) and from the recent past, there are claims that this weed shows a poor control also by Glyphosate (Prematilake, 2010). Recent investigations under upcountry conditions have shown that such poor control of weed is attributed to the dosages of Glyphosate applied and age or growth phase of weeds under up country conditions (Prematilake and Nawaratne, 2010 ; Prematilake and Darshani, 2011) . Hence, this study was aimed to determine the degree of control of *E. sumatrensis* weed at its different stages of growth by different dosages of Glyphosate under the conditions of Uva region.

## Materials and Methods

Plants of *E. sumatrensis* at five different growth phases, having 3-5, 6-8, 9-11, 12-14 and more than 15 leaves per plant, were collated from Ury Estate, Passara (30 plants from each of the five growth phases) and planted them on a raised bed, randomly at a spacing of 50 x 50 cm. Plants were left on beds for 2 weeks period to establish. Plants of each of the five growth phases were treated with two dosages of Glyphosate (3ml/Land 5ml/L) at two weeks after planting. An untreated control was also maintained. A drenching application of Glyphosate was given to each plant during morning time using a hand sprayer. The experimental design was Complete Randomized Design with two factor factorial with 2 replications.Visual injury symptoms in the weed (chlorosis of leaves, wilting of leaves, drying and scorching of leaves and leaf fall) were observed and scored at 7, 14 and 21days after application (DAA). The degree of damage on leaves and whole plant was taken in to account in scoring using a scale (0 to 9).The viable plants were counted and the dry weight of above ground part and roots were measured at 21 DAA.

## Results and Discussion

All visual symptoms such as chlorosis, wilting, scorching and drying of leaves and leaf fall were occurred at a higher intensity with Glyphosate at 5ml/L (2.75 L/ha) than the Glyphosate at 3 ml/L (1.65L/ha). Chlorosis of leaves and wilting of leaves were most prominent at seven DAA and scorching and drying of leaves and leaf fall prominent at 14 DAA.

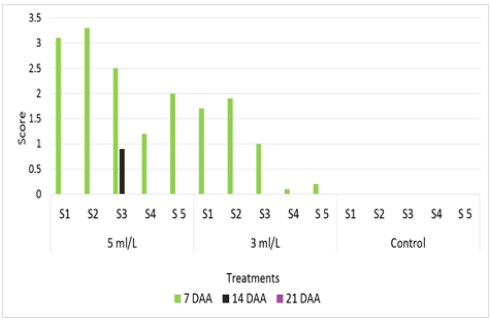


Fig 1: Chlorosis

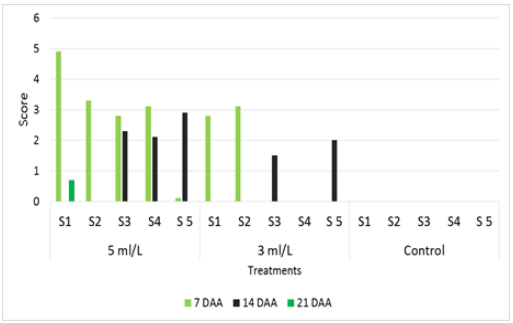


Fig 2: Wilting of leaves

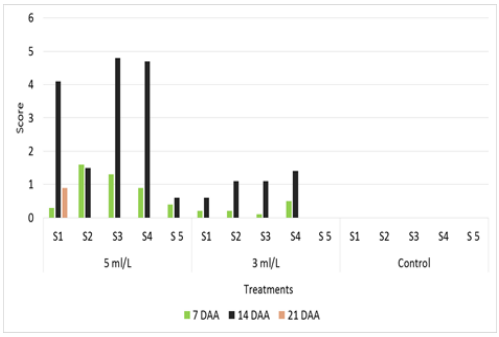


Fig 3: Scorching and drying of leaves

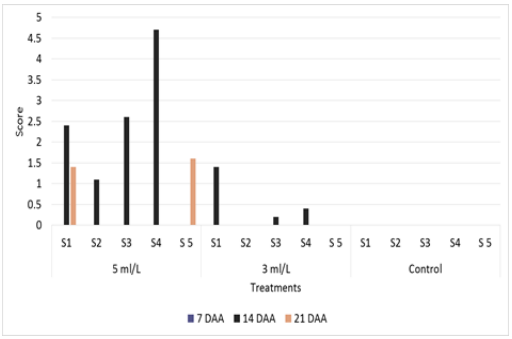


Fig 4: Leaf falling

The interaction effect between Glyphosate dosage and growth stages of *E. sumatrensis* on dead plant percentage and recovered percentage was significant ($p < 0.05$).

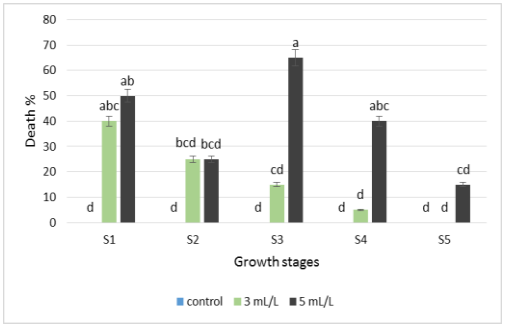


Fig. 5: Dead plant percentage

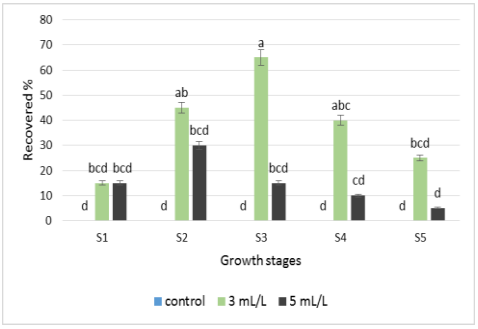


Fig. 6: Recovery percentage

The highest dead plant percentage was observed with 5ml/L (2.75 L/ha) Glyphosate compared to that of 3ml/L (1.65L/ha) Glyphosate. Furthermore, the highest dead percentage was reported from 9-11 leaf stage, and it was comparable at 3-5, 9-11 and 12-14 leaf stages. Highest recovery percentage was observed with 3 ml/L Glyphosate than that of Glyphosate at 5 ml/L at 9-11 leaf stage and it was comparable at 6-8, 9-11 and 12-14 leaf stage.

Dry weight of above ground part was not significantly affected by the dosage of Glyphosate at any of the growth phases. However, there was relatively a lower dry weight with Glyphosate at 5 ml/L

than that of 3 ml/L. Similar to the dry weight of above ground parts there was no significant difference in dry weight of roots between the Glyphosate dosages at all the leaf stages and also compared with the control except 12-14 leaf stage. However, comparatively a lower dry weight was recorded with Glyphosate treatments than the control and comparatively lower dry weight with 5 ml/L than that of 3 ml/L of Glyphosate.

Table 1: Mean dry weight (g/ plant) of above ground parts of at different growth stages (*E. sumatrensis)* by different Glyphosate dosages at 21 DAA

| Glyphosate dosage | **Mean dry weight of above ground parts at different growth stages (g/ plant)** | | | | |
|---|---|---|---|---|---|
| | **3-5 leaf stage** | **6-8 leaf stage** | **9-11 leaf stage** | **12-14 leaf stage** | **Above 15 leaf stage** |
| 5 ml/L | $0.056^{e}$ | $0.188^{de}$ | $0.185^{de}$ | $0.354^{cde}$ | $0.728^{bc}$ |
| 3ml/L | $0.064^{e}$ | $0.211^{de}$ | $0.532^{bcd}$ | $0.710^{bc}$ | $0.917^{ab}$ |
| Control | $0.061^{e}$ | $0.254^{de}$ | $0.343^{cde}$ | $0.808^{b}$ | $1.284^{a}$ |

(In each column mean followed by the same letter are not significantly different at $p<0.05$)

Table 2: Mean dry weight (g/ plant) of roots of E. sumatrensis at different growth stages as affected by two Glyphosate dosages at 21 DAA

| Glyphosate dosage | **Mean dry weight of roots at different growth stages (g/ plant)** | | | | |
|---|---|---|---|---|---|
| | **3-5 leaf stage** | **6-8 leaf stage** | **9-11 leaf stage** | **12-14 leaf stage** | **Above 15 leaf stage** |
| 5 ml/L | $0.037^{f}$ | $0.057^{f}$ | $0.154^{cde}$ | $0.162^{cd}$ | $0.304^{ab}$ |
| 3ml/L | $0.055^{f}$ | $0.073^{ef}$ | $0.156^{cde}$ | $0.234^{bc}$ | $0.339^{a}$ |
| Control | $0.086^{ef}$ | $0.073^{ef}$ | $0.223^{bc}$ | $0.329^{a}$ | $0.352^{a}$ |

(In each column mean followed by the same letter are not significantly different at $p<0.05$)

**Conclusion**

*E. sumatrensis* can be controlled to a certain level with the use of higher dosages of Glyphosate exceeding 5 ml/L or 2.75 L/ha. Lower dosage of Glyphosate such as 3 ml/L or 1.65L/ha was sufficient to get good control. The maturity of the weed has some attribution to resist to Glyphosate herbicide. Thus 9-11 leafy stage and 3-5 leafy stages are found to be more susceptible phases of *E. sumatrensis* for Glyphosate when used at 5 ml/L or 2.75 L/ha. Finally can be suggested that further higher dosages of Glyphosate (>5 ml/L or 2.75 L/ha) could be tested for an effective control of *E. sumatrensis.*

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# Clientele satisfaction towards the services rendered by government to the tea small holding sector

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## Introduction

Tea is pre-eminent among Sri Lanka's plantation crops and it is one of the most important industries in the country in terms of employment and foreign exchange earnings (Basnayake , 2002). Next to China and India, Sri Lanka is the oldest tea producing country in the world producing nearly for 150 years (Asopa, 2004). Over the years, the word Ceylon has become synonymous with quality tea.

The entire economic base of the country was centered on the plantation sector at the time when Sri Lanka was gaining independence in1948; nearly 32% of GDP came from exports of plantation crops, which contributed 92% of the total export earnings. The development of the small holder sector, especially in the Low country helped to maintain the production level during the 1980's despite the deterioration of the estate sector production. The smallholder sector expanded very rapidly and presently accounts more than half (76%) of the total production.(Annual Report, Tea Small Holding Development Authority, 2012)

Small holders must receive current information and technology for effective management of their production, marketing and financial decisions. Individual characteristics of producers affect on the demand for information services while confidence in the information services is a central determinant of the frequency at which a producer refers to the services. (Yapa and Ariyawardana, 2005).Coupled with the information, financial support is vital to expand and maintain the tea production. This requirement is fulfilled through the subsidy policy of the government.

Tea small Holding authority is the institute established as the main supportive body to the small holding sector. Other institutions that are responsible for tea are, namely, Tea Research Institute, Sri Lanka Tea Board and Tea Commissioner's Department.

So the research was conducted to identify the satisfaction level of the small holders towards the services rendered by the government, to identify major factors that cause to farmers satisfaction, to evaluate strong and weak areas of the government service procedure and to make suggestions to overcome the weaknesses in government services.

## Materials and methodology

Data were collected through a sample survey by giving structured questionnaire to randomly selected 150 small holders in 8 tea inspector's (TI) ranges at Badulla administrative district .

The degree of satisfaction of the small holders was the dependent variable and it was measured with respect to five different dimensions of the present government service. The dimensions considered were quality of the service, relevancy of technologies/service, competency of extension personnel, general usefulness/effect and characteristics of extension agent. Responses were obtained from five point Likert scale with scores of 5, 4, 3, 2, 1.

Coded and scored data were analyzed by Using SPSS software package. Based on mean and standard error, farmers were grouped in to three as less satisfied group, moderately satisfied group and highly satisfied group. The cut-off points for this categorization was derived by using the formula "mean (X) + or – 1.96 Standard Error (SE)" (V.S Sidhakaran, 2008).

Descriptive statistical techniques were used to present the demographic features of the sample. Simple correlation coefficient values were worked out to find out the strength of association between dependant variable and independent variables.

Multiple linear regression analysis was worked out to find out the contribution of independent variables to dependant variable. Age, Gender, Education level, farming experience, innovativeness, number of training attended, membership of a small holder association and contact intensity with an extension agent were selected as independent variables.

**Results and Discussion**

Larger proportion of respondents expressed low level of overall clientele satisfaction. Equal proportion of them was highly satisfied with the present government service procedure followed by less proportion of them moderately satisfied. This further indicates that there is a wide variation with respect to the clientele satisfaction levels.

Table 1: Distribution of small holders according to their overall clientele satisfaction levels towards the government services (n=150)

| No | Overall clientele | Satisfaction | Number | Percentage |
|---|---|---|---|---|
| 1 | Low | <62.22% | 58 | 38.66% |
| 2 | Medium | 62.22%-69.48% | 34 | 22.66% |
| 3 | High | >69.48% | 58 | 38.66% |

Table 2: Correlation of Independent Variables with the Dependent Variable

| Variable | Description | Co-efficient |
|---|---|---|
| X1 | Constant | 1.00 |
| X1 | Age | 0.15 |
| X2 | Gender | 0.068 |
| X3 | Education Level | 0.063 |
| X4 | Farming Experience | 0.173* |
| X5 | Membership of a small holder association | 0.741** |
| X6 | Frequency of meeting a extension Agent | 0.824** |
| X7 | Innovativeness | 0.719** |
| X8 | Communication channel usage | 0.876** |
| X9 | Time spend for tea cultivation | 0.046 |

*Correlation is significant at the 0.05 level

**Correlation is significant at the 0.01 level

Out of nine independent variable studied, only five variables farming experience, membership of a small holder association, frequency of meeting a extension agent, innovativeness, communication channel usage shows positive and significant association with the clientele satisfaction

Farming experience was significant under 0.05 significant level. It shows that there is a weak positive relationship between Overall clientele satisfaction and farming experience.

The variable, membership of a small holder association, frequency of meeting extension agent, communication channel usage and time spend for tea cultivation is significant at 0.01 significant levels. It shows that there is a strong positive relationship between overall clientele satisfaction and the mentioned variables.

Table 3: Regression Analysis of Factors affects on overall Clientele Satisfaction towards the Government Services

| Variable No | Description | P value |
|---|---|---|
| | Constant | 0.000 |
| X1 | Age | 0.302 |
| X2 | Gender | 0.840 |
| X3 | Education Level | 0.766 |
| X4 | Farming Experience | 0.233 |
| X5 | Membership of a small holder association | 0.000 |
| X6 | Frequency of meeting a extension Agent | 0.000 |
| X7 | Innovativeness | 0.002 |
| X8 | Communication channel usage | 0.000 |
| X9 | Time spend for tea cultivation | 0.623 |

Table 3 reveals that out of nine independent variable studied, only four variables Membership of a small holder association, Frequency of meeting a extension Agent, Innovativeness, Communication channel usage shows positive and significant association with the clientele satisfaction at 5% significant level .

**Conclusion**

Based on the results of the study, it can be concluded that government services have been effective in creating general awareness on agricultural practices. The extension services have been helpful in solving agriculture related problems. Most of the services seem to be received on time. Extension personnel are competent in communication and they have been maintaining a friendly relationship with the farmers.

The findings suggest that there are several drawbacks in the government service procedure. The technologies and recommendations are cost ineffective and incompatible with socio-economic conditions. Clients are facing inconveniences when assessing to the service providing places such as TRI and sub office of TSHDA. Clients are not having a positive attitude towards the way of distributing the subsidies. Also there are some weakness in monitoring and evaluation after launching a new project.

Membership of a small holder association, Frequency of meeting a extension Agent, Innovativeness of the farmer, Communication channel usage are having positive relationship with clientele satisfaction.

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# Firewood energy utilization in different dryers used in Tea processing

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**Introduction**

Tea industry is one of the most key important drives in Sri Lankan economy. Sri Lanka Sustainable Energy Authority is one of the important government institutions for energy management and enhancing awareness and creating technical capacity on energy conservation in Sri Lanka. Tea industry utilizes both electrical and thermal energy for its processing. The tea factories predominantly use fuel wood to meet their thermal energy needs, in the drying process, which is the major transformation process in the tea industry. The lack of researchers on the energy utilization of different dryers used in Sri Lankan tea industry and different types of dryers are used depending on the production capacity of the tea factory.

The objectives of the research are to find out firewood energy utilization of different dryers and performance of different dryers in Sri Lanka.

**Materials and methodology**

The research was carried out to Sustainable Energy Authority during the period from April to August 2014. Specific thermal energy utilization (MJ/kg) was used to measure the level of firewood consumption for dryers and it was tested for different dryers, location and combustion technology. Two factor factorial design was implemented as the experimental design where dryer type and combustion technology were taken in to consideration .There are three types of dryer commonly used in tea drying such as, conventional endless chain pressure type dryer (ECP), Fluidized bed drier (FBD), and combination drier which works on a combination of ECP and FBD principles .There are two types of combustion technologies used for tea drying such as, Boilers and furnace. Primary data were collected from factory officers by providing the structural questionnaires. Secondary data were also collected from the annual reports of Sri Lanka Sustainable Energy Authority and factory reports of different tea factories. Collected sample was surveyed based on the factory records during 2012 to 2013 to gather necessary information. Factory observations were also was carried out to confirm the accuracy of data that were collected by the interviews of factory officers and Factory managers.

Minitab 16 Statistical Software was used for both descriptive and interferential statistics. ANOVA General linear model was used to analyze the variance of dryer output in relation to dryer types and combustion technology. Collected data were analyzed using descriptive statistical methods. Descriptive statistics were graphical explained with using of Microsoft Excel and Minitab software. Pearson correlation was used to determine the association of consumption of firewood and total production. The relationship of firewood consumption and total production were analyzed by using simple regression technique.

**Results and Discussion**

According to descriptive statistics, firewood Energy Source was highly used in tea processing. The result revealed that, 19% firewood and saw dust, 8% firewood and furnace oil, only 3% of firewood

and coconut shell was also used. Jungle wood was highly used in tea processing. The results showed that 36% rubber firewood and only 19% rubber and jungle wood were also reported.

The low country and mid country tea factories use only firewood and saw dust. But up country tea factories use different types of energy sources. Up country tea factories mainly use Fluidized Bed dryers and mid country and low country highly use Endless Chain Pressure dryers. Low country and up country mainly trended in small scale production and mid country highly trended in large scale production. In mid country, it is available large, medium and low price firewood. But in up country and low country, it is available only large and medium price fire wood.

The Endless Chain Pressure dryer was the highly used dryer type.it was revealed that, 28% of Fluidized Bed dryers and only 25% of combination dryers were also used in tea processing. Endless Chain Pressure dryers had the dryer capacity of 180-280 kg/hr, Fluidized Bed dryers had 280-500 kg/hr and Combination dryers had 250-450 kg/hr capacity. Endless Chain pressure Dryers are easy to be maintained than others. Endless Chain Pressure dryers were mainly used in small scale production, Fluidized Bed dryer and Combination dryers were highly used in large scale production in tea factories.

The furnace combustion technology was highly used in tea processing. 61% furnace and only 39 % of boilers were reported. Majority of tea factories in small scale production use furnace and tea factories in large scale production use boilers. Majority of low country and mid country tea factories use furnaces and up country tea factories use boilers and prominently Endless Chain Pressure dryers utilize the energy of furnace and Fluidized Bed dryers use the energy of boilers.

When consider the Regression output, P value 0.000 of the model suggests that at 5% significant level, firewood consumption is significant in relation to the dryer made tea production. R – Square was recorded as 49.3 % and it implies that 49.3% of the firewood consumption is explained by the made tea while the 50.7% is explained by unexplained variables.

Table1: Firewood Energy Utilization of Different Dryers and Combustion Technology.

| Dependent Variables | Independent Variables | P Value |
|---|---|---|
| Firewood Energy Utilization | Dryer types | 0.078 |
| | Combustion Technology | 0.398 |
| | Dryer types*Combustion technology | 0.209 |

According to ANOVA Analysis, P value > 0.05, there is no significant different of dryers firewood energy utilization mean. So there is no effect of dryer types and combustion technology for dryer firewood dryer firewood energy utilization.

## Conclusion

The outcome of the study revealed that, about 70% of firewood and 44.4% jungle wood are mainly used for the dryers used in the thermal energy. Majority of the studied tea factories use Endless Chain Pressure dryers (47%) and the furnace combustion technology (61%).

Endless Chain Pressure dryers are mainly used in small scale production and Fluidized Bed dryer and the Combination dryers are highly used in large scale production. The low country and up country factories function towards a small scale production and while the mid country factories towards a large scale production. Majority of small scale production tea factories use furnace and large scale production tea factories use boilers.

The types of the dryers and the combustion technology do not affect significantly for the firewood energy utilization.

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# Protocol for callus induction of *Camellia japonica* L. (Tea rose)

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## Introduction

*Camellia japonica* (the Japanese Camellia) is one of the best known species of the genus *Camellia*. Among the *Camellia* species, the economic value of the *C. japonica* ranks the highest due to its beautiful ornamental flowers, edible uses (dried flowers, oil), medicinal uses (astringent, antihaemorrhagic, haemostatic, salve and tonic) and material uses (dye, oil) (Salinero *et al*., 2012).

Although *C. japonica* has a high ornamental and medicinal value, it is not popular in tea cultivating tropical agricultural country like Sri Lanka yet. Further, it was revealed that the difficulties of propagating Tea Roses are significant and therefore growers discourage to propagate them. Also C. *japonica* multiplication and improvement through seeds is rare due to poor seed set in the white and pink varieties present in Sri Lanka. *C. japonica* is usually propagated only using stem cuttings in Sri Lanka at present. But rooting was very poor in both pink and white varieties (Fernando and Alwis, 2013). But a good economic potential can be achieved in Sri Lanka due to its beautiful ornamental flower which is having long life span if it is scientifically developed to get different colors and shapes. Therefore, it is very important to *in vitro* propagation of *C. japonica* in large scale to commercially enhance its real value especially in the up country and mid country regions of Sri Lanka.

Therefore this study was aimed to develop a protocol to induce the callus culture of *Camellia japonica* L (Tea Rose).

## Material and Methods

This research study was conducted at Tissue Culture laboratory at Uva Wellassa University during the period of 22.04.2014 to 15.08.2014. The explants were collected from the Ury estates in Balangoda Plantations and Hakgala Botanical Garden, Hakgala, Nuwara Eliya.

This study was conduct to develop an efficient protocol for rapid and prolific callus induction of *Camellia japonica* (Tea Rose). In the first experiment, leaves and nodal segments used as explants. Nine different combinations of 20% sodium hypochlorite for three different time durations (20 minutes, 30 minutes, 40 minutes ) and 70% ethanol for three different time durations (30 seconds, 1 minute, 1 and half minutes ) were used to select the best sterilization method. Number of contaminated vessels were counted after one week. Above nine treatment combinations were succeeded only for *C. japonica* leaves. Because of again used another nine different treatment combinations for surface sterilization of nodes by adjusting soaking time duration in the 20% sodium hypochlorite (35 minutes, 40 minutes, 45 minutes).

In the second experiment, leaves, nodal segments and un opened flower bud flower petals used as explants. The sterilized explants were cultured on MS medium with three different hormone combinations of 3-indolebutric acid (IBA) and 6-benzylamino purine (BAP) to investigate the effect on callus induction.

Table 1: Nine different treatment combination used for callus induction of white and pink varieties of *Camellia japonica*

| Medium / Explant | Leaves | Nodal Segments | Petals |
|---|---|---|---|
| MS + 1mg/L IBA+2mg/L BAP | $T_1$ | $T_4$ | $T_7$ |
| MS + 1mg/L IBA+3mg/L BAP | $T_2$ | $T_5$ | $T_8$ |
| MS + 1mg/L IBA+4mg/L BAP | $T_3$ | $T_6$ | $T_9$ |

Shortest time duration was recorded as minimum number of days for callus initiation for each treatment separately. After three weeks from establishment of explants morphology of callus was observed.

**Results and Discussion**

**Selection and Preparation of Explants**

Developmental stage of an explant is an important factor for initiation of cultures for *in vitro* propagation. Younger the tissues better the *in vitro* response. Age of stock plant, physiological age of the explant and its developmental stage, as well as its size can determine the success of a procedure. Mature plant derived explants reported to be highly recalcitrant *in vitro*. Moreover, high degree of contamination in mature tissues poses problem in the establishment of culture. Juvenile explants are more responsive in culture than the mature explants from mature trees (Ahuja, 1993).

Accordingly, young, disease free, healthy fully expanded light green color leaves and light brown color nodal segments were selected as explant.

**Experiment 1**

Table 2: Contamination percentages of C. japonica leaves

| Treatment | Contamination % |
|---|---|
| 20% NaOCl for 20 min + Ethanol for 30 seconds ($T_1$) | 90% |
| 20% NaOCl for 20 min + Ethanol for 60 seconds ($T_2$) | 50% |
| 20% NaOCl for 20 min + Ethanol for 90 seconds ($T_3$) | 50% |
| 20% NaOCl for 30 min + Ethanol for 30 seconds ($T_4$) | 60% |
| 20% NaOCl for 30 min + Ethanol for 60 seconds ($T_5$) | 40% |
| 20% NaOCl for 30 min + Ethanol for 90 seconds ($T_6$) | 40% |
| 20% NaOCl for 40 min + Ethanol for 30 seconds ($T_7$) | 40% |
| 20% NaOCl for 40 min + Ethanol for 60 seconds ($T_8$) | 20% |
| 20% NaOCl for 40 min + Ethanol for 90 seconds ($T_9$) | 40% |

Contamination percentages of *Camellia japonica* leaves in each treatment were showed in table 2. The results showed that 20% NaOCl for 20 minutes with 70% ethanol for 30 seconds showed 90% contamination. All other treatments showed the contamination, below 60%. Among the nine treatments 20% NaOCl for 40 minutes with 70% ethanol for 60 seconds showed the lowest contamination percentage (20%) for leaves. That was acceptable for sterilization of leaves ($T_8$).

Table 3: Contamination percentages of *C. japonica* nodal segments

| Treatment | Contamination % |
|---|---|
| 20% NaOCl for 20 min + Ethanol for 30 seconds ($T_1$) | 100% |
| 20% NaOCl for 20 min + Ethanol for 60 seconds ($T_2$) | 80% |
| 20% NaOCl for 20 min + Ethanol for 90 seconds ($T_3$) | 100% |
| 20% NaOCl for 30 min + Ethanol for 30 seconds ($T_4$) | 100% |
| 20% NaOCl for 30 min + Ethanol for 60 seconds ($T_5$) | 100% |
| 20% NaOCl for 30 min + Ethanol for 90 seconds ($T_6$) | 100% |
| 20% NaOCl for 40 min + Ethanol for 30 seconds ($T_7$) | 90% |
| 20% NaOCl for 40 min + Ethanol for 60 seconds ($T_8$) | 80% |
| 20% NaOCl for 40 min + Ethanol for 90 seconds ($T_9$) | 70% |

Contamination percentages of *Camellia japonica* nodes in each treatment were showed in table 3. The results revealed that all treatments showed more than 70% contamination for nodal segments. T1, T3, T4, T5, T6 shows 100% contamination for nodal segments. That was doubtful for surface sterilization of nodal segments. None of surface sterilization method could be recommended. Therefore, again another nine different treatment combinations were used for surface sterilization of nodes by adjusting soaking time duration in the 20% sodium hypochlorite. Table 4 shows the results of adjusted treatments.

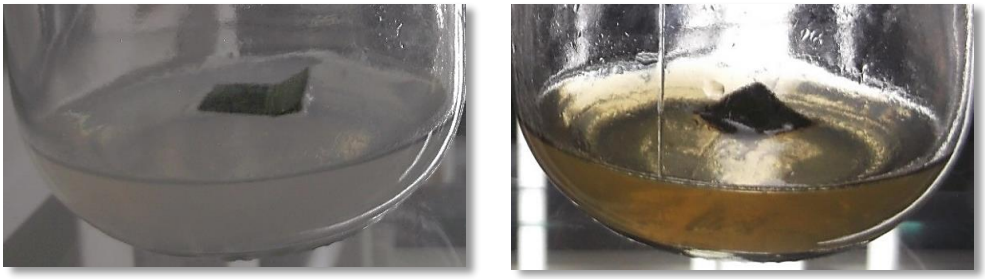
Table 4: Contamination percentages of *C. japonica* nodal segments

| Treatment | Contamination % |
|---|---|
| 20% NaOCl for 35 min + Ethanol for 30 seconds ($T_1$) | 100% |
| 20% NaOCl for 35 min + Ethanol for 60 seconds ($T_2$) | 90% |
| 20% NaOCl for 35 min + Ethanol for 90 seconds ($T_3$) | 90% |
| 20% NaOCl for 40 min + Ethanol for 30 seconds ($T_4$) | 80% |
| 20% NaOCl for 40 min + Ethanol for 60 seconds ($T_5$) | 90% |
| 20% NaOCl for 40 min + Ethanol for 90 seconds ($T_6$) | 80% |
| 20% NaOCl for 45 min + Ethanol for 30 seconds ($T_7$) | 90% |
| 20% NaOCl for 45 min + Ethanol for 60 seconds ($T_8$) | 70% |
| 20% NaOCl for 45 min + Ethanol for 90 seconds ($T_9$) | 30% |

Contamination percentages of *Camellia japonica* nodes in each adjusted treatments were showed in table 4. The results revealed that among the nine treatments only one treatment ($T_9$) showed 30% contamination where as all the other eight treatments showed more than 70% contaminations. 20 % NaOCl for 45 minutes with 70% ethanol for 90 seconds showed the lowest contamination (30%) for nodal segments of *C. japonica.* Thus T9 was accepted for surface sterilization of nodal segments of *C. japonica.*

Seran *et al.* (2007), Bidarigh and Azarpour (2013) reported that the surface sterilization of *Camellia sinensis* leaf and nodal explants were treated with 70% ethyl alcohol for two to three minutes time duration and 20% sodium hypochlorite for 30 minutes. The surface sterilization of the present study was strongly success with the using above chemicals with changing soaking time duration. 20% NaOCl for 40 minutes and ethanol for 60 seconds for leaves and 20% NaOCl for 45 minutes and ethanol for 90 seconds for nodal segments were succeeded for surface sterilization of *Camellia japonica*.

**Browning Effect of Explant in Culture Establishment**



**(a)** **(b)**

**Plate 1: Browning of explants (a) Just after establishment of the explant b) Browning after establishment of the explant**

One of the most common problems associated with the *in vitro* establishment of *Camellia japonica* is the deleterious effects of oxidized phenols (Forrest, 1969).The oxidation of exuded phenolic cause darkening or browning of explants of *Camellia japonica*. Leaf explants margins were light brown in the beginning, after it has become dark brown. Some leaf explant totally became brown color after the establishment and the oxidation of exuded phenolic cause browning of culture media after established the explants of *Camellia japonica* as shown in plate 1.

**Experiment 2**

Callus were initiated from *Camellia japonica* leaves and nodal segments, but among the three explants, flower petals did not respond to any of the treatment tried for callus initiation.

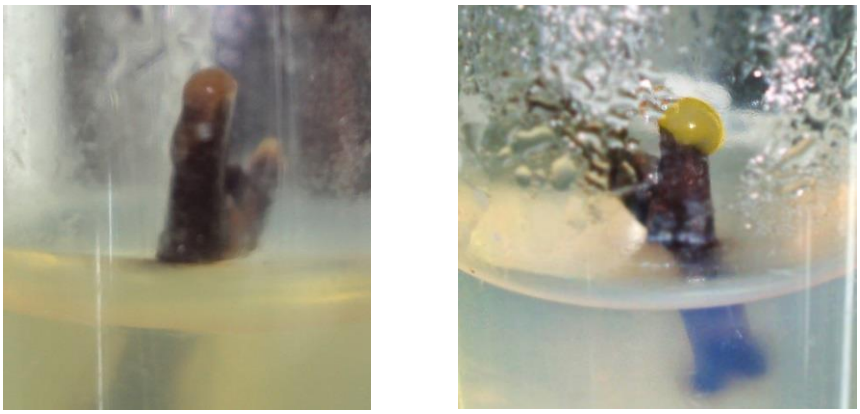
The minimum number days to callus initiation was 25 days from the leaves on Murashige and Skoog medium (MS) supplemented with the 1mg/L IBA + 4mg/L BAP (T3). Color of leaf pieces turned into light yellow in the beginning and gradually became dark brown and then initiated callus from the uncut surfaces.

**Plate 2: Calli of leaves after three weeks**

Leaves callus tissue was yellow in the beginning, it has become friable and greenish patches appeared on the top of the callus. Friable in texture and irregular shaped calli formed from *C. japonica* leaves explants.

The minimum number days to callus initiation was 19 days from the nodal segments on MS medium supplemented with the 1mg/L IBA and 2mg/L BAP (T4). MS medium supplemented with 1 mg/L

IBA and 3 mg/L of BAP (T5) took 23 days to initiate the calli. The minimum number days to callus initiation was 25 days from the leaves on MS medium supplemented with the 1mg/L IBA + 4mg/L BAP (T3).



(a) (b)

**Plate 3: Nodal callus (a) Initiated calli of nodal segments after three weeks (b) Calli of nodal segments after four weeks**

The color of nodal segments turned in to brownish orange and gradually became light yellow and then initiated callus from cut surfaces. When the callus aged, nodal callus was appeared as light yellow in color, watery and soft in texture and globular shaped.

Arulpragasam *et al.* (1988) reported on the successful production of callus from the tissues of cotyledons, nodal segments with axillary buds and leaves of *Camellia sinensis*. In the present study nodal segments with axillary buds and leaves of *C. japonica* were found effective explants for callus initiation.

*Camellia sinensis* friable calli were first initiated on cultured leaf segments in the presence of BAP (2.0 mg/L) and NAA (3.0 mg/L) after 21 days of incubation. A combination of BAP (2.0 mg/L) and NAA (1.0 mg/L) also induced greenish yellow friable calli but at a low frequency (Seran *et al.*, 2007). In the present study, MS supplemented with 4mg/L BAP and 1mg/L IBA was found effective for leaf callus formation of *Camellia japonica*. Callus color also greenish yellow and minimum number of days for callus initiation was 25 days. This is in accordance with the findings of Seran *et al.* (2007).

**Conclusion**

According to the results obtained, the protocol developed for initiation of the callus culture of *Camellia japonica;*

Semi mature light brown nodal segments (1cm) and light green leaves ($1cm^2$) as explant are favorable to induce callus on MS medium.

*Camellia japonica* leaves can be treated with 20% NaOCl for 40 minutes and 70% ethanol for 60 seconds (T8) and nodal segments can be treated with 20% NaOCl for 45 minutes and 70% ethanol for 90 seconds (T9) for proper surface sterilization.

MS supplemented with 0.9% agar, 3% sucrose, 0.001% myo-inositol, with 1mg/L IBA and 2mg/L BAP or 1mg/L IBA + 3mg/L BAP is better hormone combination for earlier callus formation from *Camellia japonica* nodal segments and MS supplemented with 0.9% agar, 3% sucrose, 0.001% myo-inositol, with 1mg/L IBA and 4mg/L BAP is better hormone combination for earlier callus formation

from *Camellia japonica* leaves. Among the different explants, nodal segments with axillary bud is the best explant for earlier callus formation for *Camellia japonica*.

Vertically placed nodal segments and leaves with a cut surface in contact with the medium is better for callus induction. Cultures should be maintained at 25±2ºC temperature under completely dark conditions in an incubator. The callus formed should be subcultured on the MS medium of same combination after two weeks of induction.

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# Distribution and accumulation of selected heavy metals in Tea plants

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## Introduction

Tea (*Camellia sinensis (L.) O.* Kuntze) is the mostly consumed beverage in the world after the water. Currently, as a natural beverage, its demand is increasing drastically all over the world. But, with the reporting of contamination of tea from different hazardous (Heavy metal, pesticides…*etc*.), which cause adverse health consequences to human being, the attention for food safety regulations are being promoted by the different counties to protect their people. As a result different quality assurance and food safety regulations and certifications such as ISO, HACCP, GAP, MRL, Acceptable limits for heavy metals …*etc.* have been introduced to the tea industry also.

At field level due to usage of agricultural fertilizers and pesticides, migration of contaminants into a non-contaminated land as vapors and leach through soil, or as dust, or spreading of sewage sludge…*etc* cause to contamination of tea from above mentioned hazardous. Among them, contamination of tea from heavy metals has a critical issue. According to Sri Lanka Tea Board Standard acceptable limits for Fe - 500, Cu – 100, Pb – 2, Zn – 100 and Cd – 0.2 mg/kg and each country sets its own allowable limit for heavy metal in made tea.

Hence, this research was carried out as a primary study to find out the how those heavy metals are being (zinc, copper and lead) distributed and accumulated in tea plants and the impact of Glyphosate application for distribution and accumulation of those heavy metals. The ability of plants to tolerate and accumulate heavy metals can be assessed using Translocation factor (TF) which is defined as the ratio of metal concentration in the shoots to the roots ([Metal] Shoot/ [Metal] Root). Hence, Translocation factor was calculated for each treatment and metal also.

## Material and Methods

Experimental unit were 18 months old tea plants (TRI 4052) which were planted in pots and for 45 days experiment was carried out in a shade house of Uva Wellassa University, Badulla. Research design was Complete Randomized Design. Control (Distilled water), Glyphosate (20 µl per pot) and heavy metal mixture (Zinc 300, copper 300 and lead 200 mg/kg per pot) were applied to plants diluting in 500 mL distilled water as treatments. Number of replications were five. Concentrations of Zn, Cu and Pb were determined in shoots, mature leaves, stem, mature roots and feeder roots using Atomic Absorption Spectroscopy after digested them. Plant tissues were digested using wet digestion procedure, thoroughly washed (from the tap water and distilled water) tea plant parts were dried at 80 $^{o}$C overnight. They were ground and sieved through 1 mm mesh. 0.5 g of sample placed in a small beaker and 5 ml of Con. $HNO_3$ was added. Then, it was kept for overnight to digest the organic compound in plant materials. Digested samples were heated on hot plate at 100 $^{o}$C for three hours (until emission of $NO_2$ fumes has ceased). Each sample was diluted with 25 ml of distilled water and filtered through filter paper. Filtered transparent solution were analyzed using Atomic Absorption Spectrometry.

## Result and Discussion

There was a significant difference ($p< 0.05$) between the treatments on accumulation of each heavy metal in different parts of tea plant. The treatment of Heavy metal mixture was significantly

difference from other two treatments. And there was no any significant difference between the control and Glyphosate treatments on accumulation of Zn, Cu and Pb each part of tea plant.

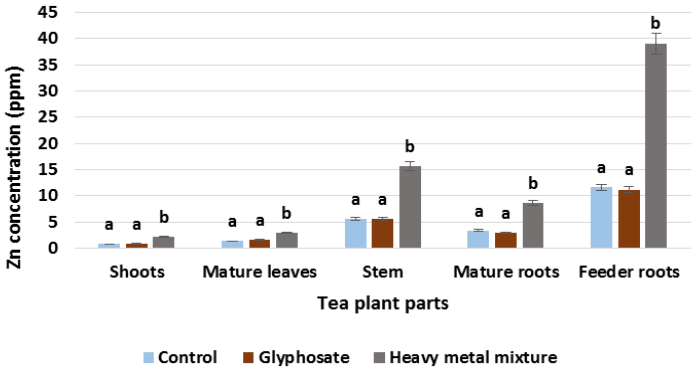



**Figure 1. Zn accumulation in different parts of the tea plant**

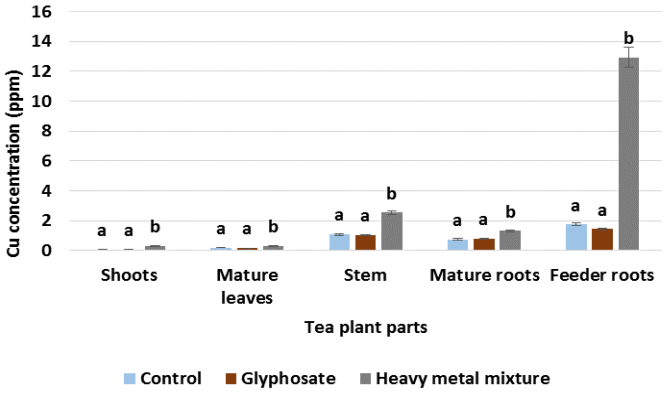
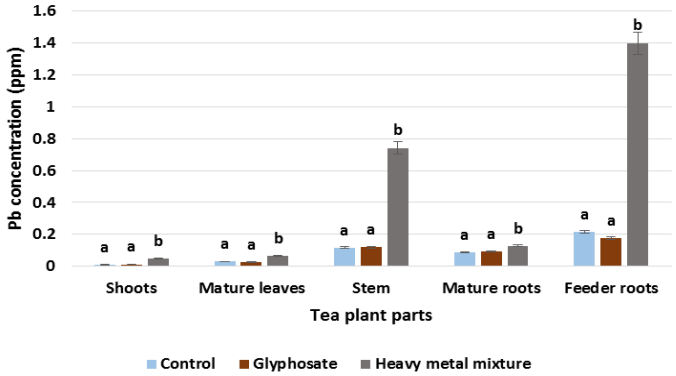



**Figure 2. Cu accumulation in different parts of the tea plant**




According to Figure 1, 2 and 3 the concentration of Zn, Cu and Pb in tea plants were in the order of: feeder roots > stems > mature roots > mature leaves > shoots. Most of the heavy metals were fixed in feeder roots and less amount of heavy metals transferred to the above ground parts. This implies that, there might be a mechanism to prevent heavy metals being transferred to above ground part in tea plants.

The ability of plant to tolerate and accumulate heavy metals can be assessed using Translocation Factor (TF). According to the Figure 4, it is reveal that there is a significant difference of TF values between the treatments in lead (Pb). Highest TF values were given by the Glyphosate treatments for all metals. Hence, it can be concluded that Glyphosate application has an impact on heavy metals distribution and accumulation and TF values in heavy metal mixture were lower than other treatments. It is further proved the mechanism that prevent heavy metals being transferred to the above ground parts in tea plant, under the condition of addition of external Zn, Cu and Pb to the soil.

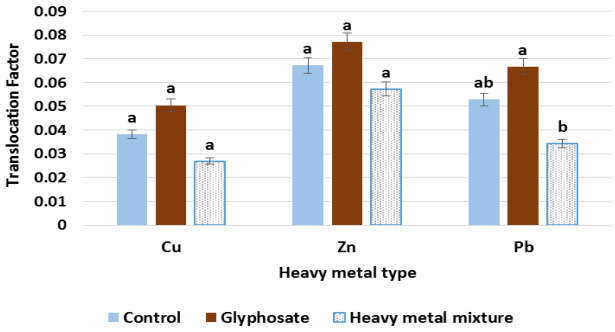



**Figure 4. Translocation Factor in different treatments**

## Conclusion

Concentrations of Zn, Cu and Pb in tea plants from high to low levels follow the order: feeder roots > stems > mature roots > mature leaves > shoots. Feeder roots and stems were the main channels of Zn, Cu and Pb transmission in tea plants, and also the main accumulation parts and roots preserve the absorption of most Zn, Cu and Pb under the condition of addition of external Zn, Cu and Pb to the soil. Reference to TF values it can be concluded that there might be a mechanism to prevent heavy metals being transferred to the above ground part and Zn, Cu and Pb accumulation in different parts

of tea plant was not significant in Glyphosate treatment compare to control. But, Glyphosate application has an impact on heavy metals distribution and accumulation in tea plant.

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